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NORD STREAM 2 ENVIRONMENTAL AND SOCIAL MONITORING IN SWEDISH WATERS, 2019



CONTENTS

1.	SUMMARY	4
1.1	Introduction	4
1.2	Construction activities in 2019	4
1.3	Monitoring of cultural heritage	4
1.4	Monitoring of ship traffic	5
1.5	Monitoring of Turbidity in Natura 2000 area	5
1.6	Monitoring of Underwater noise	6
2.	INTRODUCTION	8
2.1	Construction permit and commitment related to monitoring	8
2.2	Environmental and socio-economic Monitoring	8
2.3	Purpose of the document and reading instructions	9
3.	CONSTRUCTION ACTIVITIES IN 2019	11
3.1	Pipelay in 2019	11
3.2	Other construction activities in 2019	12
4.	ENVIRONMENTAL MONITORING	15
4.1	Monitoring of sediment transport	15
4.2	Monitoring of turbidity in Natura 2000 area	15
4.3	Monitoring of ecotoxicological effects	18
4.4	Monitoring of benthic fauna	18
4.5	Monitoring of underwater noise	19
5.	SOCIO-ECONOMIC MONITORING	26
5.1	Monitoring of commercial fishery	26
5.2	Monitoring of cultural heritage	26
5.3	Monitoring of ship traffic	32
6.	MONITORING RESULTS VS. ES-ASSESSMENTS	37
6.1	Monitoring of turbidity in Natura 2000 area	37
6.2	Monitoring of underwater noise	37
6.3	Cultural heritage	37
6.4	Monitoring of ship traffic	38
7.	TECHNICAL INSPECTIONS DURING OPERATION	39
7.1	External inspections	39
7.2	Internal inspections	39
7.3	Inspection frequency	40
8.	CONCLUSION AND RECOMMENDATIONS	41
9.	REFERENCES	42

ABBREVIATIONS AND DEFINITIONS

ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
AUV	Autonomous Underwater Vehicle
BCM	Billion cubic metres
CHO	Cultural Heritage Object
DP	Dynamically Positioned
CTDO	Conductivity, Temperature, Depth, Optical (sampler)
DCE	Danish centre for environment and energy (Aarhus university)
DHI	Danish Hydrological Institute
EEZ	Exclusive Economic Zone
ES	Environmental Study
FOI	Swedish Defence Research Agency
KP	Kilometre point
MBES	Multibeam echo sounder
NSP	Nord Stream project
NSP2	Nord Stream 2 project
NTU	Nephelometric Turbidity Unit
PIGS	Pipeline Inspection Gauges
ROV	Remote Operated Vehicle
SMA	Swedish Maritime Administration
SMTM	Swedish Maritime and Transport Museums
SSC	Suspended Sediment Concentration
SwAM	Swedish Agency for Marine and Water Management
TSS	Traffic Separation Scheme
UXO	Unexploded ordnance

1. SUMMARY

A Swedish translation of this summary is attached as Appendix A.

1.1 Introduction

The Nord Stream 2 Pipeline system (NSP2) through the Baltic Sea will deliver natural gas from vast reserves in Russia directly to the European Union (EU) gas market.

Pipelaying started in 2018 and was carried out by specialised vessels handling the entire welding, quality control and pipelaying process. Both pipelines were laid to a large extent during 2019. The route stretch from the Russian Baltic coast at Kurgalsky Peninsula in Narva Bay to the landfall near Lubmin, Germany. The NSP2 routing is largely parallel to NSP, however, the landfall facilities in both Russia and Germany are separate from NSP.

This document provides an overview of environmental and socio-economic monitoring activities carried out by NSP2 in 2019 (also slightly into 2020 where suitable) within the Swedish EEZ in relation to the following:

- Monitoring of cultural heritage
- Monitoring of ship traffic
- Monitoring of turbidity in Natura 2000 area
- Monitoring of underwater noise

This document is the second of seven planned annual reports (2019-2025), the purpose of which is to document the status and the results of the monitoring activities in the Swedish EEZ and if necessary recommend appropriate adjustments to the monitoring scope.

1.2 Construction activities in 2019

The pipelay activities for NSP2 started in 2018 and the remaining part of the pipelay scope in Swedish EEZ was completed in 2019, with a total of 995 km of pipeline laid in 2019. Both main lay vessels, the *Pioneering Spirit* and the *Solitaire*, laid pipe throughout the year. *Pioneering Spirit* left the Swedish EEZ into Finland whilst laying Line B end of May. *Solitaire* laid down Line A six km before the Danish border at the end of October. In end November, both lines were completed in Swedish EEZ and the vessels entered Denmark.

Rock placement and mattress installations prior to pipelay were completed in 2019. Post lay trenching in four sections (out of six) were completed in Q4 2019. Post-lay rock placement continued during 2019, with the plan to complete the work during the first half of 2020.

1.3 Monitoring of cultural heritage

The purpose of cultural heritage monitoring is to identify and document the condition of cultural heritage objects (CHOs) before construction and to verify the condition of those objects after pipeline construction.

The condition and location of each of the selected cultural heritage sites was surveyed by a visual inspection by ROV and a MBES (multibeam) survey prior to start of pipelay activities, in the beginning of January of 2019. The results of these surveys were presented in the Monitoring report 2018¹ (Ramboll 2019a).

¹ Construction activities in Swedish EEZ started in the beginning of 2019. ROV and MBES surveys have also been conducted in the beginning of 2019. Since monitoring report for the year 2018 to the authorities was presented in June 2019 the results of the initial ROV and MBES surveys were presented in the report for 2018.

Before the pipelines were laid in the beginning of January 2019, the survey company MMT filmed seven objects that were of interest for the Swedish authorities. The Swedish National Maritime and Transport Museums (SMTM) analysed the videos in March/April 2019. The analysis resulted in five shipwrecks, of which three were considered to be ancient monuments, i.e. wrecks older than 1850, according to the definitions in the Swedish Heritage Conservation Act (1988:950). The condition of these five wrecks that were monitored in the archaeological analysis before the construction have also been monitored after the construction of the pipeline and are presented in this report. The post-pipelay analysis of the five shipwrecks by SMTM showed that the objects were undisturbed by the construction of the pipeline.

1.4 Monitoring of ship traffic

The purpose of the control and monitoring related to marine traffic was to verify that agreed efforts and measures to minimize the risk of collisions or other accidents were implemented and that those measures were efficient. The monitoring activities for maritime traffic focused on the information provided from NSP2 to the authorities, up-front as well on a day-to-day basis in relation to notification of work plans and monitoring of third-party vessels passing the construction activities.

In the Swedish sector, NSP2 construction activities resulted in increased ship traffic in the form of pipe-laying, pipe supply to the lay vessel, mattress installation, rock placement and post-lay trenching. Based on the assessment in the Swedish ES, the activities cause a slightly increased risk of accidents involving third-party vessels. The assessment was based on the expected behaviour of both the construction vessels and the third-party vessels passing the construction vessels.

The marine traffic monitoring in Swedish waters in 2019, as in the previous year, included the following activities:

- Notifications to authorities as agreed (Activity 1);
- Monitor construction ship traffic using AIS (Activity 2);
- Monitor the commercial ship traffic, passing the slow-moving construction vessels (e.g. the lay-vessel), using AIS data (Activity 3)

The methodology included gathering and analysing of construction notifications sent by NSP2 to the authorities as well as daily information sent from the construction ships. For confirmation of actual construction activities within the Swedish EEZ, as well as movement to and from the construction locations, historical AIS data was analysed.

The results showed that NSP2 followed the commitment in the permit and informed the shipping authorities at least one month before construction work started. Construction vessels sent notifications to the authorities 48 hours before they entered Swedish EEZ or 24 hours before actual work started. Analysed recorded AIS data confirmed that the movements of the construction vessels were within the reported areas and that official shipping lanes generally were used for transportation to and from the construction locations.

1.5 Monitoring of Turbidity in Natura 2000 area

Turbidity is a measure of suspended sediments in the water columns. The purpose of the monitoring programme is to control and verify that no high sediment concentrations (15mg/l) are reaching the valuable shallow banks of Hoburgs bank and Norra Midsjöbanken (within the Natura 2000 area of Hoburgs bank and Midsjöbankarna) as a result of the trenching activities within the project.

Released sediments during trenching may travel by currents to neighbouring areas but numerical modelling of the sediment dispersion has been carried out for NSP2 and the modelling has shown

that increased sediment concentrations as a result of seabed interventions work in Swedish waters will be limited to the close vicinity of the construction sites, and not reach the shallow banks.

Measuring equipment was mounted on a submersible carousel during monitoring in the trenching zones. The carousel was towed after the turbidity monitoring vessel during trenching and data from the measuring equipment was continuously delivered to the on-board survey room and stored on computers. The data was immediately accessible to the surveyor and if the alarm thresholds of turbidity were exceeded, along with currents in the direction of the banks, suitable mitigation measures could be initiated.

There were no indications that high concentration sediment plumes would be able to reach the banks, with respect to both currents and the concentration in the plume directly behind the plough with most around values 4-12 mg/l. The highest value behind the plough was at Zone 2 and was measured to 24,7 mg/l, significantly under the alarm value of 35 mg/l, and this with a weak current towards north east. With a current of 2-10 cm/sec, it would take 13-14 hours for the plume to reach the bank north of the pipeline and dispersion and dilution would lower the concentrations to background levels.

To ensure that the background concentrations along the borders of Hoburgs bank and Norra Midsjöbanken were not rising, several background monitoring transects along these banks were performed. Background concentrations along the banks varied from 0,5 – 1,2 mg/l, regardless of when they were measured. This is verifying that the trenching activities did not increase the sediment concentration at the banks at any point.

1.6 Monitoring of Underwater noise

Due to concerns for disturbance of behaviour and masking effects on harbour porpoise, monitoring of underwater noise have been conducted to further verify the conclusions in the Environmental Study and expert opinions presented during the public referral. The purpose of the monitoring has been to measure underwater noise before and during the construction of the NSP2 pipeline within defined frequencies, including those that cover most of the hearing range of porpoises. In order to assess potential underwater noise impacts on harbour porpoises, ambient noise and noise from pipelay and rock placement has been measured. In addition to that, the presence of harbour porpoises has been documented using acoustic devices.

Noise measurements were conducted during winter, spring and autumn from four stations close to the actual pipelay transect (station B, C and D) and from 25 km away from it (station A), acting as a background monitoring station. The fieldworks were carried out by MEWO, while data processing and reporting were performed by DHI with external quality assessment by DTU Aqua. Fieldwork results have been reviewed by Jakob Tougaard and other experts on underwater noise evaluations with regards to marine mammals working at the Danish Centre for Energy and Environment (DCE).

Measured sound pressure levels were classified depending on the occurrence of noise events using the L95 and L5 exceedance levels, depending on location and season. L95 exceedance levels were used to measure the background level in the absence of noise events whereas L5 was used to measure the background level were other noise events occurred (such as pipe lay activities).

Background noise and passing vessels:

The L95 exceedance level at louder locations like station A that was near the main shipping route and stations B and C during the winter/spring was 110 (± 2) dB re 1 μ Pa. At more silent locations like station B and D in autumn, the background L95 exceedance level was only 104 (± 2) dB re 1 μ Pa. If vessels were passing or other noise events occurred (L5 exceedance level), the background level rose to 127 (± 2) dB re 1 μ Pa at stations A-C and 122 (± 2) dB at station D. Computed source levels of passing vessels ranged from 165.9 – 192.5 dB re 1 μ Pa over all stations and deployments,

most passages were detected and analysed at station A though, where a major marine traffic route passes close by.

Pipe-lay activities

The computed source level for pipelaying was 188 (± 5) dB re 1 μ Pa. The rather high uncertainty reflected the variability in the single estimates, which was most likely due to superposition with noise from supporting vessels. In one case, the frequency signature of a supporting vessel (Symphony Provider) could be identified. The computed source-level agreed well with the previous FOI-measurements done for Nord Stream in 2012 and was within the range of passing vessels.

The computed source level for rock placement reached 180 (± 3) dB re 1 μ Pa and thus remained below the source levels for pipelay and in the range of passing vessel noise (165.9 – 192.5 dB re 1 μ Pa).

Presence of harbour porpoise

Porpoises were detected both before and after pipelaying but in rare numbers. The results indicated a spatiotemporal variation in porpoise presence in the studied area during the whole monitoring period. There were more porpoises' detections at station A and B compared to C and D. Moreover, station A had more per cent porpoise positive days (% PPD) in the autumn months than in the winter/spring months. This is in line with results obtained by the SAMBAH project performed in 2011-2013. In line with the results from SAMBAH it was concluded that overall, the occurrence of the harbour porpoises in the studied area was relatively low.

Impact on harbour porpoise

The presence of porpoises was clearly documented on numerous occasions before and after passage of the pipe laying vessel. The number of detections were too low to allow proper statistical analysis with any appreciable statistical power to be conducted. Since the pipe laying operation during Nord Stream 2 construction was faster than during construction of Nord Stream, the time spent inside the Natura2000 area was shorter than what was assumed in the impact assessment and thereby also the potential impact. This was also concluded when rerunning the habitat loss model used for the impact assessment with the traffic data from the actual construction of Nord Stream 2. All in all, the observations support the assumptions on which the original assessment was made, indicating that with respect to harbour porpoises the integrity of the Natura2000 site was not compromised by the construction of the pipeline. The measurements obtained will remain a valuable addition not only to the knowledge about impact of pipeline construction on porpoises, but also on the general acoustic soundscape of the central Baltic Sea.

