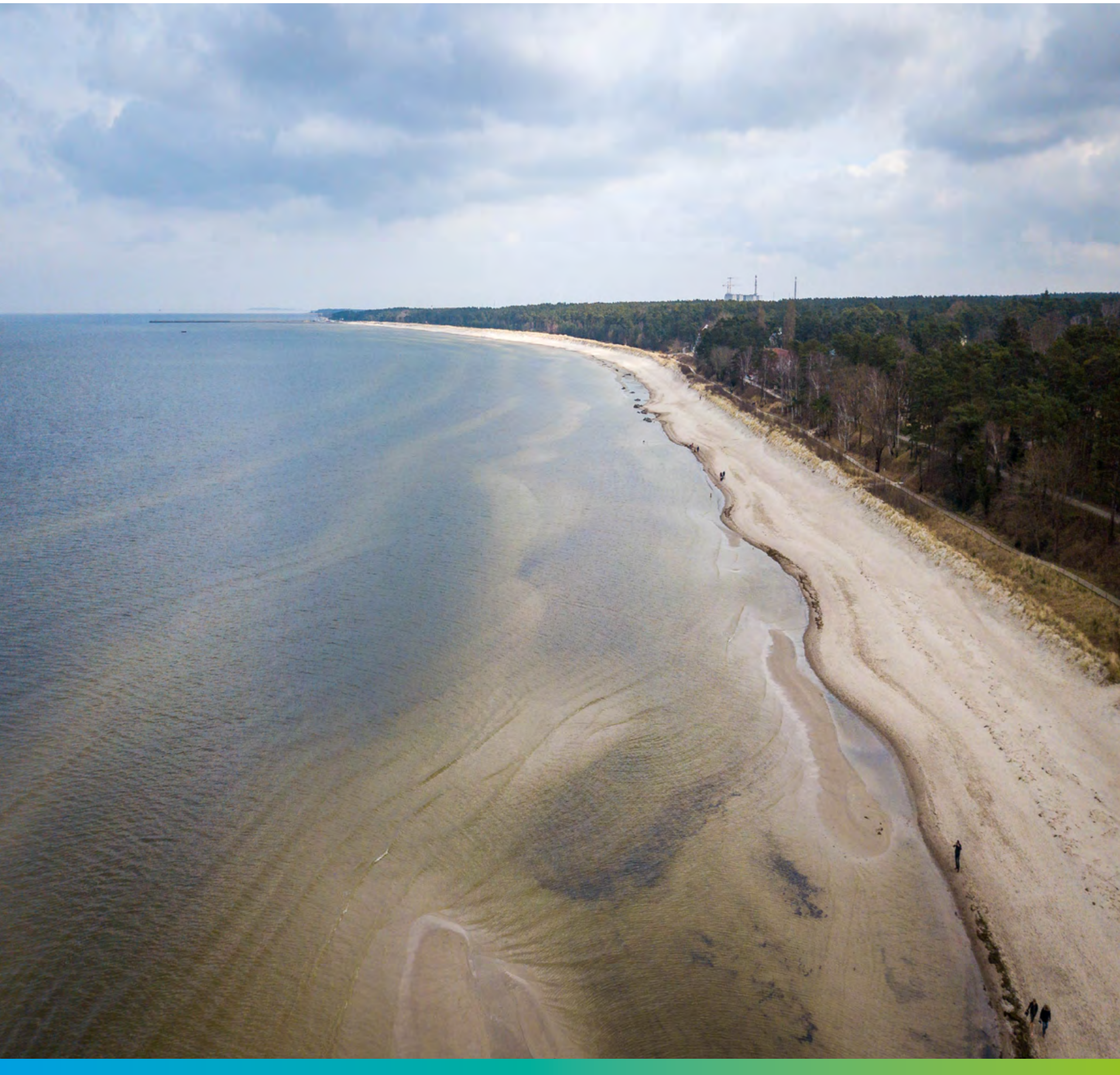
Nord Stream 2
Committed. Reliable. Safe.

Overall Environmental Monitoring Report 2018



Contents

Abbreviations

ABS	Automatic buoy station
ADCP	Acoustic Doppler current profiler
AIS	Automatic identification system
BOD	Biochemical oxygen demand
CFU	Colony forming unit
COD	Chemical oxygen demand
C-PODs	Cetacean porpoise detector
CPU	Colony producing unit
DP	Dynamically positioned
DPD	Mean detection rate
EAL	Environmentally acceptable lubricants
EEZ	Exclusive economic zone
EIA	Environmental impact assessment
EPA	Environmental protection agency
ES	Environmental study
ESMPs	Environmental and social management plan
FNU	Formazin nephelometric units
FTU	Formazin turbidity units
HELCOM	Baltic marine environment protection commission
IFC	International finance corporation
IUCN	International union for conservation of nature
JNCC	Joint nature conservation committee
KP	Kilometre point
MPA	Marine protected area
MPC	Maximum permissible concentration
MPL	Maximum permitted level
NSP2	Nord Stream 2 project
NT	Near threatened category group in IUCN red list
PTA	Pig trap area
PTS	Permanent hearing threshold shift
RDBS	Red Data Book species
SAMBAH	Static acoustic monitoring of the Baltic Sea Harbour Porpoise
SCI	Sites of community importance (Natura 2000 site)
SEER	State environmental expert review
SEL	Sound exposure level
SPA	Special protection area (Natura 2000 site)
SPNA	Special protected nature area
SwAM	Swedish Agency for Marine and water management
TBC	Thermotolerant coliform bacteria
TBT	Tributyltin
TC	Total coliforms
TSS	Total suspended solids
TTS	Temporary hearing threshold shift
TW	Territorial water
TWA	Temporary work area
ZIN RAS	Zoological Institute of Russian Academy of Sciences

Summary

The Overall Environmental Monitoring Report 2018 presents the results of environmental monitoring related to construction of the Nord Stream 2 pipeline in 2018. Nord Stream 2 environmental monitoring is based on the five national environmental monitoring programmes for Russia, Finland, Sweden, Denmark and Germany which are approved by the competent authorities. The monitoring work is designed to verify, as assessed, that there is no significant impact on the environment of the Baltic Sea from project implementation and to fulfil the requirements and commitments under the respective jurisdictions of the five countries in which the Nord Stream 2 pipeline is built.

Environmental monitoring started in 2018 in Russia, Finland, Sweden and Germany upon receipt of the respective construction permits and start of construction activities. No construction was performed in Denmark since no permit decision was made in 2018 and thus no monitoring results from the Danish section are presented in this report.

Construction activities in 2018 comprised the following:

- Russia: onshore construction, dredging including interim and permanent soil storage;
- Finland: munitions clearance, rock placement, mattress installation and pipelay;
- Sweden: mattress installation, rock placement and pipelay;
- Germany: onshore construction, dredging including interim soil storage and backfilling and pipelay.

Some construction activities may cause impacts on the marine and terrestrial environment depending on their nature, location along the pipeline route, and the period when the activity is undertaken. Therefore, the construction works have governed which parameters are monitored and when monitoring takes place in the individual countries. Furthermore, certain investigations are carried out only at selected sites, depending on specific national regulations and environmental variations.

Thus, as part of the permit conditions, each country has specified the monitoring requirements to demonstrate that environmental and social conditions remain within defined levels and standards and are in line with environmental impact assessments. In some cases additional monitoring activities, that are outside the scope of the national monitoring programmes, have been implemented through specialist studies to strengthen the assessment of impacts from Nord Stream 2 implementation and/or to enhance scientific knowledge of the Baltic Sea environment.

Environmental monitoring focuses on relevant physico-chemical, biotic and socio-economic parameters likely to be impacted during various construction activities. The table below lists the parameters monitored in 2018 during certain offshore and onshore Nord Stream 2 construction activities.

Offshore monitoring in 2018

Monitored parameters	Before construction	Munitions clearance	Dredging	Dredged soil storage	Backfilling	Rock placement	Pipe-lay
Physico-chemical environment							
Seabed sediments	R, F, G	F	R, G	R, G	G		G
Turbidity / Water quality	R, F, G	F	R, G	R, G	G	F	G
Underwater noise		F, E*	G		G		G
Biotic environment							
Ecotoxicological effects	S						
Benthic flora and fauna	R			R			
Plankton	R			R			
Fish / Fish migration	R		R				
Birds			R, G		G		G
Marine mammals	R, G	F	R, G	G	G		G
Socio-economic environment							
Commercial fishery	S						
Cultural Heritage	F, S, G						
Ship Traffic**			G	G	G		S, G

R-Russia; F-Finland; S-Sweden; G-Germany, E-Estonia
*Monitoring of transboundary impacts to Estonia from munitions clearance in Finland; no construction activities in Estonia.
**Monitoring of ship traffic is performed in all countries where relevant construction activities take place; additionally in Sweden and Germany monitoring of ship traffic is part of the national monitoring programmes.

Onshore Russia monitoring in 2018

Monitored parameters	Construction camp and site	Kurgalsky Nature Reserve	Rosson river
Physico-chemical environment			
Soil quality		X	
Exogenous processes		X	
Air quality	X		
Airborne noise	X		
Water quality	X		X
Riverbed sediments			X

Monitored parameters	Construction camp and site	Kurgalsky Nature Reserve	Rosson river
Biotic environment			
Terrestrial flora		X	
Terrestrial fauna		X	
Birds		X	
Hydrobiological environment			X
Fish			X
Socio-economic environment			
Cultural Heritage		X	

Onshore Germany monitoring in 2018

Monitored parameters	Tunnelling	Pipe pull in	Civil works
Physico-chemical environment			
Airborne noise	X	X	X
Ground water	X	X	X

Conclusions for offshore monitoring

Monitoring associated with the offshore construction activities demonstrated that no impacts other than those predicted occurred in 2018.

Monitoring of munitions clearance showed that due to implementation of mitigation measures (e.g. “bubble curtains”) the impacts related to underwater noise were smaller than previously predicted and no impacts on marine mammals at the Kallbådan protected area were observed. Other impacts, such as increased turbidity and release of contaminants from the seabed were monitored as well, showing that the impacts were in line with or below the assessed values.

Monitoring of turbidity and water quality during munitions clearance, dredging and rock placement showed that no significant impacts on water quality have occurred, which is in line with the results presented in the national environmental impact assessments (EIAs) and compliant with requirements defined by the national standards. The quality of reinstatement of trenches in German territorial waters after backfilling met the tolerances defined by the principal permit.

Monitoring of the biotic environment showed that the general conditions of the monitored populations of plankton, benthos, fish, marine mammals and birds were typical for the monitored areas. Impacts related to the construction activities were generally of a temporary nature and in line with the prediction from the different EIAs. Monitoring of third party shipping traffic was successfully implemented during construction activities in all countries and no incidents were recorded.

Conclusions for onshore Russia monitoring

Construction activities at the construction camp and sites were generally in line with the EIA assessment. Monitoring of air emissions and airborne noise, measured both in the construction camp and in the vicinity of the nearest settlement proved to be in line with the national legislation. Continuous monitoring and additional mitigation measures were implemented during water discharge.

The Kurgalsky Nature Reserve is a highly sensitive area and it has therefore been extensively monitored. Monitoring results for 2018 have demonstrated that no significant impacts on the flora and fauna of the protected site have occurred. Neither counts of migratory birds nor breeding bird surveys revealed significant changes in numbers and distribution patterns. Red Data Book species relocated from the construction corridor to undisturbed area were often found to be in a better state than the plants in their original location (due to anti-drought measures implemented for the relocated species). No objects of cultural heritage significance were identified during the earthworks.

Monitoring of the Rosson river was designed to collect baseline information to be used in the future to evaluate potential impacts on the river from the construction activities. The monitoring results showed that the river is already experiencing some level of anthropogenic pressure, with pollutants in some cases showing higher concentrations than permitted. However, no negative trends or any pollutant accumulation in riverbed sediments were found compared to earlier baseline environmental survey results and literature data. Monitoring of the biotic environment in the river was in line with earlier baseline surveys and with official statistical data from the literature. No objects of special protection were found during the macrophytes survey.

Conclusions for onshore Germany monitoring

The German landfall and pig trap area are located inside a designated industrial development area. A number of industrial projects have been established there since 2005, including an industrial harbour, marina, Nord Stream gas receiving terminal, transformer substation, roads and gas pipelines, chemical plants, and sewage treatment plant. Remaining terrestrial habitats have been heavily degraded in the past by former use for various facilities associated with a nuclear power plant between 1975 and 1995. Environmental impacts potentially resulting from beach crossing could be avoided entirely by microtunnelling. Onshore monitoring in Germany was therefore restricted to environmental construction supervision including airborne noise immission control for sensitive human receptors (Lubmin village and marina) as well as documentation of ground water levels and discharge volumes.

Construction activities were conducted in line with permit conditions and planned mitigation measures. The footprint did not exceed the planned design due to the installation and maintenance of a habitat protection fence prior to the start of any construction works. Loss of reptiles and amphibians was prevented by installation and maintenance of a guard fence. The use of construction lights during night-time microtunnelling works was in line with permit conditions. Airborne noise remained within threshold defined by law and/or permit conditions. Abstraction of ground water was much less than planned/permitted. No significant change in ground water level resulted from tunnelling and pipeline installation works. Only clean groundwater was discharged into the industrial harbour. Dirty water resulting from microtunnelling was disposed of at the nearby sewage treatment plant.

1 Introduction

Nord Stream 2 is a twin pipeline system running over 1,230 kilometres through the Baltic Sea from the Russian to the German coast. The pipelines are built and operated by Nord Stream 2 AG.

The parallel pipelines pass through the territorial waters (TW) and/or through exclusive economic zones (EEZ) of Russia, Finland, Sweden, Denmark and Germany (see Figure 1). The starting point of Nord Stream 2 is located near Narva Bay in the Kingisepp District of Russia's Leningrad Region, where the pipeline connects to the Russian gas network. The receiving station at the German landfall near Greifswald connects Nord Stream 2 with the neighbouring natural gas receiving facility from Gascade, and thus with the European pipeline network. When fully operational the twin pipelines will have the capacity to transport a total of 55 billion cubic metres (bcm) of natural gas per year to businesses and households in the EU for at least 50 years.

Construction of the Nord Stream 2 pipeline commenced in 2018 in Russia, Finland, Sweden and Germany upon receipt of the respective permits. Environmental monitoring is carried out before, during and after construction to demonstrate that impacts are in line with the environmental impact assessment (EIA) reports and certain permit conditions, as well as in compliance with the International Finance Corporation (IFC) Environmental and Social Performance Standards.

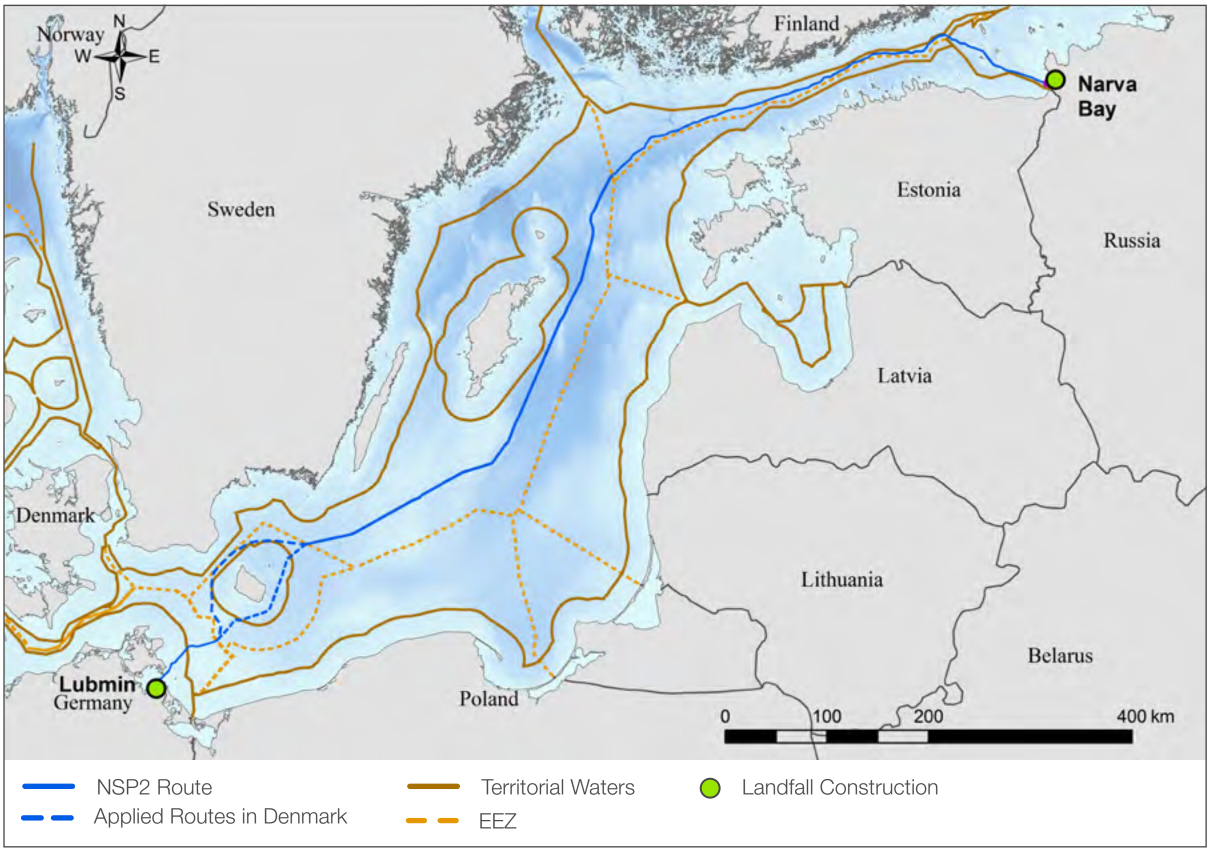


Figure 1. *Nord Stream 2 pipeline route.*

1.1 Purpose

The purpose of this report is to present the results and conclusions of environmental monitoring carried out during construction of Nord Stream 2 in 2018 following approved national environmental monitoring programmes.

The Nord Stream 2 monitoring programmes were designed and implemented to verify that there are no significant impacts on the environment of the Baltic Sea and to ensure that certain permit requirements and commitments under the respective jurisdictions of the five countries are fulfilled. Further requirements and commitments, arising from the project financing phase, resulted in Nord Stream 2 implementing the project in conformance with the International Finance Corporation's Environmental and Social Performance Standards, the associated World Bank guidelines, Equator Principles, and the environmental and social requirements of the export credit agencies.

Nord Stream 2 is committed to building a safe and sustainable subsea pipeline system that causes no significant or lasting impacts on the Baltic Sea, the onshore environment or local communities. Monitoring programmes are based on comprehensive environmental surveys and studies to determine the conditions of the marine environment with focus on sensitive areas and receptors that require monitoring as defined in the national EIAs and Espoo report.

1.2 Permits

The offshore route proposed for Nord Stream 2 passes through the TW and/or EEZs of Russia, Finland, Sweden, Denmark and Germany, with landfalls in Russia and Germany. Consent for construction and operation of the pipeline from the coastal states is based on various national laws, such as EIA Procedure Acts, Water Acts, EEZ Acts, Continental Shelf Acts and Energy Acts, which are specific for each individual country.

The national permits required for onshore and offshore construction of Nord Stream 2 were obtained in 2018 in four countries – Russia, Finland, Sweden and Germany (see Table 1). In Denmark two permit applications for two route alternatives (Base Case route and North-Western route) were under consideration by the Danish authorities and no permit decision was made in 2018.

Agreement on the EEZ border between Denmark and Poland was reached in November 2018 with ratification in the following year. The EEZ border shown on the maps in this report indicates the agreed border.

Table 1. *Status of the construction permits in five countries.*

Country	Regulation	Permit granted
Russia	– Federal laws about Internal Sea Water, Territorial Sea, Continental Shelf	14 August 2018
	– Decree of the goverment	7 June 2018
Finland	– Water Act	12 April 2018
	– Finnish Act on the EEZ	5 April 2018
Sweden	– Act on the Continental Shelf	7 June 2018
Denmark	– Act on the Continental Shelf	Decision pending
Germany	– Energy Industry Act	31 January 2018
	– Federal Mining Act	27 March 2018

1.3 Overview of monitoring programme and reporting

An environmental monitoring programme is an integral part of the national permits allowing construction and operation of the Nord Stream 2 pipelines. The Nord Stream 2 monitoring programme is based nationally and aligned to the legislation in each country. However, the international consultation process (Espoo consultation) as part of the permitting process has enacted environmental monitoring of transboundary impacts allowing assessment of the impact on the global project-wide level, e.g. transboundary monitoring of underwater noise in Estonia during munitions clearance in Finland.

The purpose of the environmental monitoring programmes is to verify that environmental impacts which may potentially occur during various stages of the project are in line with the assessment in the national EIAs and Espoo report /01/-/05/ thus supporting certain permit requirements and permit conditions. Furthermore, the data collected from the monitoring programme may establish the need for environmental mitigation and corrective measures if, contrary to expectations, the data indicate unforeseen environmental impacts.

The national monitoring programmes are framed by the legislation of the five countries whose waters the pipeline passes as well as through consultation with the relevant national authorities. Depending on sensitivity of the marine environment and on the nature of the construction activities, the location along the pipeline route, and the period when the activity is undertaken, the construction works may cause different effects on the environment. Therefore, the construction works in conjunction with the sensitivity of the marine environment have governed which monitoring activities take place in the individual countries, and when. Furthermore, certain investigations are carried out only at selected sites, depending on specific national regulations and environmental variations.

The monitoring programmes have been planned and developed with the following objectives:

- To verify that the pipelines are installed and operated in accordance with certain permit conditions;
- To demonstrate that environmental conditions remain within required levels and standards;
- To verify that the pipeline construction and operation does not cause unforeseen environmental impacts, or impacts are not greater than anticipated;
- To provide the basis for mitigation/ corrective measures if necessary;
- To monitor the recovery of the environment after construction.

The Nord Stream 2 environmental monitoring programmes, which include monitoring before, during and after construction of the Nord Stream 2 PipeLine Are described in /06/-/10/. The majority of baseline studies along the route were performed during the EIA phase and thus were not included in the monitoring programmes. However, a number of parameters were included in the programmes to be monitored before construction to collect more information or update existing baseline data. Additional monitoring activities that are outside the scope of the national monitoring programmes have been implemented through specialist studies to strengthen the assessment of impacts from Nord Stream 2 implementation and/or to enhance scientific knowledge of the Baltic Sea environment.