2. INTRODUCTION

2.1 Construction permit and commitment related to monitoring

The Nord Stream 2 Pipeline system (NSP2) through the Baltic Sea will deliver natural gas from vast reserves in Russia directly to the European Union (EU) gas market. The twin 1,230 km subsea pipelines will have the capacity to supply about 55 billion cubic metres (bcm) of gas per year in an economical, environmentally safe and reliable way.

NSP2 builds on the successful construction and operation of the existing Nord Stream Pipeline system (NSP), which has been recognised for its high environmental and safety standards, green logistics as well as the transparent public consultation process applied during its development. NSP2 is developed by a dedicated project company: Nord Stream 2 AG.

The NSP2 project envisages construction and subsequent operation of twin subsea natural gas pipelines with an internal diameter of 1,153 mm (48 inches). Each pipeline requires approximately 100,000 24 tonne concrete-weight-coated steel pipes laid on the seabed. Pipelaying has been performed by specialised vessels handling the entire welding, quality control and pipelaying process. Pipelaying began in 2018 and continued throughout 2019. The route stretches from the Russian Baltic coast at Kurgalsky Peninsula in Narva Bay to the landfall near Lubmin, Germany. The NSP2 routing is largely parallel to NSP. The landfall facilities in both Russia and Germany are thus separate from NSP.

Kilometre Points (KPs) presented in this report are Global KPs, with KP 0 being at the Russian landfall. The KPs for the 511 km long Line B (East) through the Swedish EEZ range between the global KPs 492 and 1003.

The permit for construction and operation of the two pipelines was issued by the Swedish Government on 7 June 2018. According to the permit and the project's commitments, the monitoring program shall include:

- Environmental Monitoring modules, such as sediment spreading and release of contaminants during intervention works and the impacts of this on mussel banks. Furthermore, NSP2 committed to measure that turbidity during trenching do not exceed 15 mg/l above the natural background values at Hoburgs bank and Norra Midsjöbanken.
- Socio-Economic Monitoring modules, such as shipping (e.g. that agreed communication procedures are followed) and that Cultural Heritage Objects should be avoided.

2.2 Environmental and socio-economic Monitoring

The program presented in this document focuses on the monitoring activities that were carried out based on work performed in the Swedish EEZ in 2019 (also slightly into 2020 where suitable) and includes:

- Monitoring of turbidity within the Natura 2000 area
- Monitoring of underwater noise
- Monitoring of cultural heritage
- Monitoring of ship traffic

The document covers the status of monitoring in general terms along with the overall results. Detailed descriptions of environmental and socio-economic monitoring activities and results are presented in specific monitoring reports, one for each monitoring module.

The monitoring program (Ramboll 2018) has been finalised in consultation with relevant Swedish authorities and has been adjusted where necessary to accommodate permit condition and permit commitments.

2.3 Purpose of the document and reading instructions

This document provides an overview of all environmental and socioeconomic monitoring activities carried out by NSP2 in 2019 (also slightly in to 2020 where suitable) within the Swedish EEZ. It is the second of seven planned annual reports (2019-2025), the purpose of which is to document the status and the results of the monitoring activities in the Swedish EEZ and if necessary recommend appropriate adjustments to the monitoring scope (see table below). The reports are planned to be submitted in May/June each year and cover all activities undertaken the previous year.

Table 1 Preliminary schedule for NSP2 environmental and social reporting

Monitoring target	2019	2020	2021	2022	2023	2024	2025
Sediment transport (after construction) ¹			*			*	
Turbidity in Natura 2000 area (during construction)		*					
Ecotoxicological effects (prior, during and after construction)	*						
Benthic fauna - reef effect (after construction) ¹					*		*
Commercial fishery (prior and after construction) ¹				*			
Cultural heritage (prior and after construction)	*	*					
Ship traffic (during construction)	*	*					
Underwater noise (prior and during)		*					
Technical Inspections (during operations) ²			*	*		*	

¹ Might also be reported after 2025

² The frequency depends on the results from previous inspections, but this will be monitored during the whole operation phase

This document starts with a summarised description, in Chapter 3, of all construction activities undertaken in 2019. In Chapter 4, the status of the monitoring of the environmental parameters is described, followed by a status of the monitoring of socioeconomic parameters in Chapter 5. A comparison with the results of the monitoring and the assessments made in the Environmental Study is presented in Chapter 6, followed by conclusions and recommendations in Chapter 7.

The monitoring activities are divided into eight different modules in accordance with the alignment below.

- Environmental monitoring parameters:
 - Monitoring of benthic fauna
 - Monitoring of ecotoxicological effects
 - Monitoring of turbidity
 - Monitoring of underwater noise
 - Monitoring of sediment transport

- Socio-economic monitoring parameters:
 - Monitoring of commercial fishery
 - Monitoring of cultural heritage
 - Monitoring of ship traffic

The yearly monitoring report is based on individual module reports. A brief presentation of each module is given in this main report along with the overall results in Chapter 4 and 5.

3. CONSTRUCTION ACTIVITIES IN 2019

3.1 Pipelay in 2019

Allseas with the DP (Dynamically Positioned) vessel "Solitaire" started the pipelay of line B close to the Danish border already in December 2018 and continued to lay northbound in Swedish EEZ until April 2019, when line B was laid down on the seabed east of Gotland. Solitaire then picked up line A east of Gotland and laid it southbound. "Solitaire" needed to lay down line A when it reached the border of the Natura 2000 area end July, as pipelay was restricted in that area between June-August. On the 1st of September, "Solitaire" picked up line A again and completed the construction through the Natura 2000 area and laid down close to the Danish border on the 21st of October.

The other DP pipelay vessel "Pioneering Spirit", laid both lines A and B in the northern part of the Swedish route. In Swedish EEZ, she began to lay line A from the Finnish border on the 4th of February and laid southbound through Swedish EEZ to the east of Gotland until April. In April "Solitaire" and "Pioneering Spirit" swapped lines and Pioneering Spirit continued to lay line B northbound, back to the Finnish border until the end of May 2019.



Figure 1 The dynamically positioned vessel Pioneering spirit

The Danish construction permit was approved on the 30th of October 2019, so the remaining part of both lines A and B towards the Danish border started end of November. The last ca. 6 km (per line) were completed by both "Pioneering Spirit" (line A) followed by "Solitaire" (line B) between 27-30 November 2019. At the end of November 1022 km (each line 511 km) was completed in Swedish EEZ and 995 of those kilometres were laid in 2019. The average lay-rate was ca. 4 km per day and the pipelines were placed within the permitted corridor. A safety zone of one nautical mile (1,852 m) was requested around the lay-vessels, which was communicated to third party maritime traffic via the Swedish Notice to Mariners.

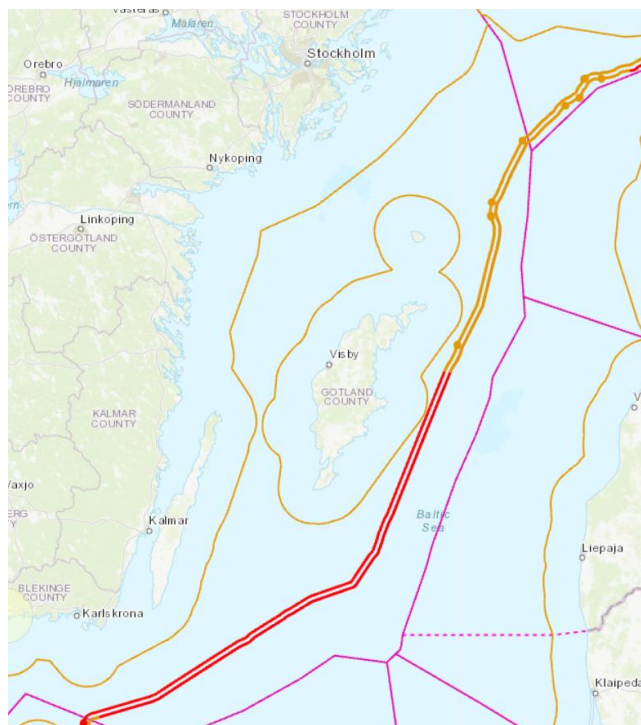


Figure 2 Distances laid by Solitaire (red) and Pioneering Spirit (orange).

During the time period 1st January to the 22nd of July four to five pipe carriers continuously transported pipes from the stockyards at **Kotka and Koverhar in Finland** and **from Karlshamn in Sweden** to the Pipelaying vessels. After July 22nd, the pipe supply came from Mukran in Germany.

Pre- and as-laid surveys were done during pipe lay activities 2019. Vessels like Oceanic, Fortitude and Normand Poseidon worked in the vicinity of the two pipelay vessels, supported with pre-lay surveys (for preparation) and touchdown monitoring (in order to confirm the correct positioning of the pipeline on the seabed).

In addition, one general supply vessel (Alegria) was operating from the supply base in Karlshamn and Koverhar, delivering food and other necessary material to Solitaire and Pioneering Spirit.

3.2 Other construction activities in 2019

3.2.1 Rock placement

74 rock placement installations with a total volume of ca 105 000 m³ were installed along the route throughout 2019 by the vessels Rockpiper, Nordnes, Seahorse and Bravenes, from the joint venture BoVo (Boskalis / Van Oord). The Swedish Maritime Administration (SMA) were informed well in advance, so that they could send out navigation warnings or notice to mariners if necessary.



Figure 3 Rockpiper installing a rock berm in the Swedish EEZ

3.2.2 Mattress installations

Most mattress installations were installed in 2018. The remaining mattress installations at the SWEPOL cable crossings in the southern part of the Swedish EEZ, just outside the Natura 2000 area, were installed by the vessel "OCV Oceanic" by the company Allseas in the beginning of July 2019.



Figure 4 Mattresses to be loaded on to the vessel Oceanic

3.2.3 Post-lay Trenching

Trenching in two out of three planned sections (per pipeline) in the Natura 2000 area were done in November and December 2019 by the main vessel "Havila Phoenix", with supporting tow vessels "Normand Prosper" (first) and "Normand Ranger" (later), from the contractor Deep Ocean.

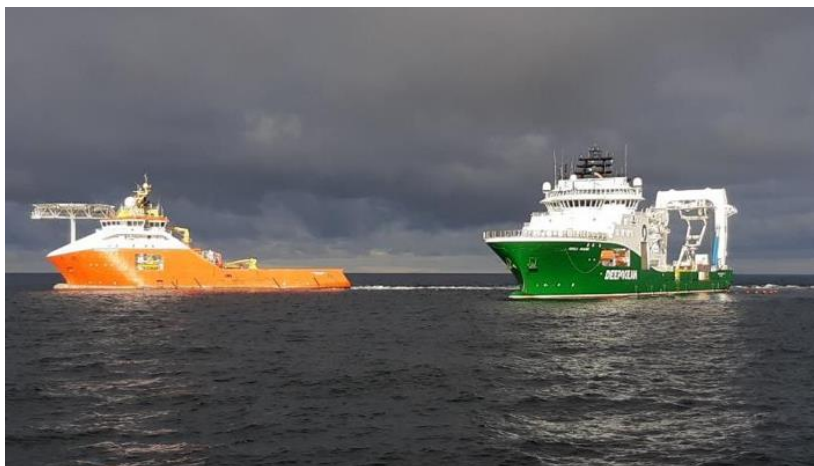


Figure 5 The trenching vessel Havila Phoenix with the tow vessel Normand Prosper

3.2.4 Construction related Monitoring Activities

The water quality (turbidity) was monitored during the trenching activities by the vessels "Fortuna Kingfisher" (first) and "Cecilia" (later) from the contractor DHI. They measured the density of the turbidity behind the plough and followed the plume to investigate if it could travel in the direction towards the banks "Norra Midsjöbanken" and "Hoburgs bank". See chapter 4.2 for more information.



Figure 6 The turbidity monitoring vessel Cecilia

5 wrecks were filmed after pipelay in 2019 and the results proved that they were not disturbed by NSP2 construction works. Three wrecks in the north part of the route (S-R17-04285, S-R19-1026 and S-R24-5317) were filmed in end of August by the vessel "CSV Normand Poseidon" and the remaining two wrecks (S-R30-0997 and S-R28-5046) were investigated in October by the vessel "Fortitude" organised by Allseas. See chapter 5.2 for more information.

Underwater noise, in the Natura 2000 area, during pipelay and rock placement activities, were measured in spring and in autumn 2019. The vessel "Mintaka I" from the company MEWO deployed three rigs with SM3M/SM4M Hydrophones, PAM Guards and C-PODs to monitor the noise level and to detect any Harbour Porpoises at three locations in the Natura 2000 area. This was done in two campaigns, the first started in March and the second started in August 2019. The monitoring rigs were collected in May (first campaign) and in December (second campaign). See chapter 4.5 for more information.

4. ENVIRONMENTAL MONITORING

4.1 Monitoring of sediment transport

Monitoring of sediment transport will be performed in order to verify that the pipelines will not impact the topographical environment along the route, and that the pipelines (including rock berms) will not significantly hinder natural sediment movements.

4.1.1 Method for monitoring of sediment transport

The sediment height will be measured using a multibeam echo sounder (MBES) at nine positions in transects across the pipelines. The collected data from the maintenance surveys will be compared to the data captured in the "as build survey" (which will be performed after the construction activities have been completed) to detect any possible changes in the surrounding seabed up to 5 m from the installed pipeline.

4.1.2 Monitoring and results 2019

No monitoring was carried out in 2019 and results will be presented in a later yearly report.

4.2 Monitoring of turbidity in Natura 2000 area

Turbidity is a measure of suspended sediments in the water columns. The purpose of the monitoring programme is to control and verify that no detrimental sediment concentrations are reaching the shallow banks of Hoburgs bank and Norra Midsjöbanken (within the Natura 2000 area of Hoburgs bank and Midsjöbankarna) as a result of the trenching activities within the project. The turbidity is determined by the seabed composition, ploughing depth and the speed of the ploughing.

4.2.1 Monitoring program, purpose and period of monitoring

The focus of the monitoring programme of turbidity are the environmental values on the shallow banks of Hoburgs bank and Norra Midsjöbanken (within the Natura 2000 area of Hoburgs bank and Midsjöbankarna).

Released sediments may travel by currents to neighbouring areas but numerical modelling of the sediment dispersion has been carried out for NSP2 and the modelling has shown that increased sediment concentrations as a result of seabed interventions work in Swedish waters will be limited to the close vicinity of the construction sites. The purpose of the program for monitoring of dispersion of released sediments is to verify the modelling results and control that the threshold value of 15 mg/l above the natural background values at the boundaries of the banks is not exceeded. If the alarm thresholds of turbidity are exceeded in the direction of the banks, suitable mitigation measures will be initiated (this could e.g. be: slowing down the trenching speed, delaying start of next trenching section, pausing work awaiting lower turbidity levels or shifting the order of sections to be trenched).

As the assumed sediment spill rate from trenching is 1-2 orders of magnitude larger than the assumed sediment spill rate from rock placement, the sediment spill monitoring only measured turbidity arising during trenching activities. The monitoring programme took place between 5th of November and 5th of December in 2019. Trenching was performed on both pipelines (A and B) in two zones (1 and 2) (Figure 7).

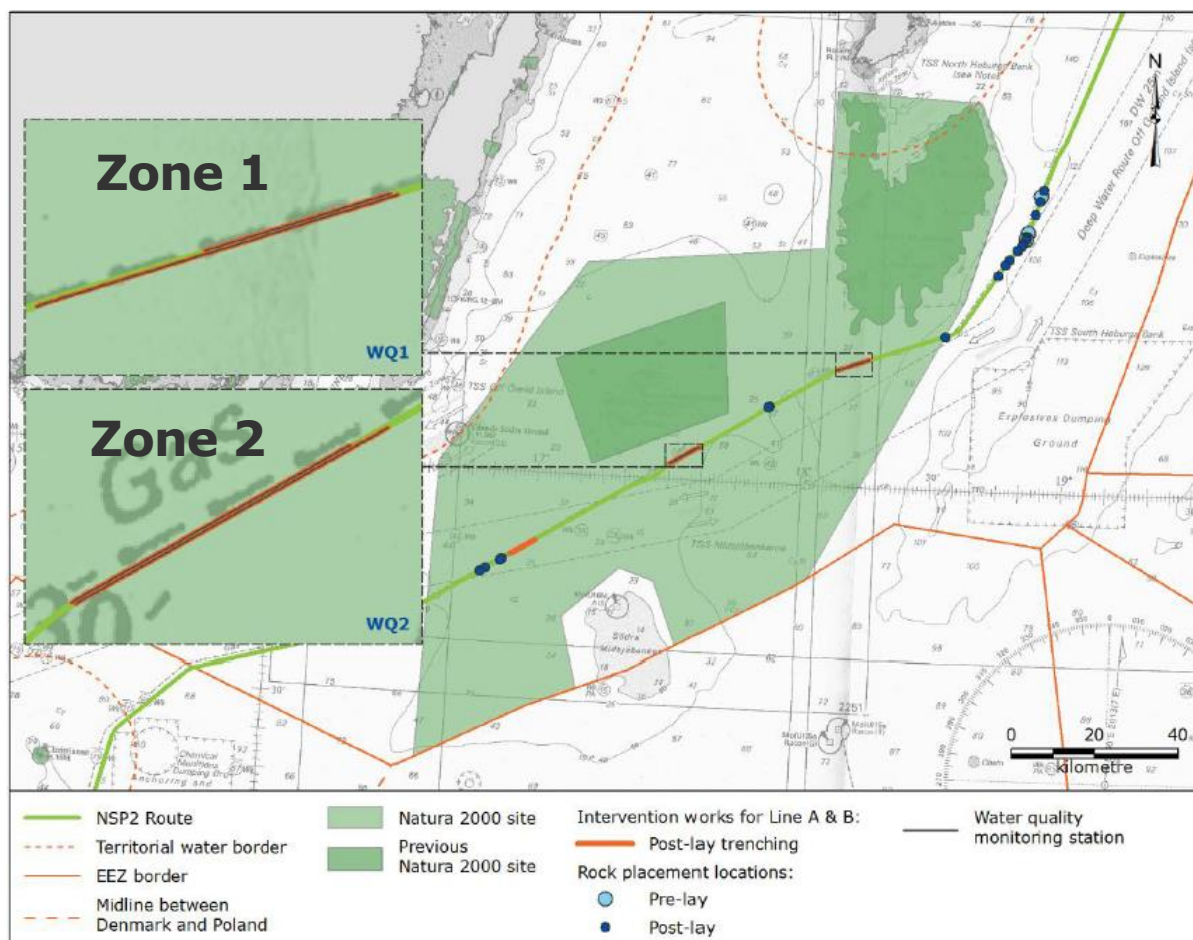


Figure 7 Map showing the two zones that were trenched in autumn 2019. The unnumbered orange zone south west of zone 2 was not monitored because it was assessed to be too far away from the sensitive banks to be considered. Image by DHI, 2020.

4.2.2 Methods for NSP2 monitoring of turbidity

Turbidity is a measure of suspended sediments in water columns and is measured in NTU (Nephelometric Turbidity Unit). However, the SSC (Suspended Sediment Concentration) is the value used when comparing the monitoring results with the threshold values in this control programme. To translate NTU to SSC, a conservative factor of 2 is used, hence $2 \text{ NTU} = 1 \text{ SSC}$ (1 mg/l).

NTU measuring equipment was mounted on a submersible carousel, along with 9 water sampling bottles. The carousel was towed after the turbidity monitoring vessel, five meters above the seabed, controlled by an altimeter that makes sure the right height is maintained during the operation. Data from the NTU measuring equipment was continuously delivered to the on-board survey room and stored on computers. The data was immediately accessible to the surveyor, who could activate the water sampling bottles if and when the NTU numbers were at or above specific values. The water samples were later analysed in a laboratory and the SSC value calculated. This means the translation between NTU and SSC could be verified/adjusted afterwards by comparing the data sets.

The turbidity was monitored by a monitoring vessel using the equipment described above, cruising in transects around the tow vessel plus the supporting vessel and sailing through the sediment plume measuring the NTU. All guidelines regarding safety distances from the other participating two vessels were followed.

In case the alarm concentration limit near the trenching site was exceeded ($>35\text{mg/l}$), depending on current velocities and direction, control transects were immediately performed between the

pipeline and the nearest bank. To be able to assess current and foresee the movements of the sediment plume from the trenching activities an ADCP (Acoustic Doppler Current Profiler) was used, providing current velocity and direction.

To ensure that the background concentrations along the borders of Hoburgs bank and Norra Midsjöbanken were not rising, several background monitoring transects along these banks were performed.

The monitoring of turbidity was performed by DHI for Zone 1 and 2 in the two lines (A and B) respectively, between 5th of November and 5th of December. A more detailed description of methods is found in the report by DHI (DHI 2020a).

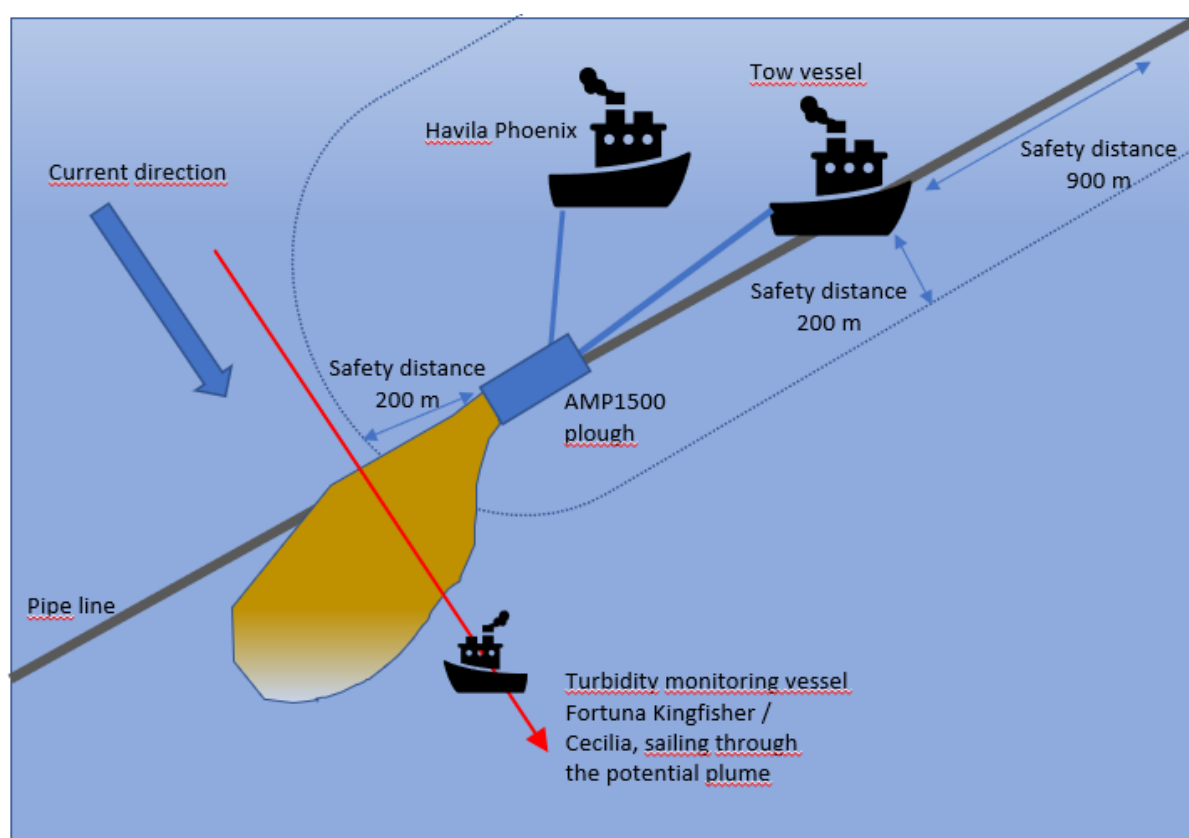


Figure 8 Schematic overview of the monitoring of turbidity during trenching. Please note that the sediment plume is exaggerated for illustration purposes only. Image by DHI, 2020.

4.2.3 Monitoring and results 2019

The monitoring in Zone 1 and Zone 2, for Line A and B respectively, was performed as described above. There were no indications that high concentration sediment plumes would be able to reach the banks, with respect to both currents (mostly towards south, east and west) and the SSC in the plume directly behind the plough (most values 4-12 mg/l). With respect to SSC and the current currents, no plumes were tracked further.

The highest value behind the plough was at Zone 2, Line B, and was measured to 24,7mg/l, significantly under the alarm value of 35 mg/l, and this with a weak current towards northeast. With a current of 2-10 cm/sec, it would take 13-14 hours for the plume to reach the bank north of the pipeline and dispersion and dilution would lower the concentrations to background levels.

Background concentrations along the banks, and the ploughing zones, varied from 0,5 – 1,2 mg/l, regardless of when they were measured. This is verifying that the trenching activities did not increase the SSC at the banks at any point.

The last 3,5 kilometres of Zone 2, Line B, was not monitored. This was decided by NSP2 and DHI with respect to 1-2 days of weather shut down and the data from Zone 2, Line A. Only very low SSC was measured in Line A, just 80 metres north of Line B, and there were no reasons to suspect that the seabed composition would differ and therefore effect the SSC during ploughing of Line B.

Also, the last kilometre of Line A Zone 1 was not monitored because of plough breakdown. Plough repairs and crew change would impose a lot of mobilisation and idle time for just a few hours of work, and therefore the last segment was left out. The data from the rest of the segment that was monitored showed that the sediment plume was very restricted, and no transport of sediment was detected towards Hoburgs bank.

A more detailed description of results is found in the report by DHI (DHI 2020a).