These studies include:

- Telemetry studies of the Baltic Ringed Seal in the Gulf of Finland (2017 – planned 2020);
- Aerial surveys of the Baltic Ringed Seal in the Gulf of Finland (2018);
- Turbidity monitoring of Russian dredging/backfilling activities by satellite monitoring (2018–2019);
- Hydrological monitoring of the Kurgalsky site (planned for 2019);
- Reinstatement of the onshore Russian landfall site (planned for 2020);
- Monitoring of sediment toxicity in Finland after munitions clearance (2018);
- Additional monitoring of marine mammals as defined by Finnish authorities (2018).

A brief summary of the above additional monitoring activities that took place in 2018 is included in this report.

Further mitigation measures are implemented in the project throughout the construction phase. Such measures include environmental supervision according to certain permit conditions, environmental and social management plans (ESMPs), environmental audits and contractor reporting. Furthermore, a number of engineering inspections and surveys applicable to the entire route are carried out immediately before, during and after construction works to ensure the highest level of safety and accuracy in construction. These activities are not described further in this report.

An overview of the environmental monitoring activities before, during and after construction is given in Table 2. Monitoring activities in Denmark are not included since no permit decision was made in 2018 and therefore the monitoring programme was not approved. Generally, the objective of environmental monitoring in Denmark will be to verify that construction and operation do not have significant environmental impacts. It is expected that environmental monitoring in Denmark will be included in the 2019 overall environmental monitoring report once the permit is granted.

Table 2. *Overview of monitored parameters before, during and during construction in Russia, Finland, Sweden and Germany.*

Parameter	Before construction	During construction	After construction
		Offshore	
Sediment transportation			S
Seabed sediments	R, G	R, F*, G	R, G
Turbidity / Water quality	R, G	R, F, S, G	R, G
Underwater noise		F, E**, S, G	
Ecotoxicological effects	S		
Benthic flora and fauna	R, G	R, G	R, S, G
Plankton	R	R	R

Parameter	Before construction	During construction	After construction
Fish	R, G	R	R
Birds	R, G	R, G	R, G
Marine mammals	R, G	R, F, G	R, G
Commercial fishery	S, G		F, S
Cultural heritage	F, S, G		F, S
Ship traffic***		S, G	
Pipeline footprint			R, F, S, G
		Onshore	
Riverbed sediments	R	R	R
Water quality	R	R	R
Hydrobiology/Ichthyology	R	R	R
Ground water	G	G	
Terrestrial flora	R, G	R	R
Terrestrial fauna	R, G	R	R
Birds	R, G	R	R
Air quality		R	
Airborne noise		R, G	
Cultural heritage		R	
Exogenous processes	R	R	R

R-Russia; F-Finland; S-Sweden; G-Germany; E-Estonia
*Supplementary monitoring outside the scope of national monitoring programme.
**Monitoring of transboundary impacts to Estonia from munitions clearance in Finland; no construction activities in Estonia.
***Monitoring of ship traffic is performed in all countries where relevant construction activities take place; additionally in Sweden and Germany monitoring of ship traffic is part of the national monitoring programmes.

Environmental monitoring is focused on environmentally sensitive areas and receptors in five countries that have been assessed as likely to be impacted by Nord Stream 2 construction and operation. Thus, not all construction activities required environmental monitoring and not all parameters are monitored in all countries. Construction activities and associated environmental monitoring is described in detail in Sections 3–6. Maps showing construction activities in each country and monitoring locations are provided in Appendix A–D.

Monitoring results are submitted to the authorities on a monthly, quarterly and/or annual basis as per national requirements:

> Russia: monthly, quarterly and annually (depending on type of monitoring);
> Finland: quarterly (during construction) and annually (during construction and operation);
> Sweden: annually;
> Denmark: annually;
> Germany: monthly/quarterly (during construction) and annually (during construction and operation).

Annual overall monitoring reports similar to the present report will be prepared for each year of construction and through the initial operation phase when environmental monitoring takes place. To facilitate comparison of the progress and results year on year, future yearly reports will be similar in structure to this report.

2 Construction works

Construction in 2018 included onshore activities in Russia and Germany and offshore activities in Russia, Finland, Sweden and Germany, see Figure 2. No construction activities took place in Denmark in 2018.

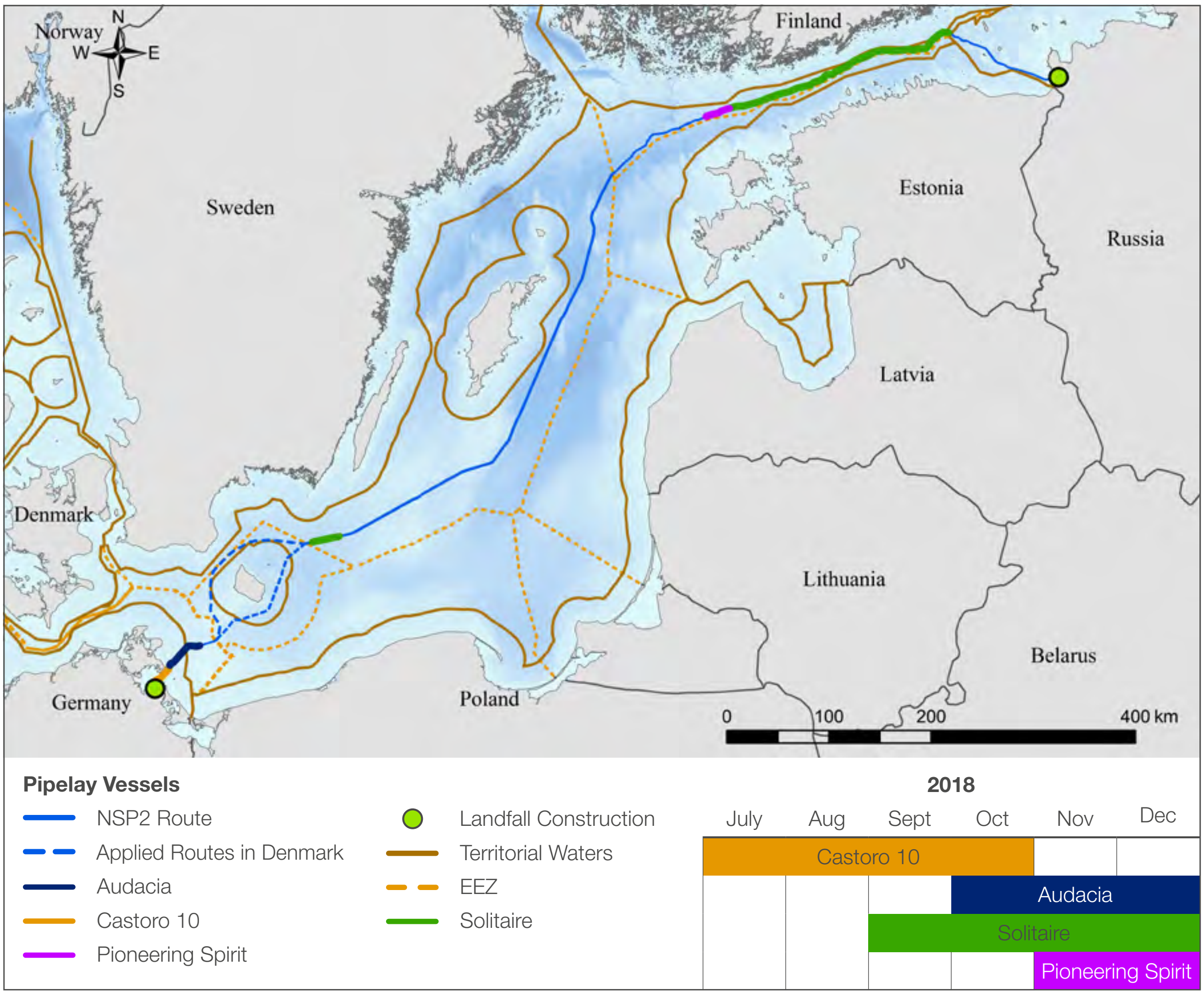


Figure 2. *Installation of Nord Stream 2 pipeline in 2018.*

2.1 Construction overview

Excavation of trenches, munitions clearance as well as pre-lay rock placement were the first offshore construction activities starting in May / June 2018. Offshore pipe-lay started in July in Germany with pulling of Line A and Line B through the 700 m long microtunnel which runs from the onshore facilities into the Bay of Greifswald, crossing the coastal pine forest and various infrastructure. Pipe-lay was also performed in the Finnish and Swedish waters. By the end of 2018, 328 km of Line A and 95 km of Line B were laid on the seabed comprising 17 % of the total length of the pipeline.

Onshore construction progressed at the Russian and German landfalls. An overview of construction milestones is given in Figure 3. Details of construction activities in the four countries are outlined below in Sections 2.2–2.5