4.3 Monitoring of ecotoxicological effects

The monitoring of ecotoxicological effects have been finalized and results are presented in the 2018 yearly report (Ramboll 2019a). The monitoring program was designed to describe and evaluate potential effects on the common mussel caused by release of sediment and associated contaminants during the construction work. The monitoring set-up was divided in three different steps to represent actual environmental impacts on the marine fauna/mussels:

1. Sampling and analysis of sediments at the planned trenching site
2. Leaching tests on the sediment samples
3. Laboratory accumulation tests using mussels from trenching region

Whether the monitoring program should proceed to the next step or not depended on the results of the previous step, e.g. high or low levels of obtained contaminants. The monitoring was cancelled after the first step in consensus with the Swedish environmental protection agency due to low levels of contaminants in trenched sediments.

4.4 Monitoring of benthic fauna

The purpose of monitoring benthic fauna along the pipeline route will be to evaluate and document the establishment and growth of epifauna on and in the near vicinity of the pipelines and rock berms following completion of all construction activities in order to identify the establishment of communities on the new habitats (artificial reefs).

4.4.1 Method for monitoring benthic fauna

Visual inspection/video recording of the pipeline and rock berms will be conducted using ROV. Epifauna inspections will take place in four sections along the route; two sections on the pipeline within the Natura 2000 area and in two sections where rock placement is planned.

At each of the suggested locations, a 250 m section of the pipeline will be recorded using three video cameras mounted on an ROV covering the top and sides of the pipeline.

4.4.2 Monitoring and results 2019

No monitoring was carried out in 2019 and results from monitoring in 2022 and 2024 will be presented in the yearly reports in the following years.

4.5 Monitoring of underwater noise

Due to concerns for disturbance of behaviour and masking effects on harbour porpoise, monitoring of underwater noise have been conducted to further verify the conclusions in the Environmental Study and expert opinions presented during the public referral regarding potential impact from NSP2 construction activities on harbour porpoise in the Natura 2000 area.

4.5.1 Monitoring program, purpose and period of monitoring

Harbour porpoises produce short ultrasonic clicks (130 kHz peak frequency, 50-100 μ s duration). Previous investigations have indicated that noise from pipeline construction is at medium levels and can be compared to other sources of continuous sound such as dredging and shipping (Johansson och Andersson 2012). Likely impacts on harbour porpoises from such noise would then be restricted to behavioural responses unless the animals remain in the immediate vicinity of the construction, which is unlikely. However, the previous studies excluded frequencies due to technical limitations that are very relevant for porpoises, causing a knowledge gap on the likely effects of pipeline construction noise on this taxon. Since then, the technology has evolved making such measurements possible.

The purpose of this monitoring has therefore been to measure the underwater noise before and during the construction of the NSP2 pipeline within defined frequencies, including those that cover most of the hearing range of porpoises. In order to assess potential underwater noise impacts on harbour porpoises, background noise, noise from pipelay and rock placement has been measured. In addition to that, the presence of harbour porpoises has been documented using acoustic devices.

Noise measurements along the pipeline transect in Swedish waters were conducted close to the actual pipelay transect and from one station 25 km away from it, acting as a background monitoring station. The fieldworks were carried out by MEWO, while the data processing and reporting were performed by DHI with external quality assessment by DTU Aqua. The report conducted by DHI (DHI 2020b) has been reviewed by Jakob Tougaard at DCE and other experts on underwater noise evaluations with regards to marine mammals, who has given their conclusions on potential impacts from the project (DCE 2020).

Initially, the monitoring was planned to take place from end of December 2018 onwards, but due to delays of pipelaying work, the monitoring was postponed to the end of January 2019. Five cruises were undertaken in total to deploy, service and retrieve acoustic devices. These ranged from January to December 2019 and involved three periods (January – March = winter; March – May = spring; August – December = autumn).

4.5.2 Methods for NSP2 underwater noise modelling

In order to align with the previous underwater noise measurements performed by FOI (for NSP) in 2012 and benefit from those efforts in the analyses of the results, the set-up of these new measurements follow those used by FOI where possible and deemed appropriate. However, since the focus is somewhat different to what was requested by the authorities at that time, the set-up deviates to some extent. The monitoring includes both measurements of the background noise (baseline), pipelay noise and rock placement operations noise (noise from pipe lay activity). Below is a description of the monitoring set-up is summarized. A full detailed method description is attached in the DHI report (DHI 2020b).

Data collection

Acoustic recording was done from four stations in the Baltic Sea (A, B, C and D) to monitor the background noise, noise from passing vessels, pipeline construction activities and presence of harbour porpoises. Measured broadband levels and transmission losses based on a log-law were used to estimate source levels of passing vessels as well as for the pipelay and the rock placement work.

Each of the stations contained a rig with additional backups: stations A, B and C contained in total three rigs (A1 - A3, B1 - B3, C1 - C3) with data loggers, while at station D, that existed only in autumn 2019, five rigs were installed (D1-1, D1-2, D2, D3-1 and D3-2) to capture both pipelay and rock placement with two hydrophones recording simultaneously during each activity.

While stations B-D were in close vicinity to the pipeline path to capture pipelay (stations B-D) and rock placement (station D), station A monitored the background noise at a distance of 25 km from the pipeline. At this distance, noise from pipelay operations experienced a transmission loss of about 75 dB and was therefore considered not to disturb the background measurement. The four monitor stations are shown below in Figure 9.

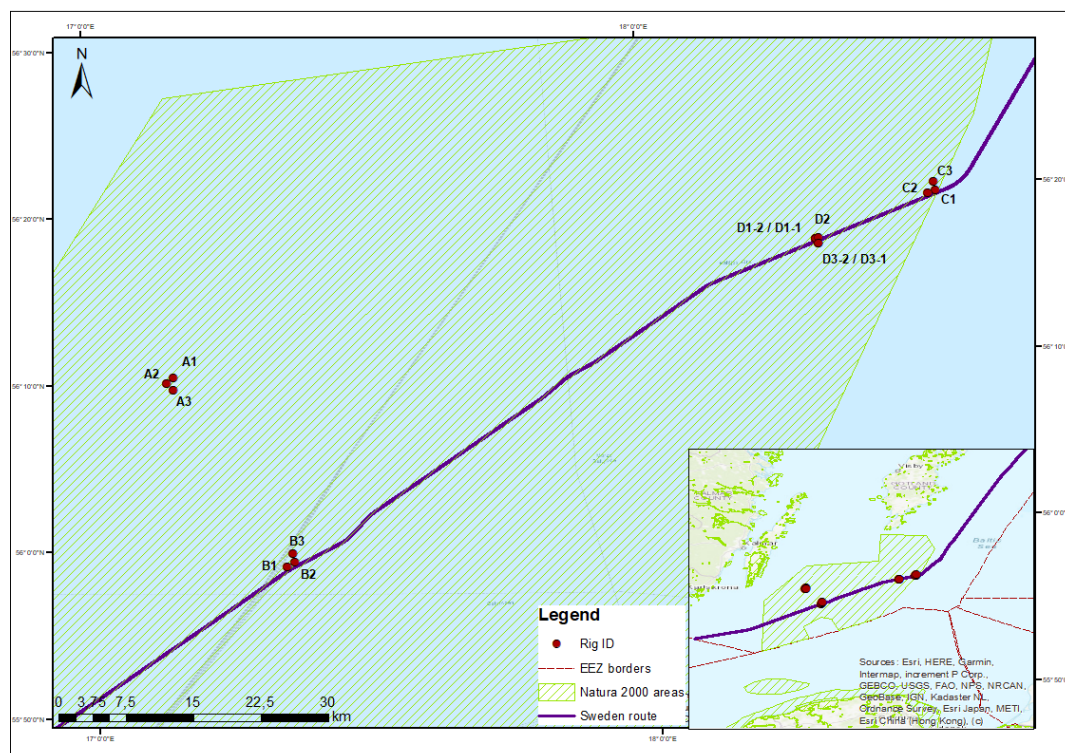


Figure 9 Overview of the four positions of monitoring stations with stations B, C and D along the pipeline and station A as background station. All the stations are within the Natura 2000 area "Hoburgs bank och Midsjöbankarna" (green area).

Noise measurements were provided with use of SM3M and SM4M recorders with a frequency range of 0-192 kHz. Harbour porpoises were detected by PAMGUARD using data from the mentioned recorders and with additional data from CPOD recorders designed to detect transient sound with a frequency range from 20-160 kHz. The devices were deployed using a custom-built mooring system containing a floating buoy, keeping the rig straight up from the seafloor, an acoustic releaser, the underwater noise recorder (SM3M/SM4M), the porpoise click detector (C-POD), an elastic part of the mooring system and finally a small concrete or iron anchor (see Figure 10)

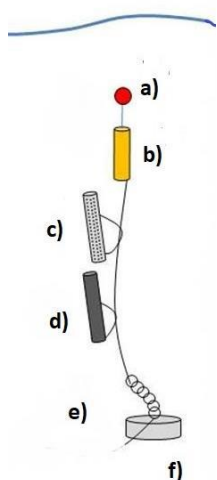


Figure 10 The mooring system for the noise and marine mammal monitoring. (a) floating buoy in depth, b) acoustic releaser, c) ambient noise monitoring sensor (SM3M/SM4M) d) marine mammals monitoring sensor (C-POD) e) elastic part of the mooring system, f) small concrete or iron anchor.

To ensure that rigs were not put on top of unexploded ordnance (UXO) that were dumped after World War II or any artefacts of cultural heritage, MEWO used a ROV vehicle on each station for visual inspection of the seabed in the area before the deployment. A vertical profile of conductivity and temperature with depth intervals of 1 m from the surface to the bottom were also measured at each of the four sites with a CTDO sampler.

Data analysis

Sound pressure level estimates and transmission loss were calculated accordingly (DHI 2020b).

Ship passages near to the stations were observed based on an AIS database from the MarineTraffic-web site (www.marinetraffic.com), where DHI has obtained an exclusive license.

The PAMGUARD software (Scottish Oceans Institute, Scotland) was used to analyse the raw wav files collected by the recorders. The software comprises a click detector module, which scans wav files for transient sounds within a specified frequency band. The detector was triggered at 12 dB. The click classification for porpoises was performed by comparing frequency band 110-150 kHz to control bands 40 - 90 kHz and 160-190 kHz with a threshold of 8 dB. After automatic detection of harbour porpoise's clicks, manual validation was performed using criteria for harbour porpoise click from the literature:

1. If there is more than one click detected, the interclick interval (ICI) should show patterns typical for harbour porpoise, i.e. approximately 10 % difference between ICIs of subsequent clicks
2. Click duration = 35-113 μ s
3. The main frequency of the clicks occurs in the range of 112-145 kHz (mean values 137 ± 6 kHz)

To be able to compare the PAMGUARD with the C-POD detection of harbour porpoise, the PPM ('Porpoise positive minutes') were created from PAMGUARD data.

The C-POD data were processed in the CPOD.exe software with the so-called KERNO classifier, which is specifically designed to detect narrowband high-frequency clicks (NBHF) which are

characteristic of harbour porpoises. From each station, C-POD data were exported as a PPM ('Porpoise positive minutes') within 1-minute resolution.

Presentation of PAM results

For the CPOD data, porpoise activity is given by the number of porpoise positive minutes (PPM) per day divided by the number of recorded minutes in a day and multiplied by 100 to derive %PPM for each day.

For the PAMGUARD data analysis, two approaches were taken:

1. Analysis with a similar approach as in C-PODs: at least 5 porpoise's clicks in the minute to be included;
2. Analysis including all detected clicks by PAMGUARD: including less than 5 porpoise clicks.

4.5.3 Monitoring and results 2019

Below the findings are summarized. For a full description of results from each rig and time point see DHI report (DHI 2020b).

During the whole monitoring period, the following devices were not found at the position of deployment: Rig C3 on May 18th 2019 and Rig A1 on December 17th 2019, likely lost due to trawling. Therefore, data from these devices were lost. Additionally, a problem with one SD card occurred at the rig D1-1, where the SM4M did not record any data on the slot B and the only data from the first SD card (slot A) were obtained.

Background noise and passing vessels

Received sound pressure levels were classified depending on the occurrence of noise events using the L95 and L5 exceedance levels, depending on location and season. L95 exceedance levels were used to measure the background level in the absence of noise events whereas L5 was used to measure the background level where other noise events occurred (such as pipe lay activities).

The background noise measurements showed in general a large number of individual noise events (spikes) that were most likely associated with ship passages. Using AIS data, a few vessels could be identified.

The L95 exceedance level at louder locations like station A that was near the main shipping route and stations B and C during the winter/spring was 110 (± 2) dB re 1 μ Pa. At more silent locations like station B and D in autumn, the background L95 exceedance level was only 104 (± 2) dB re 1 μ Pa. If vessels were passing or other noise events occurred (L5 exceedance level), the background level rose to 127 (± 2) dB re 1 μ Pa at stations A-C and 122 (± 2) dB at station D. Computed source levels of passing vessels ranged from 165.9 – 192.5 dB re 1 μ Pa over all stations and deployments, most passages were detected and analysed at station A though, where a major marine traffic route passes close by.

Pipe-lay activities

The pipelay source level was derived from 12 individual estimates from 6 different instruments with an L5 exceedance level estimate and a peak in 5-min Leq estimate for each instrument and deployment. The computed source level for pipelaying was 188 (± 5) dB re 1 μ Pa. The rather high uncertainty reflected the variability in the single estimates, that was most likely due to superposition with noise from supporting vessels. In one case, the frequency signature of a supporting vessel (Symphony Provider) could be identified. The computed source-level agreed well with the previous FOI-measurements of pipelay-induced noise in this region (Johansson och Andersson 2012) and was within the range of passing vessels.