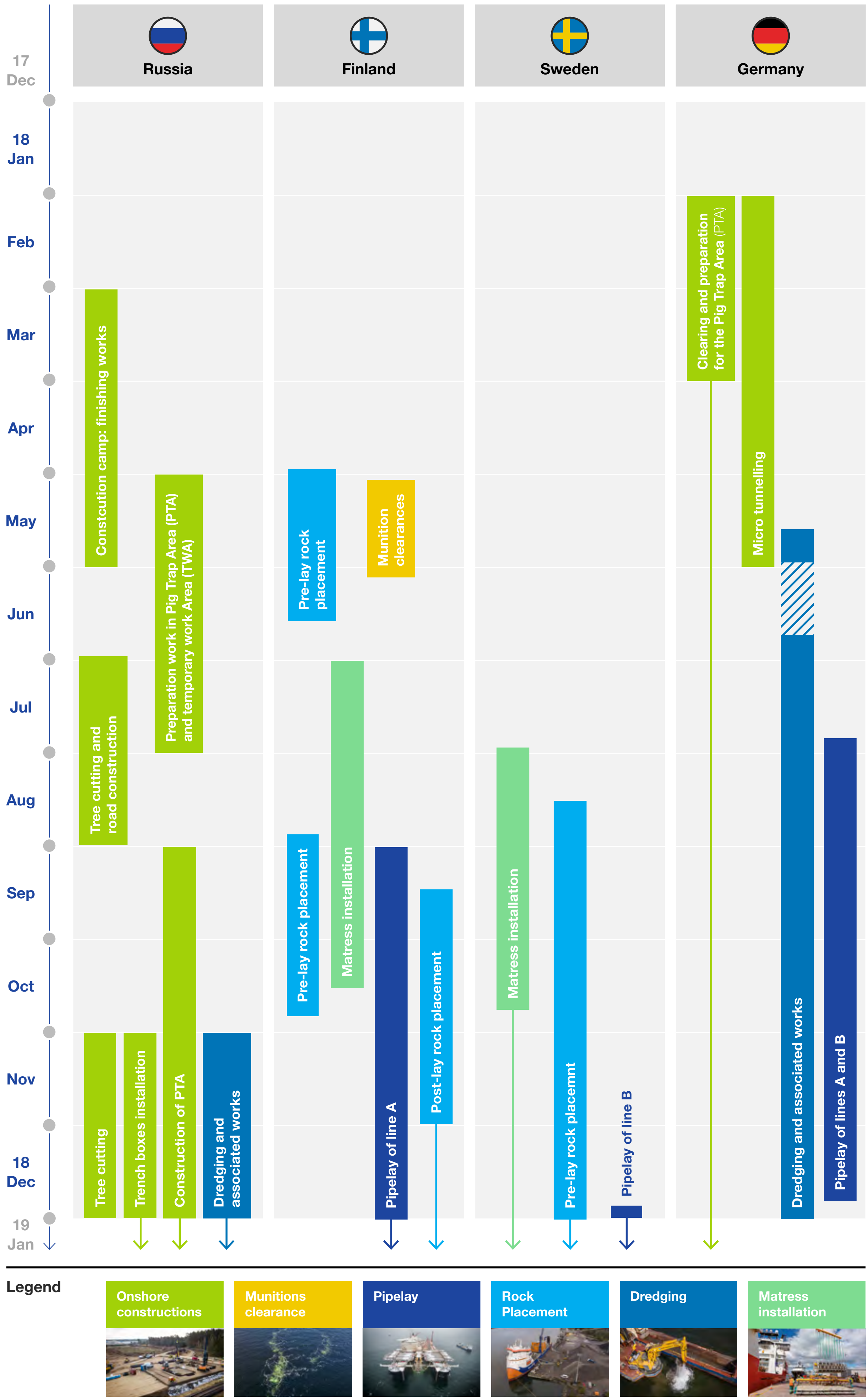


Figure 3. *Construction milestones in 2018*

2.2 Construction in Russia

Onshore construction

Onshore construction in Russia started with the construction camp, which was finalized between March and May 2018, creating accommodation for 520 people. Preparation works such as fencing and topsoil stripping were performed in the Pig Trap Area (PTA) and Temporary Work Area (TWA) area in May–July. Construction of a temporary access road to the construction area started in August. Clearing of trees in the right-of-way took place in July–August and November–December along the 3.7 km line section across the Kurgalsky Reserve. Relocation of protected (red data book) plans took place prior to the clearance of trees.

Trenching and installation of trench boxes along the right-of-way started in October. Within the PTA installation of concrete piles started in September and construction of concrete foundations and anchor blocks started in October, and these activities will continue into 2019.

Offshore construction

Offshore construction in the Russian TW started in November 2018 with nearshore dredging between KP 1 and KP 3 using the dredging vessel Hippopotes. Dredged material was transported by the barges Wadden 1 and Johannis de Rijke to the temporary underwater storage area in Narva Bay. Silty material (ca. 2,100 m^3) was transported by the barge Pieter Calland to the permanent storage area in Ust-Luga bay.

No pipe-lay took place in Russian waters in 2018.

2.3 Construction in Finland

Construction activities in the Finnish EEZ started in April 2018 with pre-lay rock placement. In total, two pre-lay and a post-lay rock placement campaigns took place in the Finnish EEZ in 2018.

Munitions clearance started in May and was completed at the beginning of June with 74 munitions having been cleared. From June to October all mattresses required for infrastructure crossings were installed on the seabed.

Pipe-lay commenced on 5th September with installation on Line A by the Allseas dynamically positioned (DP) pipe-lay vessel Solitaire. Construction started in an easterly direction towards the Russian border before returning to the starting point and laying westward towards Sweden. The Allseas DP pipelay vessel Pioneering Spirit replaced Solitaire in mid-December.

In total, construction activities in the Finnish EEZ comprised the placement of 478,700 m^3 of rock, the installation of 492 mattresses and approximately 260 km of pipeline (Line A) were laid on the seabed (KP 117 to KP 376).

2.4 Construction in Sweden

Construction activities within the Swedish EEZ started on 28th July 2018 with the installation of mattresses over cables to be crossed in the northern part of the Swedish EEZ. Thereafter, other preparatory construction activities such as additional mattress installations and pre-lay rock placement were performed at several locations during Q3 and Q4.

Pipe-lay began on 23rd December when Allseas DP pipelay vessel Solitaire started installation of Line B in the southern part of the Swedish EEZ, close to the Danish EEZ border, laying in a northerly direction. By the end of the year, a 27 km section of pipeline (Line B) had been laid on the seabed in the Swedish EEZ (KP 994 to KP 967).

2.5 Construction in Germany

Onshore construction

Construction activities for the German onshore section started in February 2018 with clearing and preparation of the construction site for the future PTA. Preparation works for the microtunnels were started in February as well. Drilling of both microtunnels was completed by the end of May.

Excavation works for the anchor blocks were started in October after onshore pull-in of the pipelines in July/August. Concrete pouring for the anchor blocks started in November and was completed by December 2018. Onshore piping works began in October 2018 and will continue into 2019.

Offshore construction

Offshore activities started on 15th May 2018 with excavation of trenches in the Greifswalder Bodden. Due to an accidental release of grease by a backhoe dredger, dredging works were interrupted for a period of 4 weeks. After replacing the grease and hydraulic oils liable to come into contact with the sea water by environmentally acceptable lubricants (EALs) dredging continued from late June onwards. The dredged material was stored at the interim storage area off the island of Usedom for later use for backfilling. Dredged material unsuitable for backfilling was taken to Mukran harbour for onshore use.

Pipelay started on 24th July 2018 and was completed on 20th December 2018. Two anchored pipelay vessels were involved: the shallow water vessel Castoro 10 (Saipem) laid 30 km (Line A and Line B) in the nearshore section while the vessel Audacia (Allseas) continued pipelay towards the German EEZ for an additional 38 km (Line A and Line B). Both lines were laid to 16.5 km from the Danish-German EEZ border by 20th December 2018.

Backfilling of the trenched section started immediately after pipelay. Backfilling was completed by 31st December 2018.

3 Monitoring prior to/during onshore construction in Russia

The EIA and Espoo report concluded that the main potential impact from the construction activities at the Russian Landfall could occur as damage to biotopes crossed by Nord Stream 2 within the Kurgalsky Nature Reserve. Therefore, since Nord Stream 2 recognises the particular environmental importance of the Kurgalsky Reserve, a very thorough monitoring programme at the Russian landfall has been developed to cover both the construction activities at the construction camp and construction sites (PTA and right-of-way) as well as the environmental conditions of the Kurgalsky Nature Reserve. In addition, baseline data regarding the Rosson river was collected in 2018.

The Kurgalsky Nature Reserve comprises a network of sensitive biotopes, the most vulnerable being coastal, forest and swamp biotopes that function as habitats for protected and rare species. Monitoring in the Kurgalsky Nature Reserve focuses on both the abiotic and the biotic environment.

Potential impacts originating at the construction camp and construction sites arise from water discharges which are monitored at the discharge points within the facilities and at the final outfall into the Rosson river. In addition, air emissions and noise emissions are also monitored at the construction camp and facility site, as well as at the nearest settlement.

The purpose of monitoring the Rosson river in 2018 was to collect baseline data to allow further assessment of potential impacts related to treated effluent discharge from the construction camp and facility sites. Monitoring of the Rosson river includes both the abiotic and the biotic environment.

3.1 Monitoring of Kurgalsky Nature Reserve

The Nord Stream 2 pipelines cross the Kurgalsky Nature Reserve in a 4 km long and 30–60 m wide area, defined here as the Project Area. In 2018, all Red Data Book plant species (RDBS) identified in the project area were relocated to new sites prior to the clearance of trees from the right-of-way, which was also done in 2018. Also, the right-of-way crosses a relict dune which was cut through during 2018 and was monitored for cultural heritage finds. An extensive monitoring programme has therefore been established to monitor the territory of the reserve adjacent to the Project Area and to monitor the conditions of the RDBS. The objective of monitoring in the Kurgalsky Reserve is to identify potential deviations in landscape structure (biotopes mosaic) related to the construction activities and to assess the magnitude of the changes, if any.

The programme covers all biotopes crossed by the Project Area with special focus on rare and protected species and habitats. The monitoring locations established in the Kurgalsky Nature Reserve are presented in Figure 4.

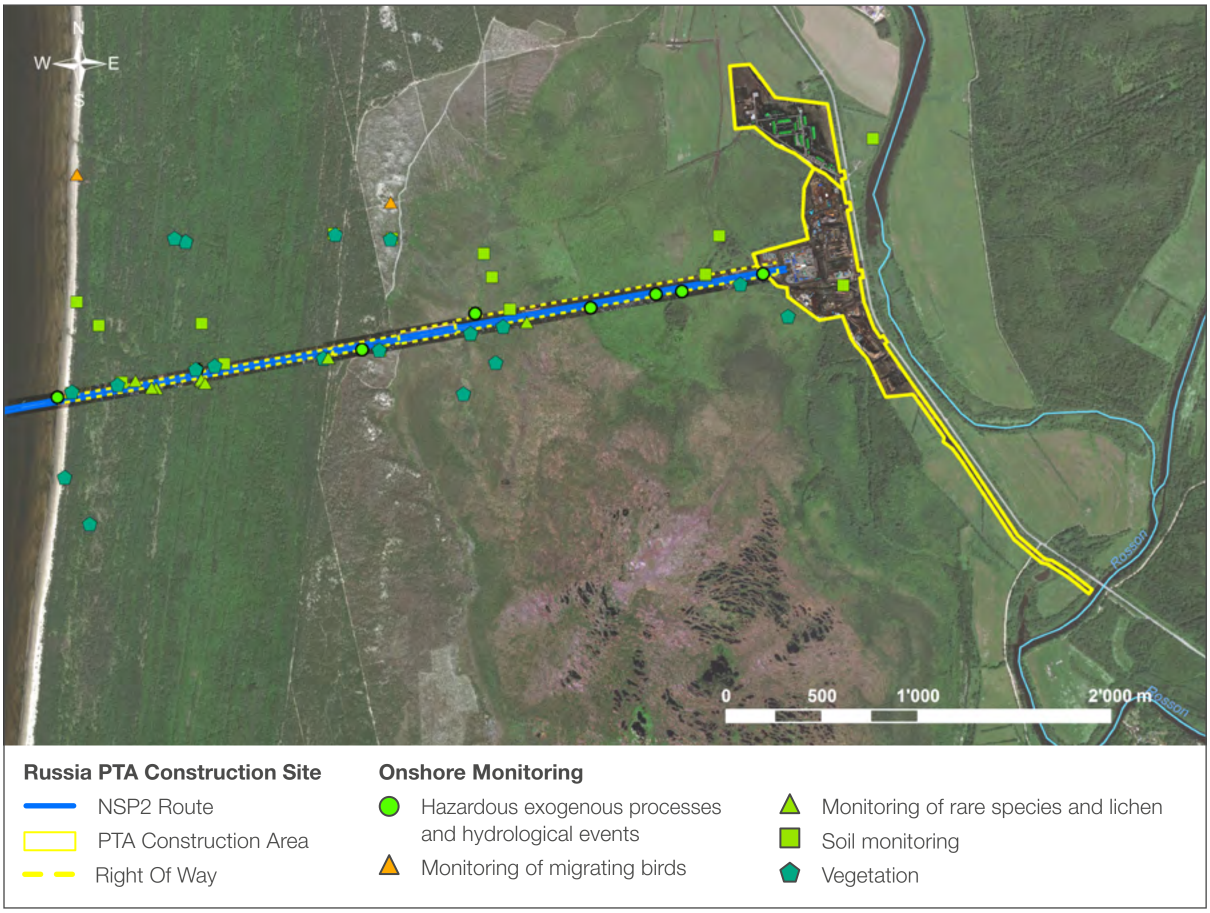


Figure 4. *Environmental monitoring at Kurgalsky Nature Reserve.*

Monitoring activities started before the beginning of construction (i.e. before tree cutting in Kurgalsky Reserve in the right-of-way) and are planned to continue throughout construction and partially into the operational phase of the pipelines. The majority of monitoring activities are seasonal and thus focus on the relevant environmental aspects (e.g. bird migrations, nesting period, flowering period, etc.) rather than on the construction activities.