Rock placement was only recorded by two instruments at station D using the same approach as for the pipelay source level. The computed source level for rock placement reached 180 (± 3) dB re 1 μ Pa and thus remained below the source levels for pipelay and in the range of passing vessel noise (165.9 – 192.5 dB re 1 μ Pa).

Spectral analysis

Spectral analysis showed that the major contribution to the sound levels was formed by the 1/3 octave levels between 31.5 Hz and 2 kHz. Most spectra during pipelay reached the highest levels at or around 125 Hz. Increased sound levels at 25 kHz during pipelay were substantial at station B and minor at station C but remained below the sound levels between 31.5 Hz and 2 kHz. During pipelay at station D, increased sound levels around 40 kHz were recorded and could be assigned to Symphony Provider. During rock placement, a small increase at 25 kHz was detected at one rig. The spectral peak during rock placement occurred however at 315 Hz.

If weighting for susceptibility to noise-induced injury for high-frequency cetaceans according to (National Marine Fisheries Service 2018) was applied, the sound pressure levels in the peaks from 25 – 50 kHz were most energetic.

Presence of harbour porpoise

Porpoises were detected both before and after pipelaying but in rare numbers. PAMGUARD analysis provided more porpoises encounters than C-POD and attributed to the different detection principles between the devices, which is consistent with other studies. However, both results indicated a spatiotemporal variation in porpoise presence in the studied area during the whole monitoring period. There were more porpoises' detections at station A and B compared to C and D. Moreover, station A had more per cent porpoise positive days (% PPD) in the autumn months than in the winter/spring months. This is in line with results obtained by the SAMBAH project performed in 2011-2013 (SAMBAH 2016). In line with the results from SAMBAH it was concluded that overall, the occurrence of the harbour porpoises in the studied area was relatively low.

Comparison to the previous FOI-study

In the previous pipelay work carried out in 2012, the Swedish FOI placed several autonomous hydrophones at two locations (station A and B) close to the Norra Midsjöbanken to determine the noise levels from the construction vessels (Johansson och Andersson 2012). The hydrophones on Station A was approximately 1.5 km from one of the main shipping routes and sufficiently far away from the pipelay area, so results could be used to demonstrate normal vessel noise. The second group of hydrophones was deployed approx. 1.5 km from the actual pipelay transect (station B). The recordings covered both the pipelay and the successive post-lay trenching. The data from the hydrophones were analysed at frequencies up to 3500 Hz with third-octave band spectra, and sound pressure levels and statistics for each of the hydrophones were calculated.

FOIs findings of average ambient noise showed levels of 116.5 – 116.6 and 110.9 – 111.5 dB re 1 μ Pa at the Stations A and B, respectively which corresponds very well to the 50% exceedance level of 116.3 dB re 1 μ Pa measured in this study. The measurements of 113.7 – 114.6 dB re 1 μ Pa measured at station B (DHI) is just about 3 dB higher than the previous measurement.

The 95% exceedance levels during background measurement – that should be almost free of vessel-induced noise – reached 104.3 and 99.2 dB re 1 μ Pa at station A and B, respectively, during the FOI study. DHIs measurements with 109.8 dB re 1 μ Pa at station A and 111.1 – 111.5 dB re 1 μ Pa at station B were substantially higher (up 12 dB more) than the FOI measurements. The authors speculate that the difference was caused by differences in the hydrophone sensitivity at high frequencies that were not measured during the FOI study. The difference between the 95% exceedance background levels during the DHI-study (≤ 1.7 dB) was much smaller than during the FOI study (5.1 dB).

For the trenching work at Station B during the previous study by FOI, the mean noise was recorded at 126.0 dB re 1 μ Pa from the vessel *Far Samson* and the source level for that particular vessel was estimated at 183.5 dB re 1 μ Pa. Compared to the noise level during trenching, the level during pipelay was then 4.5 dB higher, resulting in a source-level estimate of 188 dB re 1 μ Pa. The source level estimates for pipelaying by *Solitaire* in the DHI-study were with 189.8 – 190.1 dB re 1 μ Pa about 2 dB higher. The difference was still within the typical accuracies of underwater sound measurements of 2 – 3 dB.

Impact on harbour porpoise

Detections of harbour porpoises were scarce throughout the entire monitoring period, as anticipated from the general low abundance of porpoises in the Baltic Proper. However, the presence of porpoises was clearly documented on numerous occasions, supporting the previous observation that the Midsjö Banks is an important habitat for the Baltic porpoises (SAMBAH 2016). The number of detections were too low to allow for a proper statistical analysis with any appreciable statistical power to be conducted. The monitoring is however a significant achievement, both practically and analytically, given the very low abundance of porpoises in the central Baltic Sea and very challenging conditions for field work. It can be concluded with certainty that porpoises were in the area both before and after passage of the pipe laying vessel (DCE 2020).

From the harbour porpoise finds, together with a precautionary assumption that porpoises would react to ships up to 1 km away, a temporary habitat loss caused by construction of the pipeline was modelled. This was modelled for the initial assessments where the absolute magnitude of the habitat loss was predicted to be very low. However, since those conclusions were based on NSP-recordings where the frequency range was limited, a new model has been performed with full bandwidth recordings of both ambient noise and construction related noise during construction of Nord Stream 2 through the Natura2000 area.

Several conclusions can be drawn from the results, with implications for evaluating the actual impact on porpoises due to construction activities. These are summarized as:

- Underwater noise radiated from the pipe laying vessel (*Solitaire*) and support ships was as expected comparable in level and frequency content to noise radiated from commercial cargo ships in the area.
- Underwater noise from rock placement was likewise lower than or comparable to ship noise and with comparable frequency spectrum.
- These observations support the precautionary assumption used in the impact assessment that porpoise would not react to the pipe laying vessel, support ships, rock placement and trenching beyond 1 km from the vessel.
- Pipe laying operation during Nord Stream 2 construction was faster than during construction of Nord Stream, which was used as input to assessment of impact. This means that the time spent inside the Natura2000 area was shorter for construction of Nord Stream 2 than what was assumed in the impact assessment.
- These results lead to the conclusion that the actual temporary habitat loss due to pipeline construction was not larger than what was anticipated in the impact assessment and most likely smaller.
- This conclusion was supported by rerunning the habitat loss model used for the impact assessment with the traffic data from the actual construction of Nord Stream 2.
- Harbour porpoises were detected at low rates throughout the monitoring program, in and outside the pipe laying area. The low detection rate was anticipated based on the very low density of porpoises in the Baltic Proper and indicate that porpoises did use the Natura2000 area also when construction took place.

- Although detection rates are too low to allow for any kind of robust statistical analysis, these detections are consistent with the low level of disturbance anticipated in the impact assessment.
- Nothing in the results of the monitoring program therefore indicate that porpoises were adversely affected beyond the low and negligible impact anticipated in the impact assessment.

All in all, these observations support the assumptions on which the original assessment was made, indicating that with respect to harbour porpoises the integrity of the Natura2000 site was not compromised by the construction of the pipeline. The measurements obtained will remain a valuable addition not only to the knowledge about impact of pipeline construction on porpoises, but also on the general acoustic soundscape of the central Baltic Sea (DCE 2020).

5. SOCIO-ECONOMIC MONITORING

5.1 Monitoring of commercial fishery

From a technical point of view, the NSP2-pipeline system is designed to allow fishing over the pipelines without damage to the pipelines, i.e. to withstand hits from all types of trawling equipment used in the Baltic Sea. However, some fishery communities have raised concern about the conditions for trawling over and in the vicinity of the NSP2 (as well as the Nord Stream Pipelines - NSP). Thus, a monitoring program for fishery, similar to what was done for NSP, has been set up for NSP2.

5.1.1 Methods for monitoring commercial fishery

Analyses will be based on fisheries data collected by SwAM as part of the statutory reporting of fishery patterns and fish catches by the Swedish fishing fleet. The collected data will be compared and evaluated against the baseline conditions to see if there are any changes in the fisheries patterns due to the pipelines.

5.1.2 Monitoring and results 2019

No monitoring was carried out in 2019 and results comparing data from before and after the construction works will be presented in 2022.

5.2 Monitoring of cultural heritage

Initial detailed seabed surveys were performed before pipelay in order to prevent damage to cultural heritage sites during the pipelay. The surveys scope consisted of a geophysical survey, visual inspection and an expert evaluation of the findings made by The Swedish Maritime and Transport Museums (SMTM). This assessment resulted in seven potential CHO objects suggested to be closely monitored. Six objects were located within 250 m from either of the pipelines, but none closer than 50 m which was the protection zone established to minimize the risk of impacts to these sites. In addition, one object (S-R30-0997) was located approximately 700 m from the pipeline corridor but since this site is of special interest for the Swedish cultural heritage authorities it is also included in the monitoring program

Prior to construction in January 2019, the area of directly affected seabed was surveyed again to verify the seabed conditions i.e. that there are no new objects. In the vicinity of cultural heritage sites, the pipe-laying was also followed closely by ROV. The main two purposes of this survey were to determine if the selected seven wrecks in the pipeline corridor could be considered to be ancient monuments according to the definitions in the Swedish Heritage Conservation Act (1988:950) and to document the condition of the wrecks before construction so that their status could be analysed after the construction of the pipeline. This baseline assessment was presented in the 2018 yearly report.

In August and October 2019, a post-lay inspection was done for the same selected cultural heritage sites in the vicinity of the pipeline route which is new data presented in this report. These results were also reviewed by SMTM (Fredholm 2019b), this in order to conclude that the construction activities have not caused any impact to those objects.

5.2.1 Monitoring program, purpose and period of monitoring

The purpose of the cultural heritage monitoring was to document the condition of a number of selected potential cultural heritage objects (situated close to the pipelines route) before construction and to verify the condition of those objects after construction.

The results showed that two out of the seven objects proposed to be monitored were rock outcrops and therefore excluded from the following monitoring activities. Three of the objects were considered

to be ancient monuments, originated from before 1850. The list of CHOs included in the monitoring program is in Table 2.

Table 2 Monitoring of impacts on cultural heritage

Parameters, methods and timing of monitoring				
Target group	Parameter	Method	Location	Timing/frequency
S-R17-4285 S-R19-1026 S-R24-5317 S-R28-5046 S-R30-0997	Condition (intact/impacted)	ROV visual inspection MBES survey	Location of CHO sites	Prior to pipelay activities. After pipelay activities have been finalised.

In the figure below, the positions of the wrecks, chosen together with SMTM to be part of NSP2s cultural heritage monitoring, are shown.

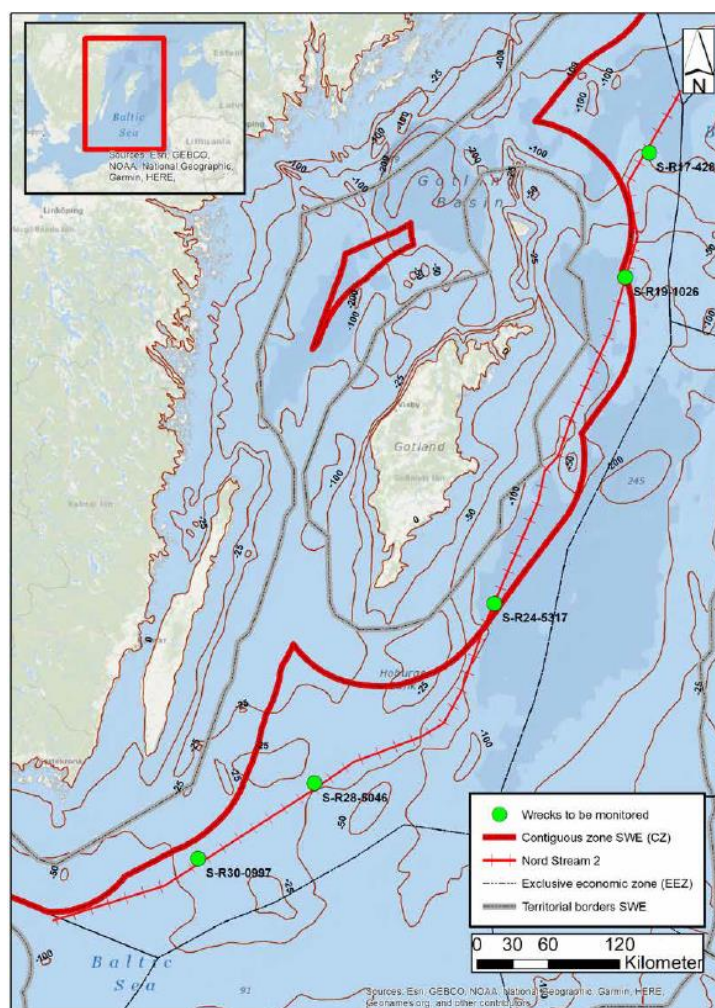


Figure 11 Objects chosen to be part of NSP2 cultural heritage monitoring

5.2.2 Methods for NSP2 cultural heritage monitoring

The methodology follows the same approach used during NSP. The pre-lay ROV-filming and multibeam-imaging of the wrecks was performed between 4 and 8 January 2019 by the survey company MMT with the vessel Stril Explorer. The post-lay inspections of the five wrecks was performed in August and October 2019. High resolution bathymetry/ multibeam-images as well as still pictures of each of the five wrecks, with “events” (photo stations) has been used for comparison of the wrecks’ status before and after construction. The impacts of the construction activities to the CHO sites was detected by comparing the baseline survey and the post-lay survey results. This assessment was done by marine-archaeological expert (SMTM).