Activities occurring within the nature reserve are governed by national requirements for protection of Special Protected Natural Areas (SPNAs), the Decree on the Kurgalsky Reserve, as well as by the national EIA.

Based on the monitoring results for 2018, no significant impacts occurred in the protected area. Soil quality and exogenous processes were found not to be affected by the construction activities (see Chapters 3.1.1. and 3.1.2). Relocated plant species from the construction corridor to undisturbed areas often proved to be in a better state than the plants in their original location (due to anti-drought measures implemented for the relocated species, see Chapter 3.1.3). Migratory birds showed some minor changes in their pattern of movement (see Chapter 3.1.4). No impacts on a total of 42 protected species of vertebrates were recorded (see Chapter 3.1.5) and no objects of cultural heritage value were found in the area (see Chapter 3.1.6).

3.1.1 Soil quality

The construction corridor crosses different soil types, which are associated with specific plant communities. The purpose of monitoring soil quality is to verify that the construction activities do not have an impact on the different combinations of soil and associated plant communities. Monitoring included a description of the soil profiles as well as chemical and physical analyses of soil samples (see Figure 4).

METHODOLOGY

To monitor the potential impact of construction activities on different soil types, 10 pairs of monitoring locations were established. For each soil type (and associated plant community), one plot was established in close proximity to the construction corridor ("control plot") and one plot was established more than 180 m from the construction area in an undisturbed area ("background plot"), for a total of 20 plots.

Description of the soil profiles involved recording the composition and thickness of the genetic horizons, groundwater depth, and root layer depth. Each soil horizon was then measured in terms of thickness, chromaticity, moisture, and mechanical composition, structure, density, presence of neoformations (i.e. a mineral or inorganic phase newly formed in the soil in the process of pedogenesis), etc.

For each plot, 5 soil samples were collected from the surface layer (0.0–0.2 m) and were analysed by accredited laboratory centres for soil texture, pH, and concentrations of heavy metals, oil products (total hydrocarbons) and benzo(a)pyrene.

RESULTS

In August 2018 there were no significant differences between the control plots and the background plots, with the exception of one control plot that showed an unusually high content of arsenic and was therefore further monitored. In general, peaty soils displayed naturally high concentrations of heavy metals, including arsenic: this is attributable to a marked sorption soil-geochemical barrier. Also, increased concentrations of oil products both in the control plots and background plots of peaty soils compared to the general background values were registered. These were attributable to imperfections in the test method rather than to anthropogenic pollution of the Kurgalsky Reserve. Total oil products were measured as total hydrocarbons which did not distinguish the anthropogenic component from the naturally occurring hydrocarbons characteristic of peaty bog soil. The results were also comparable to the environmental baseline survey data.

Additional soil quality monitoring was carried out to further evaluate the contamination of the area displaying unusually high levels of arsenic, and to determine whether a special contaminated soil management plan for excavation of the Project Area was needed. A total of 432x2 individual soil samples were collected in an area of 540x30 m (divided into 54 plots) within the Project Area (see Figure 5). The samples were analysed by two independent laboratories in order to validate the monitoring results. The analyses showed that the average arsenic content in the monitored area was 1.38 mg/kg (Maximum Permissible Level MPL is 2 mg/kg) and that values above MPL were detected only at 6 of the 54 monitoring plots (see Figure 5). Since the average arsenic concentration was below MPL and the plots with high arsenic concentration were scattered throughout the area, it was concluded that the high arsenic concentrations are related to lithological factors and not to anthropogenic ones. These findings were also in line with the existing literature regarding the geomorphology of the area. No additional protection measures or special requirements for soil management were therefore identified /11/.

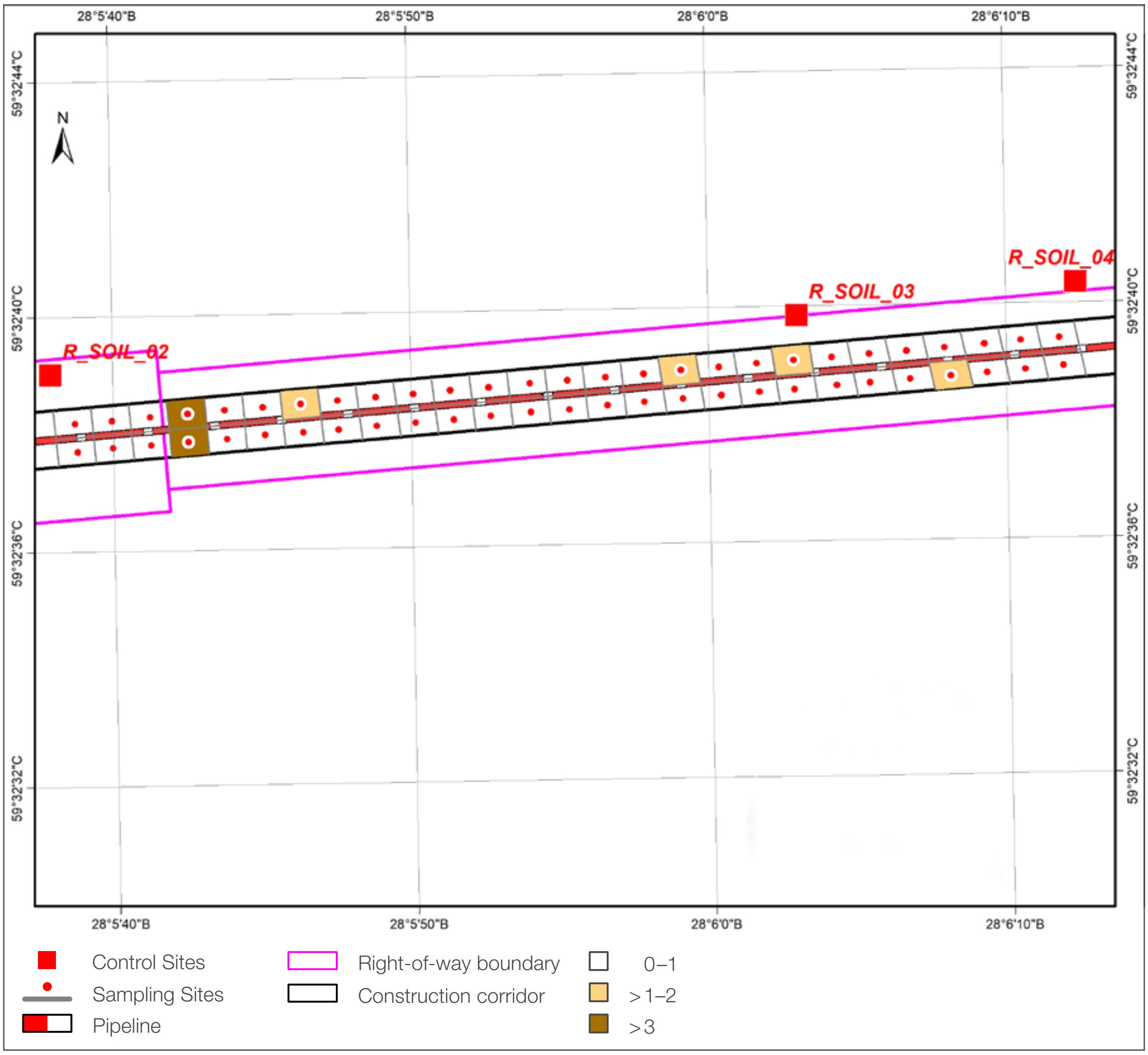


Figure 5. Sites exceeding the approximate permissible concentration of arsenic as part of additional monitoring of soil quality. Approximate permissible concentration is expressed in mg/kg.

CONCLUSIONS

According to the monitoring results, no impacts on soil quality in the Kurgalsky Nature Reserve were caused by the construction activities occurring in 2018. Project implementation was in compliance with the national EIA and national requirements for soil, water basins and SPNA protection.

3.1.2 Exogenous processes

The purpose of monitoring exogenous processes is to verify that construction activities do not cause changes in the natural landscape, such as erosion events and hydrological phenomena (see Figure 4).

METHODOLOGY

Monitoring of exogenous processes in 2018 took place during two survey campaigns: one at the end of May (before the start of construction) and one on 18 October (after the first tree cutting campaign at KP 3.7–1.2, stripping of the Project Area, during road construction between the PTA and the dune section, and during preparation of trenching and installation of trench boxes close to the PTA). Monitoring took place at the following 8 monitoring locations:

- 01 – beach;
- 02 – bog-covered dune slacks;
- 03 – relict dune;
- 04 – bog-covered lower part of the Littorina plain[1];
- 05, 06, 07, 08 – drainage ditches and adjacent areas.

RESULTS

During the monitoring period, no exogenous processes, hydrological phenomena or dangerous manifestations were observed. The dynamics of natural processes occurred within the normal framework of seasonal changes.

Due to the particularly early start of the spring season and the limited amount of precipitation in the summer, low groundwater levels and stagnation of flooding processes were noted at all monitoring locations in early summer.

Autumn monitoring revealed a natural rise of groundwater in depressions, in the raised bog, and within areas of the old drainage network. The removal of a beaver dam and the installation of drainage at monitoring point 08 led to normalisation of the groundwater level in the area /11/.

CONCLUSIONS

Based on the monitoring results, no exogenous processes caused by the construction activities in 2018 were observed. Project implementation was in compliance with the national EIA.

3.1.3 Terrestrial flora

The construction corridor crosses a heterogeneous mix of plant communities made up of both natural pristine biotopes as well as areas that have experienced some level of anthropogenic pressure. The purpose of monitoring terrestrial vegetation is to verify that construction activities do not have an impact on the different plant communities crossed by the Project Area, or on RDBS located in close proximity to the Project Area (see Figure 4).

In addition, RDBS found within the Project Area were relocated to undisturbed areas (at a maximum distance of 2 km from where they were collected) before the start of the construction activities. The monitoring work also included an assessment of the survival and general condition of the relocated RDBS.

1 The Littorina plain was formed by the Littorina Sea, which was a geological brackish water stage of the Baltic Sea, which existed around 7500–4000 BP. The surface is formed by terraces predominantly made up of glacio-lacustrine sandy loams and banded clay.

METHODOLOGY

To monitor the potential impact of construction activities on different plant communities, 9 pairs of monitoring plots were established. For each type of plant community, one plot was established in close proximity to the construction corridor (“control plot”) and one plot was established more than 190 m from the construction area in an undisturbed area (“background plot”), for a total of 18 plots.

To monitor the status of protected species near the Project Area and to allow for the implementation of additional protection measures if required, 8 plots were established in close proximity to the Project Area.