5.2.3 Monitoring and results 2019

The five analysed shipwrecks from post-pipe lay are considered by SMTM to be undisturbed by the construction of the pipeline. Minor changes on shipwreck S-R30-0997 possibly depends on trawling, fishing, waves and currents. The monitoring results are presented in Table 3. SMTM has estimated that three wrecks (S-R17-4285, S-R28-5046 and S-R30-0997) foundered before 1850 and are therefore considered to be ancient monuments according to the definitions in the Swedish Heritage Conservation Act (1988:950). These three objects are described below in more detail where pre- and post-lay analysis are compared.

Table 3 Cultural heritage monitoring results

ID No.	Distance to pipeline (m)	FMIS/ Fornreg reg.no	Ancient monument	Description	Post-lay status
S-R17-4285	203	61:3	Yes	Wreck	Undisturbed
S-R19-1026	238	2:160/ L2019:159	No	Wreck	Undisturbed
S-R24-5317	93	2:164/ L2019:143	No*	Wreck	Undisturbed
S-R28-5046	142	2:48	Yes	Wreck	Undisturbed
S-R30-0997	730	2:165/ L2019:170	Yes	Wreck	Possibly disturbed by trawling/fishing

*Although SMTM argues that it most likely has sunk after 1850, a younger wreck can be classified as an ancient monument by the County Administrative board, according to the definitions in the Swedish Heritage Conservation Act, if certain criteria are fulfilled.

S-R17-4285

This is a wooden wreck that is 17 m long and 5 m wide. In the first SMTM analysis the shipwreck was believed to be from the 17th or an 18th century, based on an assessment of the ship’s construction, anchor, ships boat, capstan, details etc. (Fredholm 2019a). An additional survey has been carried out after that by a team of archaeologists from MMT, Deep Sea Productions, Södertörn University (MARIS) and the University of Southampton which also included a 3D-photogrammetry. This survey concluded that the ships construction and especially the two possible swivel guns indicate that the ship might be from the 15-16th century (Fredholm 2019b).

The wreck is carvel-built. It has two standing masts, a mainmast and a foremast in the bow. An anchor is hanging on the starboard side near the bow and one stands on the seafloor just off the

bow. A “ship’s boat”² lies on deck on the port side. The ship’s boat has a flat bottom and the sides are clinker built (Fredholm 2019a).

The shipwreck is undisturbed by the construction of the pipeline. A comparison of the multibeam-images from the pre-lay inspection and the post-lay inspection shows no signs of changes on the wreck and the surrounding seabed.



Figure 12 Photo from the starboard side. From the left: the capstan, the flat-bottomed ship's boat, the bilge pump and to the right end the main mast. Pre-lay. Photo: MMT

² Ship's boat is a utility boat carried by a larger vessel, which is used to move loads and people between shore and ship, and between ships.



Figure 13 Photos on the possible swivel gun/beam (left) and a pulley (right) on the starboard side. Postconstruction. Photo: Allseas.

S-R28-5046/S-29-93462

This wreck was already investigated for the Nord Stream project (then having the wreck number S-29-93462). It is a clinker built ship with a cargo (ballast) of lime stones and barrels with iron, possibly a so-called Osmund iron that was a common Swedish export commodity in medieval times until the 17th century.

A comparison of the multibeam-images from the pre-lay and postlay-inspection shows no signs of changes on the wreck and the surrounding seabed. As seen from earlier inspections, the sedimentation seems to vary on this site. A ship timber and stones seem to have different sedimentation from the post-lay inspection. The sediment on the sea bottom and the wreck seems to be volatile and light. Therefore the sedimentation seems to change from time to time. The wreck as a whole does look unchanged between 2009 when the first survey for the Nord Stream project has been carried out compared to the post-lay inspection 2019 (Fredholm 2019b).



Figure 14 Photos of ship timber and stones. Pre-construction (left) and post lay (right). Photo: MMT and Allseas

S-R30-0997

This is a wooden wreck, 24 m long and 6 m wide. Based on earlier ROV-pictures and bathymetry, the wreck was preliminary dated to the 18-19th century, and the size and hull shape has similarities with the fluit ship "Jutholmsvraket" from around 1700, or galiots from 18-19th century. Most of the interior of the wreck is full with loose ship timbers, frames, planking and some blocks. Outside the wreck on the starboard side there is a gaff beam. Pictures of gaff-rigged sails appeared during the mid-17th century and became more common in the 18th century. The wreck is probably not older than late 17th century but is more likely to be from the 18th century (Fredholm 2019a).

The shipwreck is considered to be undisturbed by the construction of the pipeline, but minor changes are visible. A comparison of the multibeam-images from the pre-lay inspection and the post-lay inspection shows no signs of changes on the wreck and the surrounding seabed. The ROV-inspection confirms that three of the objects eight objects "events" on the wreck have moved slightly. The minor changes possibly depend on trawling or fishing and less likely on the pipeline construction. Because it lies on just 38 meters depth it's probably affected both by waves, currents and fishing/trawling, as parts of fishing nets were visible on the wreck (Fredholm 2019a).



Figure 15 Event A, where a brick has moved around 20 cm. Pre-construction (left) and post lay (right). Photo: MMT and Allseas



Figure 16 Event B, possible lid pot, where a wooden object might have moved a few cm. Pre-construction (left). Photo: MMT and Allseas



Figure 17 Event H; a block, where a plank has moved. Pre-construction (left) and post lay (right).

5.3 Monitoring of ship traffic

This report includes monitoring over ship traffic during the whole year of 2019 from January to December and follows the same structure as the previous report for 2018. Most of the construction activities in Swedish EEZ were done in 2019 whereas in 2018 the pipelay had only started in December.

5.3.1 Monitoring program, purpose and period of monitoring

The purpose of the control and monitoring related to marine traffic was to verify that the agreed efforts and measures to minimize the risk of collisions or other accidents (involving commercial shipping traffic and/or vessels carrying out construction activities for the project) were implemented and that they were efficient. The monitoring activities for maritime traffic focused on the information provided from NSP2 to the authorities, up-front as well on a day-to-day basis in relation to notification of work plans and monitoring of third-party vessels passing the construction activities.

5.3.2 Methods for NSP2 ship traffic monitoring

The following tasks were performed in relation to monitoring in the Swedish EEZ:

Activity 1:

- Information provided to the authorities as agreed

Activity 2:

Construction performed as planned

- Pipe-laying (incl. guard vessels as required)
- Rock placement (pre-lay and post-lay)
- Post-lay trenching
- Cable crossings
- Survey vessels during construction
- Pipe carriers
- Supply vessels

Activity 3:

- Third-party vessels around the lay-barge (and other construction vessels) acknowledging the safety zones during construction works

5.3.2.1 Activity 1

The purpose of this activity was to document that NSP2 has provided information to the authorities and other stakeholders as proposed in the Swedish ES. The details as to the information to be provided, the timing and frequency of when it is delivered etc. was further detailed during meetings with the relevant authorities, as well as the fishing organisations before construction works were

initiated. It has been agreed that NSP2 will provide monthly reports to the authorities to inform about planned activities 4 weeks in advance. NSP2 should also send authority notifications from the vessels 24 hours before they entered Swedish EEZ or 48 hours before actual work has started.

5.3.2.2 Activity 2

Activity 2 consisted of monitoring construction ship traffic in AIS data to document proper and safe behaviour of the construction vessels.

The purpose of this monitoring activity was to document to the authorities that the construction vessels followed their intended routes, performed their activities within the planned timelines, areas of work etc.

AIS data for the construction vessels have been gathered and analysed to illustrate observed ship tracks from the construction vessels. The observed ship tracks from the construction vessels have been compared to the intended behaviour of the construction vessels as described in the authority notifications for the construction activities and the restrictions given by the safety zones. The comparison was done to show how the observed behaviour of the construction vessels and support fleet matches the plans.

5.3.2.3 Activity 3

Activity 3 consisted of monitoring the commercial ship traffic, passing the slow-moving construction vessels (e.g. the lay-barge), using AIS data. This was done to document to the authorities that the commercial ship traffic had safe and free navigation when passing the construction vessels.

Any unexpected vessels entering a 'closest point of approach' radius was contacted and monitored closely. If it was deemed necessary and available, support vessels of the spread (or guard vessels) were used to alert them. In order to notify smaller vessels, fishing organizations and maritime organizations were informed (via notice to mariners from SMA) prior to the start of construction works and updated during the performance of the construction works.

AIS data for the commercial ships have been gathered and analysed to show ship tracks from the commercial vessels when passing the safety zones around the slow-moving lay barges.

The observed ship tracks from the commercial ships showed if the commercial ships were able to recognise the construction vessels and their safety zones in due time to safely plan their journey around the slow-moving construction vessels.

Furthermore, when the slow-moving construction vessels were working close to a Traffic Separation Scheme (TSS), south of Gotland, east of Hoburgs bank, then the observed ship tracks from the passing commercial ships show, if the commercial vessels were able to pass the safety zones of the construction vessels and stay inside the TSS, maintaining safe and free navigation.

5.3.3 Monitoring and results 2019

5.3.3.1 Activity 1

Nord Stream 2 has committed to notify relevant authorities at least one (1) month before the construction- or maintenance works begin. Furthermore, NSP2 must keep the authorities informed about the progress of the construction work and when the work was to be completed.

By analysing correspondence between NSP2, authorities and other stakeholders, it was verified that information has been provided as agreed. The verification of information provided to authorities was made for the work taking place in the most interesting parts of the route based on the traffic intensity

map presented in the NSP2 Environmental Study Atlas (SH-02-S) as well as work performed in sensitive areas.

NSP2 provided notifications (in an agreed format) to the authorities for intervention works and pipelay in time (one month before). In addition to those notifications, the authorities also received daily notifications from the construction vessels to inform the authorities about the construction progress and finalisation.

Construction notification (including the pipe lay)

On the 9th of November 2018, a construction notification was sent to the authorities concerning the start of pipe lay. The construction activities were forecasted to start around mid-December 2018. The pipe-laying vessel Solitaire entered the Swedish EEZ on the 19th of December, and work was initiated on the 23rd of December and therefore the authorities were informed more than one month in advance before pipe lay started. Through the year of 2019 NSP2 sent construction notification updates on a monthly basis.

Since pipelaying through the Natura 2000 area and DW Shipping lane were considered as the most critical work, the verification of NSP2 notifications to the authorities was focused on the two Solitaire pipelaying campaigns during 18th January – 29th of January (line B) and 25 September – 07 October (line A). Daily notifications were sent from the vessel during these periods which included positions, updates on the last 24 hours of operation, plans for the next 24 and 48 hours, support vessels, pipes and cables crossings. The information provided in these notifications corresponds with the scope of work for Solitaire and expected days in the DWSL provided in the monthly reports for these periods.

Pipe delivery to lay vessel

Delivery of pipes to lay vessels continued through the whole construction process by a number of pipe supply vessels. The active support vessels were mentioned in the daily authority notifications.

Rock placement

The rock placement vessel constructed rock berms over the installed pipeline for stability or free-span reduction at various locations along the pipeline route. Several vessels were involved in post lay rock placement.

Bravenes, started rock placement in late July at a few locations (Block 21-26) and in the mid-March (Block 18) of which it has been notified to authorities in Braveness daily notifications and in the monthly reports from the 25th of June and the 26th of February respectively.

Authorities have been informed about Rockpiper installation of rock berms in Block 27 and 18 between the 10th and the 12th of November. Both daily notification from the vessel as well as monthly construction update from the 25th of October followed agreed notification procedure.

Pre- and post-lay rock placement surveys with an ROV has been done to verify the results.

Mattress installation

Oceanic conducted mattress installation at the Swepol crossing in Block 32, 3rd - 6th of July. On the 2nd of July, Oceanic sent notification about plans for commencement of mattress installation in 24 hours. The monthly report dated the 25th of June also stated that the expected time for mattress installation was the 3rd of July.

Trenching

The post-lay plough was pulled along the seabed by surface tow vessel(s) in order to lower the installed pipeline into the seabed through several pre-determined sections of the pipeline route. Survey work and boulder removal started in early October. Post-lay trenching in Swedish waters

was conducted between the 5th of November to the 13th of December at four ploughing sections. Post-plough surveys of the trenched sections were also done to ascertain the as-ploughed condition of the pipeline. The notifications sent from the vessels Havila Phoenix, Normand Prosper, Normand Ranger Cecilia and Fortuna Kingfisher indicate that information about intended work has been provided correctly in 24-hours notices. Plans for the ploughing campaign has also been mentioned in the monthly report from 5th of November.

5.3.3.2 Activity 2

The major part of construction activities in the Swedish waters took place in 2019. Therefore in this monitoring report the data analysed include different types of construction activities to be controlled.

The work has been carried out in the following way: The activity log of the construction vessels has been compared with reconstructed routes of the same vessels from recorded AIS data. The purpose has been to consider if the activity log was coherent with the reconstructed routes, when looking at the locations and times of the ships.

Pipelaying

The pipelay activities by the two pipelaying vessels Pioneering Spirit and the Solitiare follow the information received from Nord Stream 2 AG.

Pipe supply

Pipe supply vessels have respected the predefined channel and followed the main commercial shipping lanes while transiting between harbour and pipelay vessels. On few occasions the pipe supply vessels cross over the most southern part of the predefined channel, but they do not enter into the areas Norra Midsjöbanken and Hoburgs bank.

Rock placement

Rock placement activities matches the AIS data for the rock placement vessels as reported by Nord Stream 2 AG.

Mattress installation

Mattress installation in block 32 by the Oceanic matches the reported activity from Nord Stream 2 AG.

Trenching

Post-lay trenching activities were performed in blocks 27 and 29 by the trenching vessels Havila Phoenix, Normand Prosper, Normand Ranger, Fortuna Kingfisher and Cecilia and matches the reported activities from Nord Stream 2.

The monitoring only shows some minor discrepancies between reported construction vessel behaviour, e.g. pipe supply traffic to the correct location, but on slightly more or different days than previously communicated. Overall, there is a good coherence between notification information and actual work performed. AIS data coverage has in some cases been low but sufficient to perform the analysis (Ramboll 2019).

The permit includes a commitment that pipe supply vessels (and other project vessels where relevant) should use a predetermined route between the shallow banks south of Gotland and use shipping lanes as far as possible to avoid disturbance of birds. Also some areas are marked as "areas to be avoided" by construction fleet. The analysis of historical AIS data has also proved that construction vessels (supply vessels and supporting vessels) were moving at significant distance to the banks and that official shipping lanes generally were used for transportation to and from the construction locations. The analysis of AIS data show that the trenching vessels at some intermittent occasions deviated from using the pre-determined channel or official shipping lanes. However, this

did not take place during the period with high density of wintering birds in the area, so the potential effect of these vessel movements is deemed insignificant.

Overall, the activities reported by Nord Stream 2 AG match the vessel behaviour. AIS data and the construction vessels are found to adhere to recommendations put forth within the environmental study (Ramboll 2016) (Ramboll 2019a) (Nord Stream 2 AG u.d.).

5.3.3.3 Activity 3

The purpose of this activity was to document that the commercial ship traffic had safe and free navigation when passing the construction vessels and that the safety exclusion zone around the NSP2 construction vessel was respected. Navigation safety was confirmed by monitoring of third-party vessels movements.

As the pipe laying vessels have the biggest safety zones (1 nm) that third party vessels shall avoid, this report concentrate on of the traffic around such construction vessels.

AIS data were used to find events where a commercial vessel intruded the safety exclusion zone of the pipelay vessels. Several events have been identified, but none of the identified events suggests that potential hazardous situation was under development or the commercial ships could not pass the pipelay vessels in a safely manner. The commercial traffic is in general observed to respect the safety exclusion zone.

No incident reports have been produced for other construction vessels than the pipelay vessels, meaning that the safety zones for those vessels have not been intruded by third-party vessels.

6. MONITORING RESULTS VS. ES-ASSESSMENTS

6.1 Monitoring of turbidity in Natura 2000 area

The impacts on the protected Natura 2000 areas were assessed in the ES (Chapter 8.11 Protected areas) (Ramboll 2016).

In the ES it was assessed that turbidity and sediment spread were potential impacts only during construction phase. Numerical modelling showed risk of temporary sediment spreading caused by trenching activities near Hoburgs bank and Norra Midsjöbanken, but that concentrations above 10mg/l would not reach the shallow banks. The modelling showed that the concentrations would be below 10mg/l at least 3 kilometres from Hoburgs bank and 4 kilometres from Norra Midsjöbanken. The impacts would also be local and in low intensity and therefore considered insignificant with respect to the protected areas.

The results from the monitoring of turbidity in 2019 verifies that no plumes with concentrations above the restricted threshold limit (15mg/l) reached the shallow banks due to the trenching activities, and that the background levels along the banks remained constantly low (0,5-1,2mg/l) over the period. These results are also in line with monitoring during the NSP-monitoring.

6.2 Monitoring of underwater noise

The underwater noise from **rock placement** was modelled and described in the ES (Chapter 8.5.3 Underwater noise) (Ramboll 2016). Noise from other activities such as **pipe laying** and **trenching** had already been monitored for NSP.

In the ES it was concluded that when comparing normal operations and rock placement activities there was no noticeable rise in the level of underwater noise, which indicated that sound levels were dominated by the vessel noise and not the rock dumping activities (Nedwell and Edwards 2004). This conclusion aligns well with the 2019 monitoring results where the computed source level for rock placement reached 180 (± 3) dB re 1 μ Pa and thus remained below the source levels for pipelay and in the range of passing vessel noise.

From the monitoring done for NSP it was showed that noise from trenching and pipe laying generated noise levels comparable to noise generated by regular shipping and slightly higher than the ambient noise levels in the Baltic, 110-116 dB re 1 μ Pa. Recorded noise level during pipelay was 130.5 dB, and for trenching 126.0 dB re 1 μ Pa. However, there was only one vessel in the area during trenching and 9 vessels during pipelay. The source level of the trenching vessel (Far Samson) was estimated to 183.5 dB re 1 μ Pa @ 1m and the source level for that particular vessel (without trenching) was estimated at 183.5 dB re 1 μ Pa (Johansson och Andersson 2012). The 2019 monitoring results agreed well with the previous FOI-measurements of pipelay-induced noise in this region and within the range of passing vessels. From the 2019 monitoring it was shown that the computed source level for pipelaying was 188 (± 5) dB re 1 μ Pa.

6.3 Cultural heritage

The impacts on cultural heritage were assessed in the ES (Chapter 8.17 Cultural heritage) (Ramboll 2016).

It was assessed in the ES that there is a low probability of any impact on cultural heritage objects during seabed intervention works and pipe laying activities, provided the procedures agreed by NSP2 are followed. Overall, the impact from seabed intervention works and pipe laying on CHOs was considered to be of no or negligible significance.

NSP2 has agreed with SMTM that five objects need to be checked before and after construction of the pipeline in order to see if the construction work has had any effect on their state of preservation. The inspection has been conducted before construction activities in the beginning of 2019. Later analysis of ROV-films from the wrecks after the pipe lay was performed at a later stage in 2019 after construction. The impacts of the construction activities to the CHO sites was assessed by marine-archaeological expert (SMTM). All five analysed shipwrecks were considered by SMTM to be undisturbed by the construction of the pipeline.

6.4 Monitoring of ship traffic

Impacts on shipping were assessed in the ES (Chapter 8.14 Shipping and shipping lanes) (Ramboll 2016).

In the ES, the impacts from safety zones around the project vessels were assessed not to entail any permanent change in the structure or function of the shipping traffic during the construction phase. There is sufficient space and water depth for the ships to plan their route and navigate safely around the construction vessels. The overall importance of the impacts on shipping traffic during the construction phase was considered to be minor.

During the construction activities in the Swedish EEZ 2019, the construction vessels followed the communication and reporting procedures that were agreed with the shipping authorities. There were no accidents or incidents involving maritime traffic, including fishing vessels. Impact on maritime traffic is thus confirmed as being minor, localised and of short-term nature.

7. TECHNICAL INSPECTIONS DURING OPERATION

In addition to the reporting of monitoring activities, it has been agreed between NSP2 and the supervisory permit authority (the Swedish Coast Guard) that reporting of performed and planned project work during the operational phase shall be included in a chapter in this yearly report. Such work mainly includes survey activities but could also include maintenance and repair measures.

Regular inspection surveys of the pipeline system will be carried out as part of the inspection, maintenance and repair program throughout the entire operation phase. The main goal of the inspection surveys is to ensure the safe and reliable operation of the pipeline system throughout its lifetime.

Before the start of operation of the pipeline system, an inspection strategy will have been finalised. It will e.g. describe the main types of inspections to be performed, their requirements and their expected frequency. All the inspection requirements identified during the design phase as affecting the overall pipeline integrity (safety and reliability) during operation are to be covered in this document. Two types of inspections are planned over the full pipeline length in Swedish EEZ, internal and external inspections. In the following sections, the work scopes for those surveys (as well as for potential other works during the operational phase) are presented based on the project's current planning.

7.1 External inspections

External inspection will evaluate the pipeline / seabed configuration and the external condition of the pipelines. This inspection survey will be executed from a survey vessel equipped with ROVs or AUVs having visual, acoustic and electro-magnetic survey tools. During offshore external inspections the following information is gathered:

- Damages to the pipelines e.g. to concrete coating and field joints.
- Damage to pipeline support structures e.g. rock berms and cable-crossing support mattresses.
- Damage or depletion of anodes and deficiencies of cathodic protection.
- Significant movement of pipelines, in particular if movement is outside of the installation corridor.
- Locations where rock placement has to be carried out as a remedial action to support the pipeline, based on the survey inspection information.
- Possible new objects (UXO, CHO or other) within the pipeline installation corridor.
- The location and condition of wrecks and cultural heritage artefacts in the vicinity of the pipelines
- The location of the munitions in the vicinity of the pipelines

All collected data will be compared with previous surveys and annual inspection surveys to allow comparison to the design and as-built condition. Historical trending is used to assess the development of such items as free spans, seabed scour, areas prone to damage and consumption and physical loss of anodes (prediction of anode wastage).

7.2 Internal inspections

Internal inspections are performed with pipeline inspection gauges (PIGS) travelling through the pipelines. The PIGS are accompanied by a survey vessel following the progress of the PIGS as they travel from the Russian landfall towards the German landfall. The main scope of these inspections is to detect potential local anomalies in the pipeline geometry:

1. Pipe internal metal losses (wall thickness anomaly) e.g. due to corrosion

2. Individual wrinkles (internal diameter anomaly)
3. Out-of-roundness (ovality) dents
4. Change in curvature of the pipelines (bending)

The location and extent of the anomalies as for aforementioned parameters are proposed to be reported, if:

1. Pipe wall thickness anomaly is greater than 10% of wall thickness
2. Pipe internal diameter anomaly is greater than 2.5 mm
3. Pipe ovality is greater than 1% of internal diameter
4. Pipeline bending is greater than 0.125% of bending strain (pipeline radius/bend radius)

7.3 Inspection frequency

The first internal and external inspections are planned to be performed shortly after that all construction works have been completed, even though theoretically the external survey could be performed on those sections of the route that already are completed. Depending on the results of those inspections, further inspections will be planned for the coming years. The frequency and the starting date of each following inspection will depend on the results of the previous inspection surveys. It is foreseen that the number of external inspections will greatly exceed the number of internal inspections during the lifetime of the pipelines.

Both the internal and external inspections are expected to include vessels with ROV capacity. The relevant national authorities will be informed well in advance before such inspections take place.

7.3.1 Maintenance

If the pipeline parameters are discovered to deviate critically from the design limits in any of the inspections, an appropriate maintenance or repair program will be implemented. The frequency and the starting date of each maintenance work will depend on the results of the previous inspection surveys and the relevant authorities will be informed well in advance of any such maintenance work.

In addition, any unexpected events which may impair the safety and reliability of the pipeline system shall be analysed and corrective action might take place, e.g. top-up rock placement on rock berms or on the pipe line to prevent unplanned movements.

8. CONCLUSION AND RECOMMENDATIONS

The monitoring program during 2019 was conducted according to Nord Stream 2 planning. All activities have been achieved with high quality on the survey data.

The monitoring of turbidity during trenching works shows that there were no indications of high concentration sediment plumes near the sensitive banks, with respect to both currents and the SSC in the plume directly behind the plough. Most values were between 4-12 mg/l, the highest value measured was 24,7 mg/l (Zone 2, Line B) during a weak current towards north east (not towards the banks). The results are in line with previous assessments made in the environmental report and the NSP monitoring results and therefore the NSP2 turbidity monitoring program is hereby ended.

The underwater noise monitoring shows that the presence of harbour porpoises was clearly documented on numerous occasions before and after passage of the pipe laying vessel. Underwater noise from the pipe laying vessel and support ships was as expected comparable in level and frequency content to noise radiated from commercial cargo ships in the area. Underwater noise from rock placement was likewise lower than or comparable to ship noise and with comparable frequency spectrum. Since the pipe laying operation during Nord Stream 2 construction was faster than during construction of Nord Stream, the time spent inside the Natura2000 area was lower than what was assumed in the impact assessment. This was also concluded when rerunning the habitat loss model used for the impact assessment with the traffic data from the actual construction of Nord Stream 2. All in all the observations support the assumptions on which the original assessment was made, indicating that with respect to harbour porpoises the integrity of the Natura 2000 site was not compromised by the construction of the pipeline. As a result, the monitoring program is hereby ended.

The monitoring results of cultural heritage shows that construction activities have not caused any impact to the five objects identified before pipe laying. The pre- and after construction monitoring have been finalised and as a result, the monitoring program is hereby ended.