Monitoring of the above 26 (18+8) plots included general geobotanical surveys. The recorded parameters included species counts and identification, measurements of density, age and height, evaluation of epiphytic (moss, lichen) cover, etc., as well as soil characteristics such as soil type, moisture content, terrain features, etc.

In addition, 27 plots were established for monitoring of relocated RDBS. Monitoring of relocated RDBS involved recording of the plants’ survival and general condition. Individual specimens from the following RDBS species were relocated: *Pulsatilla pratensis, Pulsatilla patens, Epipactis atrorubens, Drosera intermedia, Hottonia palustris, Neottia nidus-avis* and *Aulacomnium androgynum.*

RESULTS

No significant differences between the control and background plots were observed. Also, most of the protected species identified within the control and background plots and in the additional plots located near the Project Area were in a good state in summer 2018. However, the drought in July–August 2018 and recreational pressure had some negative effects on the condition of the monitored *Epipactis atrorubens, Drosera intermedia* and *Lobaria pulmonaria*. Most of the relocated plant species, even if affected by drought, were found in better condition than plants at the background plots, due to watering and other supportive measures implemented by the project. An exception was the condition of *Epipactis atrorubens*, which was damaged by tourists along all of the coastal section.

In general, several sources of anthropogenic pressure not related to the construction activities were observed in the monitored area, such as: vegetation trampling, littering, illegal tree cutting and vehicle transits related to active recreational use of the area. Other impacts, such as the presence of trees damaged by bark beetles, are attributable to selective logging of the spruce-pine coastal forest that occurred over 10 years ago. The damage caused by the forest fires that occurred in 2006 are still visible in different parts of the forests (i.e. different levels of damage to forestry stands). Also, pine monocultures planted after the forest fires are present in the area. Fallen trees and several forest clearings attributed to natural forest dynamics were also observed (see Figure 6) /11/.

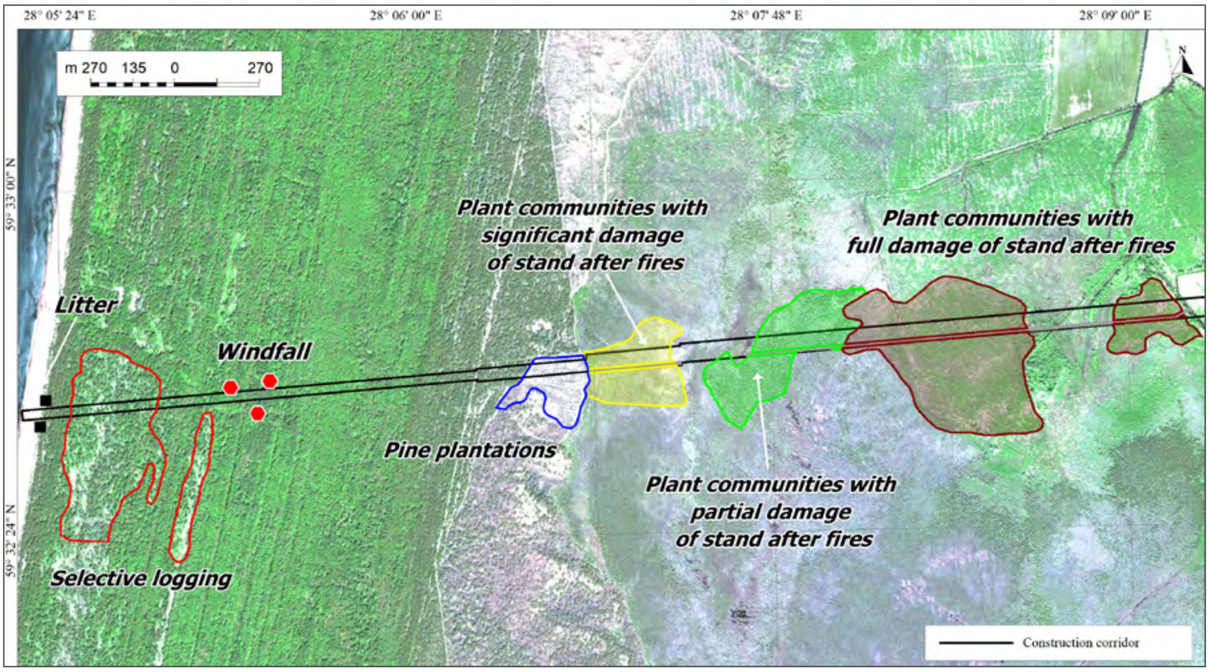


Figure 6. *Distribution of anthropogenic disturbance observed in the monitored area.*

CONCLUSIONS

According to the monitoring results, the impacts on vegetation in the Kurgalsky Nature Reserve that occurred due to the construction activities in 2018 were acceptable and in line with the EIA documentation. Different type of anthropogenic impacts that were not related to the construction activities were observed in several parts of the monitored area. Project implementation was in compliance with the national EIA, national requirements for protection of SPNAs, the Decree on the Kurgalsky Reserve, and the RDBS relocation permit requirements.

3.1.4 Birds

Monitoring of birds in the Kurgalsky Nature Reserve was undertaken with the purpose of identifying and monitoring potential changes in bird populations and dynamics due to the construction activities. The monitoring work focused on:

1. Local avifauna;
2. Migratory avifauna;
3. Three breeding indicator species[2], one for each biotope crossed by the Project Area (wetlands, forest and beach).

In addition, the monitoring work also specifically addressed protected terrestrial fauna, which is discussed in Chapter 3.1.5.

2 Monitoring of indicator species is a common tool in the study of complex ecosystems. Indicator species are selected as the representative species of a given biotope. The indicator species is generally identified as the most typical in the specific biotopes and its presence supports the associated community. The results of monitoring of indicator species are used as a proxy to understand impacts at the ecosystem/biotope level.

METHODOLOGY

Each of the above targets for bird monitoring was monitored according to specifically tailored methodologies. A brief description of the methodology is provided below, and an overview of the monitoring locations is provided in Figure 7.

1. Monitoring of local avifauna was carried out on two parallel transects: one in close proximity to the construction corridor (“control plot”), and one approximately 1 km south of the construction corridor in an undisturbed area (“background plot”). For each transect, the number of birds, species composition and species diversity in each of the traversed biotopes were recorded.
2. Monitoring of migratory avifauna was carried out during the period of seasonal migration at two observation points (shore and dune). The number of birds, species identity and main direction of movement were recorded for a period of 4 hours after sunrise at each observation point.
3. The breeding indicator species monitored were common crane (*Grus grus*) for wetland biotopes, black woodpecker (*Dryocopus martius*) for forest biotopes, and ringed plover (*Charadrius hiaticula*) for beach biotopes. Monitoring of the breeding indicator species consisted of route surveys in May and June, recording of visual sightings of the species and their tracks and signs, and passive acoustic monitoring (for the common crane only). Photographs of the species were taken whenever possible (see Table 3).

Table 3. *Scope of monitoring for breeding indicator species. Number of observations and findings include visual observations, tracks and signs, and vocalisation recordings.*

Species	Route surveys	Passive acoustic monitoring	Number of observations and findings
Common crane	6 surveys 26 h in total	3 surveys 10 h in total	63 (55+8) findings in 50 locations, 48 observations of birds
Black woodpecker	6 surveys 33 h in total	–	32 observations 40 potential nesting locations (findings)
Ringed plover	5 surveys 28 h in total	–	59 nesting locations (68-9) 17 observations

Figure 7. *Overview of bird monitoring locations at the Russian landfall.*

RESULTS

Monitoring of local avifauna showed that changes in species composition and population sizes on the different transects throughout the monitored period were comparable (Figure 8). Minor differences between the transect located near the construction site and the one located in the undisturbed area are associated with existing landscape features and the natural variability of the assessed parameters.

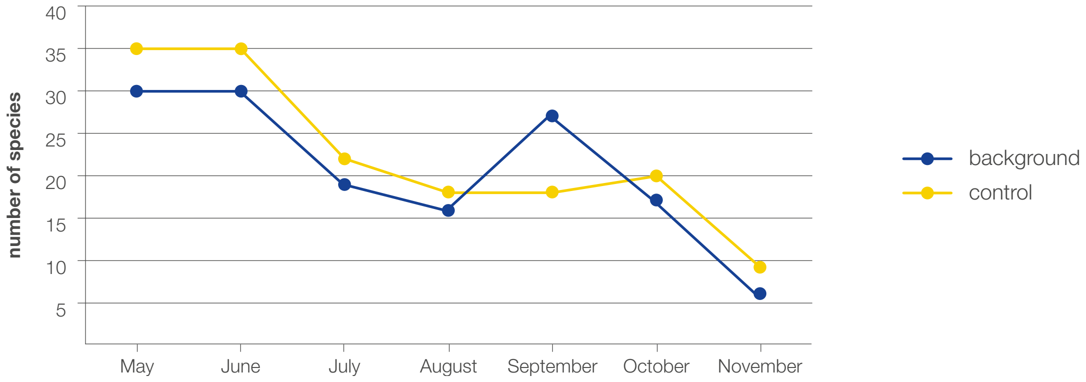


Figure 8. *Seasonal dynamics of species diversity. Control transect is located in close proximity to the construction corridor; background transect is located approximately 1 km south of the construction corridor.*

For the monitoring of migratory avifauna, more than 20,000 birds were recorded over the entire observation period, in similar proportions at the shore and at the dune observation points. The largest migration occurred in autumn (September–October) when approximately 2/3 of the observations were recorded.

Monitoring of migratory avifauna showed that the construction activities did not affect migration patterns. Slight changes in flight direction and flight altitude of geese flocks were recorded during the construction work; no changes in the flight patterns of other birds were detected. On the basis of the recorded observation data (see Table 3), maps showing estimated species distribution and breeding locations for each of the indicator species were created.

The common crane seems to occur mainly in an area more than 500 m south of the construction corridor, with an estimated population size of 7 breeding pairs. Visual observation and passive acoustic monitoring showed that the species was also temporarily present in proximity to the PTA, indicating that the birds continue to use these territories. It was also observed that the young cranes seemed to have relocated to the more southern part of the bog in June–July compared to April–May[3]. Although it cannot be ruled out that the construction works may have had some effect on the observed pattern, the extremely low rainfall in the spring–summer of 2018 caused the southern habitats characterised by open water and low-lying areas of bog to become more favourable. In general, the marshy area north of the construction corridor is not significantly used by cranes.

The black woodpecker seems to occur mostly in the southern part of the forest, where there are many old-growth and dry pine trees with the typical large cavities used as nesting sites. Few potential nest sites were located in proximity to the construction corridor (to a distance of about 215 m). In general, the monitored area contains areas unsuitable for nesting woodpeckers, such as new pine plantations, alder forests and medium aged forested dunes. The main impact from construction activity is the destruction of potential nesting trees: although two trees were found in the construction corridor before the tree cutting, in 2018 there were no signs of breeding in the cavities. Other sources of impact, such as disturbance, are assessed not to extend beyond 100 m, given that the species is relatively tolerant to anthropogenic impact (e.g. it nests in urban parks).

3 The common crane is a precocial species, meaning that the chicks can move around within a few days of hatching. The most vulnerable period in the species life cycle is incubation, which occurs in this area between mid-May and mid-June.