The monitoring of shipping shows that there is overall a good coherence between notification information and actual work performed. The analysis of historical AIS data has proved that construction vessels were moving at significant distances from the sensitive shallow banks and that official shipping lanes generally were used for transportation to and from the construction locations. The construction vessels followed the communication and reporting procedures that were agreed with the shipping authorities. There were no accidents or incidents involving maritime traffic, including fishing vessels. Impact on maritime traffic is thus confirmed as being minor, localised and of short-term nature. As a result, the monitoring program is hereby ended.

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Appendix A- Swedish summary / Svensk översättning

Introduktion

Nord Stream 2 (NSP2) är ett rörledningssystem som ska transportera naturgas genom Östersjön från de omfattande fyndigheterna i norra Ryssland till den Europeiska Unionens (EU) inre gasmarknad. Rörutläggningen startade 2018 och skedde via specialbyggda rörlägningsfartyg som svetsar samman respektive rörledningssegment ute till havs, kontrollerar dessa samt lägger ut rörledningarna succesivt. Båda rörledningarna lades huvudsakligen under 2019. Rutten sträcker sig från Östersjökusten i Ryssland vid Kurgalsky-halvön i Narvabukten till landföringen i Tyskland nära Lubmin. Sträckningen är mer eller mindre parallell till NSP med undantag av landföringarna i Ryssland och Tyskland.

Detta dokument ger en översikt över de miljö- och socioekonomiska övervakningsaktiviteter som NSP2 genomfört under 2019 (även något under 2020 där det är lämpligt) inom svensk ekonomisk zon med hänsyn till följande:

- Övervakning av kulturarvet
- Övervakning av fartygstrafiken
- Övervakning av turbiditet inom Natura 2000-området
- Övervakning av undervattensljud

Detta dokument är det andra av sju planerade årsredovisningar (2019-2025) vars syfte är att dokumentera status och resultat av övervakningsverksamheten i den svenska ekonomiska zonen och vid behov rekommendera lämpliga anpassningar till kontrollprogrammets omfattning.

Anläggningsaktiviteter under 2019

Rörlägningsaktiviteterna för NSP2 startade under 2018 och den återstående delen av rörlägningsaktiviteter inom svensk EEZ avslutades 2019, med totalt 995 km rörledning lagd under 2019. Rör lades av fartygen Pioneering Spirit och Solitaire under hela året. Pioneering Spirit lade linje B i slutet av maj och lämnade sedan den svenska ekonomiska zonen för att fortsätta arbetet inom finsk EEZ. Solitaire lade ner linje A sex km före den danska gränsen i slutet av oktober. I slutet av november slutfördes båda linjerna inom svensk EEZ och fartygen fortsatte in i Danmark.

Stenläggning och madrassinstallationer avslutades 2019 före rörläggning ägde rum. Dikning efter rörläggning slutfördes under fjärde kvartalet 2019 för 4 sektioner (av totalt 6). Stenläggning efter rörläggning fortsatte under 2019 med målet att slutföra arbetet under första halvåret av 2020.

Övervakning av kulturarv

Syftet med övervakning av kulturarvet är att dokumentera tillståndet för vrak före och efter konstruktionsarbeten.

Tillståndet och platsen för var och en av de valda kulturarvsobjekten undersöktes genom visuell visuell inspektion med hjälp av ROV och en MBES (multibeam) före rörlägningsaktiviteter i början av januari 2019. Resultaten av dessa undersökningar har presenterats i årsrapporten för 2018 (Ramboll, 2019a).

Innan rörledningarna var lagda filmade undersökningsföretaget MMT 7 objekt som var av intresse för de svenska myndigheterna. Statens maritima och transporthistoriska museer analyserade videon i mars-april 2019. Analysen resulterade i fem skeppsvrak varav tre ansågs vara forntida monument, äldre än 1850. Tillstånden för de fem objekten från den arkeologiska analysen före konstruktion har även övervakats efter konstruktion av rörledning och presenteras i denna rapport. Analysen efter

läggning av rörledningen visade att de fem skeppsvraken anses vara ostörda av konstruktionen av rörledningen enligt Statens maritima och transporthistoriska museer

Övervakning av fartygstrafiken

Inom den svenska sektorn resulterade anläggningsarbeten till en ökad fartygstrafik i och med rörläggning, rörleveransfartyg till rörlägningsfartyget, madrassinstallationer, stenläggning och dikning efter rörutläggning. Baserat på bedömningen i den svenska miljöredovisningen orsakar verksamheten en något ökad risk för olyckor med tredjeparts fartyg. Bedömningen är baserad på det förväntade beteendet hos både konstruktionsfartyg och tredjepartsfartyg som passerar konstruktionsfartygen. Syftet med kontrollen och övervakningen i samband med sjötrafiken är att verifiera att de överenskomna insatserna och åtgärderna för att minimera risken för kollisioner eller andra olyckor genomförs och att de är effektiva. Fokus för sjötrafiksövervakningen var att följa upp den information som NSP2 gav myndigheterna, inför arbetena såväl som på daglig basis, kring det planerade arbetet samt kontroll av hur tredjepartsfartyg passerade områden där anläggningsarbeten pågick.

Sjötrafikövervakningen i svenska vatten under 2019 omfattar i linje med föregående år följande aktiviteter:

- Information till myndigheter enligt överenskommelse (Aktivitet 1);
- Övervakning av konstruktionsfartyg via AIS-data (Aktivitet 2);
- Övervakning av den kommersiella fartygstrafiken, som passerar de långsamma anläggningsfartygen (t ex rörlägningsfartygen), med via AIS-data (Aktivitet 3)

Metoden innefattade insamling och analys av konstruktionsnotifieringar som skickades av NSP2 till myndigheterna samt notifieringsbrev skickade från anläggningsfartyg. För att bekräfta den faktiska konstruktionsverksamheten inom den svenska ekonomiska zonen samt rörelse till och från konstruktionsplatser analyserades historiska AIS-data.

Resultaten visade att NSP2 följde tillståndsvillkoren och informerade sjöfartsmyndigheterna minst en månad innan konstruktionsarbete påbörjades. Konstruktionsfartygen har skickat meddelanden till myndigheterna 48 timmar innan inträde i svensk ekonomisk zon samt 24 timmar innan något arbete påbörjades. Analys av fartygens rörelser från historisk AIS-data bekräftade att anläggningsfartygens rörelse befann sig inom rapporterade områden samt att officiella sjöfartsleder för transport till och från konstruktionsplatserna huvudsakligen användes.

Övervakning av turbiditet i Natura 2000 området

Turbiditet är ett mått på lösta sedimentpartiklar i vattenmassan. Kontrollprogrammet har utförts för att verifiera och kontrollera att miljötillståndets maximumgräns på 15mg/l lösta sedimentpartiklar inte når de grunda och biologiskt värdefulla utsjöbankarna Hoburgs bank och Norra Midsjöbanken i samband med nedplogning av gasledningarna.

Lösta sedimentpartiklar kan färdas med hjälp av vattenströmmar till omgivande områden men modellering av sedimentspridningen har utförts inom projektet och denna visar att den ökade turbiditeten till följd av plogningen i svenska vatten kommer vara lokal och kortvarig, och inte nå de grunda värdefulla bankarna.

Under övervakningen användes mätutrustning ombord på övervakningsfartyget, som i realtid mätte turbiditeten. Utrustning som mätte vattenströmmars riktning och hastighet användes även. Turbiditetsutrustningen drogs efter fartyget (5 meter ovan havsbotten), och om modelleringens gränsvärden (35mg/l) uppnåddes strax bakom plogningsfartyget kunde lämpliga åtgärder vidtas om strömmars hastighet och riktning pekade mot Hoburgs bank och/eller Norra Midsjöbanken.

Resultatet från övervakningen pekar på att inga koncentrationer över gränsvärdena nådde bankarna, och de flesta värdena precis bakom plogningsfartyget låg på 4-12mg/l. Det högsta värdet som uppnåddes var på 24,7 mg/l, vilket är lägre än det modellerade alarmvärdet på 35mg/l, och dessutom var strömriktningen gynnsam och det förelåg ingen risk att sedimentplymen skulle nå någon av bankarna.

För att säkerställa att koncentrationsvärdena vid bankarnas kanter inte påverkades av plogningen utfördes även flera kontrollmätningar där. Dessa bakgrundsvärden låg vid alla mätningar runt 0,5-1,2mg/l, vilket påvisar att plogningen inte påverkade turbiditeten vid bankarna över huvud taget.

Övervakning av undervattensljud

Till följd av oro för störningar i tumlares beteende och maskeringseffekter har övervakning av undervattensljud genomförts för att ytterligare verifiera slutsatserna i miljörapporten och expertutlåtanden som presenterades under myndighetssamrådet. Syftet med övervakningen har varit att mäta undervattensljud före och under konstruktionen av NSP2-rörledningar inom definierade frekvenser, inklusive de som täcker större delen av hörselområdet för tumlare. För att bedöma potentiell påverkan från undervattensljud har bakgrundsljud, ljud från rörläggning och stenläggning mätts. Utöver detta har förekomsten av tumlare dokumenterats med hjälp av akustiska enheter.

Ljudmätningar genomfördes under vinter, vår och höst från fyra stationer nära den faktiska rörledningssträckningen (station B, C och D) och 25 km bort från den (station A), som fungerade som en övervakningsstation för bakgrundsljud. Fältarbetet utfördes av MEWO. Databehandling och rapportering utfördes av DHI med extern kvalitetsbedömning av DTU Aqua. Fältarbetets resultat har granskats av Jakob Tougaard och andra experter på effekter från undervattensljud hos marina däggdjur hos DCE.

Uppmätta ljudtrycksnivåer klassificerades beroende på förekomsten av ljudhändelser med användning av överskridningsnivåerna L95 och L5, beroende på plats och säsong. Överskridningsnivån L95 användes för att mäta bakgrundsljud i frånvaro av ljudhändelser medan L5 användes för att mäta nivåer av bakgrundsljud samtidigt som andra ljudhändelser inträffade (såsom rörlägningsaktiviteter).

Bakgrundsljud och passerade fartyg:

Överskridningsnivån för L95 på platser med högre volym som station A vilken låg nära den största sjöfartsleden och stationerna B och C under vintern / våren var 110 (± 2) dB re 1 μ Pa. På tystare platser som station B och D under hösten var överskridningsnivån för L95 endast 104 (± 2) dB re 1 μ Pa. Om fartyg passerade eller andra ljudhändelser inträffade (L5 överskridningsnivån) steg bakgrunden till 127 (± 2) dB re 1 μ Pa vid stationerna A-C och 122 (± 2) dB vid station D. Beräknade källnivåer för passande fartyg varierade från 165,9 - 192,5 dB re 1 μ Pa över alla stationer, de flesta fartygspassager upptäcktes och analyserades dock vid station A, där en viktig fartygsled passerar i närheten.

Rörlägningsaktiviteter

Den beräknade källnivån för rörläggning var 188 (± 5) dB re 1 μ Pa. Den ganska höga osäkerheten återspeglade variationen i de enskilda uppskattningarna, som troligen berodde på påverkan av ljud från stödfartyg. I ett fall kunde frekvenssignaturen för ett stödfartyg (Symphony Provider) identifieras. Den beräknade källnivån överensstämde väl med de tidigare FOI-mätningarna som gjordes för Nord Stream 2012 och låg inom räckvidden för passande fartyg.

Den beräknade källnivån för stenläggning var 180 (\pm 3) dB re 1 μ Pa och förblev därmed under källnivåerna för rörläggning och inom räckvidden för ljud från passande fartyg (165,9 - 192,5 dB re 1 μ Pa).

Förekomst av tumlare

Tumlare upptäcktes både före och efter rörläggning men var få till antalet. Resultaten indikerade en rumslig och tidsmässig variation av förekomst i det studerade området under hela övervakningsperioden. Det gjordes fler upptäckter av tumlare vid station A och B jämfört med station C och D. Dessutom hade station A högre procent tumlar-positiva dagar (% PPD) under höstmånaderna än under vinter- och vårmånaderna. Detta är i linje med resultaten från SAMBAH-projektet som genomfördes 2011–2013. I överensstämmelse med resultaten från SAMBAH-projektet drogs slutsatsen att förekomst av tumlare i det studerade området generellt sett var relativt låg.

Påverkan på tumlare

Närvaron av tumlare dokumenterades tydligt vid flera tillfällen före och efter passagen av rörläggingsfartyget. Antalet upptäckter var för lågt för att möjliggöra en korrekt statistisk analys med acceptabel statistisk säkerhet. Eftersom rörläggningen under NSP2-konstruktionen var snabbare än för NSP, var den totala tiden inom Natura2000-området lägre än vad som antogs för bedömningen i konsekvensanalysen och därmed också den möjliga påverkan. Detta visades även genom en uppdatering av den habitatsmodellering som utfördes för NSP2s konsekvensanalys, som nu inkluderade trafikdata från den faktiska konstruktionen av Nord Stream 2. Sammantaget stöder observationerna de antaganden som den ursprungliga bedömningen baserades på, vilken visade att Natura 2000 området och tumlarna inte påverkades av rörledningskonstruktionen. De erhållna mätningarna kommer att förbli ett värdefullt tillskott inte bara till kunskapen om påverkan från rörledningskonstruktioner på tumlare, utan även för den allmänna akustiska ljudbilden i centrala Östersjön.