Two species of plover were found in the surveyed beach area: the common ringed plover (*Charadrius hiaticula*), a protected species in Leningrad Region, and the little ringed plover (*Charadrius dubius*). The monitoring results indicate that 2-3 pairs of these birds were nesting in the survey area during the monitoring period. In addition, larger mixed flocks of waders (about 30 individuals) including ringed plovers and dunlin (*Calidris aplina*) were observed in June and in August.

Severe anthropogenic disturbance unrelated to the construction activities was observed multiple times in the monitoring area. The area experiences high recreational load, with cars and motorcycles often driving through the birds‘ nesting areas. Such use of the beach area causes both direct (destruction of nest scrapes) and indirect (elevation of stress level) impacts to the protected ringed plover. Measures to protect the nesting biotope of the ringed prover during the breeding season are currently being discussed by the regional authority (Committee for Natural Resources of Leningrad Region) /11/.

CONCLUSIONS

Based on the monitoring results, the impacts on local and migratory wetland bird populations, woodland bird populations and shore bird populations due to the construction activities in 2018 were in compliance with the national EIA. Impacts on sensitive wetland bird species arise from anthropogenic activities unrelated to the construction of Nord Stream 2.

3.1.5 Terrestrial fauna

Monitoring of rare and protected species of terrestrial fauna was carried out in the Kurgalsky Nature Reserve. In this section we discuss the monitoring of terrestrial vertebrates included in the Red Data Book of the Russian Federation, category 3 (NT) or higher, in the Red Data Book of Leningrad Region, in the IUCN Red List and in the HELCOM Red List, category NT or higher. Monitoring of protected plants included in the Red Data Book Species List is discussed in Chapter 3.1.3.

METHODOLOGY

Visual observations of protected species of terrestrial fauna and observations of their tracks and signs were recorded during all monitoring activities of birds (see Chapter 3.1.4).

RESULTS

A total of 42 protected vertebrates (as defined above) were recorded in the survey area: these included one reptile species, *Natrix natrix*; one mammal species, the grey seal Halichoerus grypus; and the others were birds (Table 4).

Table 4. List of protected species of vertebrates found during monitoring.

Species	Status in the territory*	Months						
		May	June	July	August	September	October	November
Aves								
Gaviiformes								
Black-throated loon *Gavia arctica*	nest.? migr.	X			X	X	X	
Podicipediformes								
Horned grebe *Podiceps auritus*	migr.	X		X				
Anseriformes								
Whooper swan *Cygnus cygnus*	nest.? migr.	X				X	X	
Tundra swan *Cygnus bewickii*	migr.	X					X	
Bean goose *Anser fabalis*	migr.	X					X	
Greylag goose *Anser anser*	nest.? migr.	X						
Brent goose *Branta bernicla*	migr.		X					
Common scoter *Melanitta nigra*	migr.	X	X		X			
Velvet scoter *Melanitta fusca*	nest.? migr.	X				X		
Long-tailed duck *Clangula hyemalis*	migr.	X						
Tufted duck *Aythya fuligula*	nest.? migr.	X			X	X		
Northern pintail *Anas acuta*	migr.					X		
Falconiformes								
White-tailed eagle *Haliaeetus albicilla*	nest. res.	X	X	X	X	X	X	
Osprey *Pandion haliaetus*	nest.		X		X	X		
Peregrine falcon *Falco peregrinus*	migr.						X	
Galliformes								
Willow grouse *Lagopus lagopus*	nest. res.	X	X	X			X	
Charadriiformes								
Black-tailed godwit *Limosa limosa*	nest. res.				X			
Eurasian curlew *Numenius arquatus*	nest.	X						

Species	Status in the territory*	Months						
		May	June	July	August	September	October	November
The Common ringed plover *Charadrius hiaticula*	**nest.**	X	X		X	X	X	
Eurasian oystercatcher *Haematopus ostralegus*	**nest. res.**		X					
Terec sandpiper *Xenus cinereus*	**nest. res.**	X						
Common sandpiper *Actitis hypoleucos*	**nest. res.**	X		X	X	X		
Redshank *Tringa totanus*	**nest.? migr.**	X						
Ruff *Philomachus pugnax*	**migr.**				X			
Dunlin *Calidris alpina**	**nest.? migr.**		X		X			
Temminck's stint *Calidris temminckii*	**migr.**	X						
Northern lapwing *Vanellus vanellus*	**nest.**	X	X	X				
European golden plover *Pluvialis apricaria*	**nest.? migr.**				X	X	X	
Lesser black-backed gull *Larus fuscus*	**nest.**					X		
Caspian tern *Hydroprogne caspia*	**nest.? migr.**				X			
Razorbill *Alca torda*	**migr.**				X			
Columbiformes								
Stock dove *Columbia oenas*	**nest.**	X	X	X	X	X	X	
Piciformes								
Grey-headed woodpecker *Picus canus*	**nest.? migr.**						X	
Eurasian three-toed woodpecker *Picoides tridactylus*	**nest.**							X
Passeriformes								
Woodlark *Lululla arborea*	**nest.**	X			X			
Northern wheatear *Oenanthe oenanthe*	**nest.**	X			X	X		
Coal tit *Periparus ater*	**nest.**					X	X	X

Species	Status in the territory*	Months						
		May	June	July	August	September	October	November
Great grey shrike *Lanius exubitor*	**nest.**						X	
Rustic bunting *Emberiza rustica*	**nest.**	X	X					
Spotted nutcracker *Nucifraga caryocatactes*	**nest.**					X		
Mammalia Carnivora								
Grey seal *Halichoerus grypus*	**season.**		X					
Reptilia Squamata								
Grass snake *Natrix natrix*	**res.**	X			X			

*Only *C.a.schinzii.*
Notation keys: nest;–nesting; nest?–possibly nesting; migr.–migratory; res.–resident

Of the 40 registered bird species, 29 species are representatives of wetland avifauna, 20 species breed on the Kurgalsky peninsula, 9 may breed and another 9 species are found exclusively during their migration. In the area of the construction corridor, at least 8 protected bird species breed, namely white-tailed sea eagle, ringed plover, willow grouse, great grey shrike, woodlark, northern wheatear, northern lapwing, stock dove, and rustic bunting. No suppression of breeding, change of nesting sites or other signs of impact on these species related to the construction activities were found in 2018 /11/.

CONCLUSIONS

Based on the monitoring results, there was no impact on Red Data Book Species caused by the construction activities. Project implementation was in compliance with the national EIA, national requirements for SPNA protection, and the Decree on the Kurgalsky Reserve.

3.1.6 Cultural heritage

Archaeological supervision was performed during all earthworks at the relict dune in the Kurgalsky Reserve in the vicinity of the designated archaeological sites Vyayke-Ropsu 6 and Vyayke-Ropsu 7 (see Figure 9). A watching brief was implemented in 2018 and will continue throughout the construction phase. No objects of cultural heritage significance were identified in 2018.

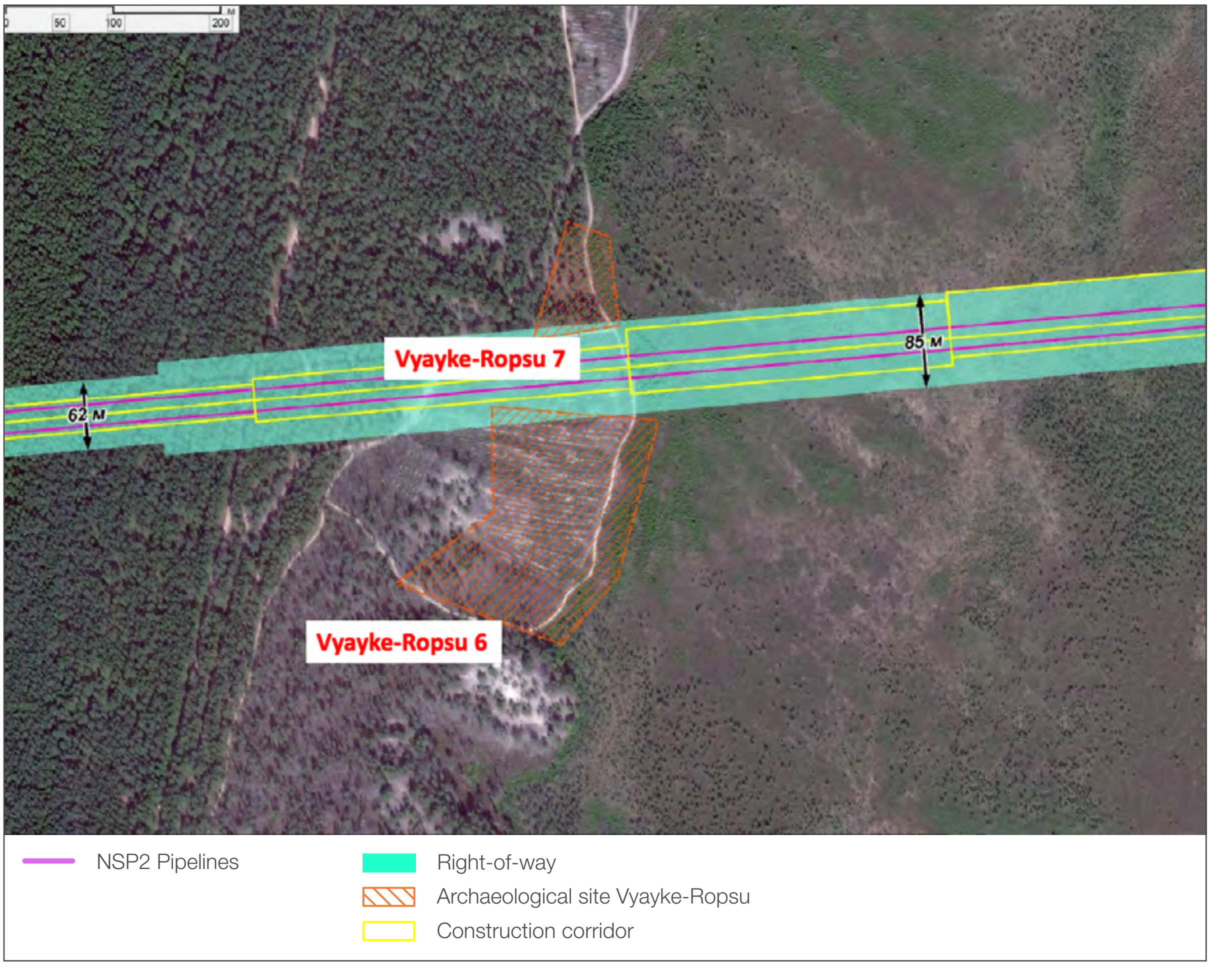


Figure 9. *Environmental monitoring at the construction camp and work areas.*

3.2 Monitoring of construction camp and work areas

Monitoring at the construction camp and work sites is designed to ensure that the project meets the requirements for water discharge, air emissions and noise emissions stated in the EIA, the State Environmental Expert Review report (SEER) and the relevant permits. In addition, monitoring was also conducted in proximity to the nearest settlement to ensure that no adverse impact affects the local community. Finally, monitoring also helps to identify possible solutions and remedial actions to be applied if permitted thresholds are exceeded. The monitoring locations established at the construction camp and work sites are shown in Figure 10.

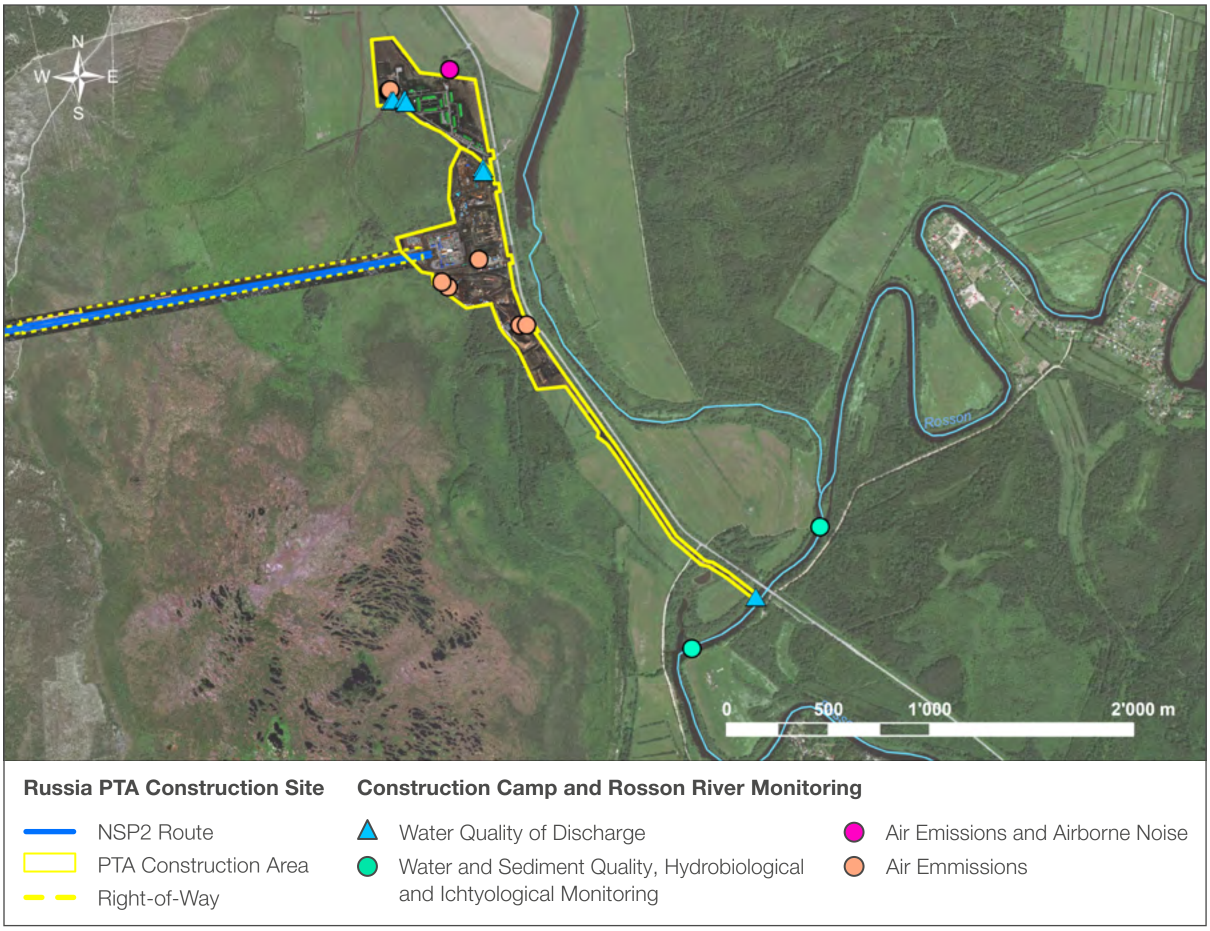


Figure 10. *Environmental monitoring at the construction camp and work areas.*

In general, the construction activities occurring at the construction camp and work sites in 2018 were in line with the estimates given in the national EIA. However, water discharges from the treatment plants were not in compliance and were therefore suspended in December 2018, and were not resumed before the treated water met the required national standards (see Chapter 3.2.1). Mitigation measures and improvement to the water treatment systems were put in place in 2019 and therefore the associated results are not presented here. Monitoring of air emissions (Chapter 3.2.2) and airborne noise (Chapter 3.2.3), measured both in the construction camp and in proximity to the nearest settlement proved to be in line with the estimated figures and with the applicable legislation. Emissions into water bodies and the atmosphere, including noise, were found to have no detrimental effects on the local population.

3.2.1 Quality of discharged water and receiving waters

Monitoring of water discharges is undertaken to verify the effectiveness of the treatment plants located in the construction camp (sewage and storm water) and PTA (drainage water). In an adaptive management sense this information enables remedial actions to be put in place. The volume and quality of water discharges are measured at the three water treatment plants which separately treat sewage and storm water from the construction camp and drainage water from the dewatering operations for excavations in the PTA. All treated water is then collected and discharged into the Rosson river.

Water discharges from the construction camp and work sites are regulated by the discharge permit, the water licence and the discharge limit documentation, which served as the basis for development of the monitoring programme for water discharges.

Where treated water quality is consistently above the thresholds, Nord Stream 2 suspends discharges into the Rosson river and the water is tankered away for treatment at licensed water treatment plants in the region. Discharge into the river is resumed only when water quality analysis demonstrates compliance with the licence conditions.

METHODOLOGY

Sewage water and storm water from the construction camp and drainage water from the PTA are sampled and analysed at 7 locations distributed as follows: one upstream of each treatment plant, one downstream of each treatment plant and one at the outfall into the Rosson river (see Figure 10). Two additional sampling locations in Figure 10 are related to baseline monitoring of the Rosson river and will be discussed in Chapter 3.3.

Water samples were analysed by accredited laboratory centres for common physico-chemical properties (including heavy metals, hydrocarbons, biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrates, phosphates, pH, temperature, oxygen) and for sanitary and epidemiological parameters.

The monitoring programme specifies quarterly sampling of water discharges. In addition the treated effluents are also sampled on a bi-weekly basis for operational reasons. Water discharge started after the commissioning of the treatment plants on 16th November and were suspended on 4th December 2018, due to the findings of the bi-weekly operational monitoring.

RESULTS

The total volume of discharged water for 2018 was 2960 m^3, approximately 11.5 % of the permitted volume for Q4 2018. However, the quality of the discharged water was not in compliance with the discharge permit requirement for 16 of the 25 measured parameters, with the most critical values being those for ammonium nitrogen and manganese concentrations.

Whilst the discharged water also did not meet the sanitary standards (see Table 5), according to the results of biotesting the discharged treated water was assessed as not having any toxic effects /12/.

Table 5. *Test results for treated wastewater discharges (T1) by sanitary-epidemiological parameters.*

Nr.	Parameter	Unit	Discharge point at the Rosson river	Sanitary requirements of SanPiN 2.1.5.980-00 for domestic and recreational water use
1.	Total Coliforms (TC)	CFU/100 ml	2,400,000**	Not more than 500*
2.	Coliphagia	PFU/100 ml	not detected	Not more than 10*
3.	Thermotolerant coliform bacteria (TCB)	CFU/100 ml	2,400,000**	Not more than 100*
4.	Pathogens of intestinal infections (pathogenic microflora)	–	not detected	Water should not contain pathogens of intestinal infections
5.	Viable helminth eggs (ascaris, whipworm, toxocar, faciol), oncoshere taeniidae	Pcs/25l.	not detected	Should not be present in 25 litres of water
6.	Viable cysts of pathogenic intestinal protozoa	Pcs/25l.	not detected	Should not be present in 25 litres of water

*MPC (standard) – ccording to SanPiN 2.1.5.980-00 for the category „recreational water use, and within the boundaries of populated areas".
**Discharge was stopped after this value was recorded.

In 2019 Nord Stream 2 adjusted the frequency of water quality monitoring to enable improvements to the performance of the treatment plants. Water treatment experts were appointed to review the design of the treatment plants, to identify the nature of any improvements required to ensure their smooth functioning, and to improve treated water quality.

CONCLUSIONS

Nord Stream 2 implemented a comprehensive water quality monitoring programme in 2018, which provides early warning of any problems with treated water quality and support for decisions to suspend discharge to the outfall on the Rosson River. The results for 2018 point to the need to continue with an intensive and comprehensive monitoring programme and a review of the water treatment infrastructure.

Based on the monitoring results, an adaptive management approach was implemented, whereby discharges were suspended when necessary, and treated wastewater was tankered away to licensed facilities for treatment.

3.2.2 Air quality

Monitoring of air quality was carried out at the construction camp and at the village of Khanike, near the construction camp (see Figure 10). The purpose of the monitoring is both to verify compliance with the national EIA, the SEER report and permits, as well as to ensure that the construction activities do not have a negative impact on the local community.

Air emissions are regulated by the emissions permit (air emission limits documentation), by the regulatory requirements of public health standard GN 2.2.6.3492-17 17 „The maximum permissible concentration (MPC) of pollutants in the atmosphere of urban and rural settlements" and SanPiN 2.1.6.1032-01 „Hygiene requirements for ensuring air quality in populated areas".

RESULTS

The diesel generators at the construction camp are the monitored air emission sources. Monitoring includes comparison of the actual location of the sources with the planned location per the EIA documentation and the sampling and analysis of the gas mixtures. Sampling took place between 20th and 24th November 2018 and each individual sample was taken over a period of 2–2.5 hours. The samples were analysed by an accredited laboratory (see Table 6).

One of the diesel generators at the construction camp (the unit operated by Sodexo) was identified as the main source of air emissions potentially affecting Khanike village.

Air immissions were monitored between 20th and 25th November at a sampling station located in proximity to the village and another less than 100 m from the construction camp. Sampling was carried out every 6 hours for a minimum period of 30 minutes. Samples were analysed by accredited laboratory centres for meteo-parameters (e.g. temperature, pressure, wind direction and speed, etc). and nitrogen dioxide, sulphur dioxide, formaldehyde and carbon monoxide.

RESULTS

The number of air emission sources at the construction camp and Khanike village was smaller than planned in the EIA documentation since not all planned construction activities started in 2018 (8 actual operational sources vs 14 planned). Total emission volumes at the construction camp and Khanike village were well below the planned volumes stated in the EIA for 2018 (see Table 6).

Table 6. *Actual volume of emissions in 2018 compared with different preliminary assessments.*

No.	Pollutant	Air emission Volume (t)	
		Measured emission in 2018	EIA, whole construction period
1.	Nitrogen oxide	0.896468	12.684546
2.	Nitrogen dioxide	5.518161	78.057830
3.	Kerosene	0.098237	20.626482
4.	Sulphur dioxide (sulphurous anhydride)	0.507809	20.834053
5.	Formaldehyde	0.002511	0.235214
6.	Black carbon (soot)	0.029282	12.778055
7.	Carbon monoxide	0.685934	79.957796
8.	Benzo(a)pyrene (3,4-Benzpyrene)	0.0000003	0.000039

In addition, monitored air immissions in proximity to the residential area met the regulatory requirements of the public health standard for inhabited areas /11/.

CONCLUSIONS

Air emissions in terms of both total volumes and concentration of pollutants in 2018 were in compliance with the national EIA and with the air emission limits documentation. The air immissions have no negative impact on the local community. It should be noted that the large discrepancy between measured and expected emissions for 2018 is attributable to the fact that fewer construction activities than planned were performed in 2018 at the Russian landfall.

3.2.3 Airborne noise

Airborne noise was monitored in the proximity of Khanike village (see Figure 10). The purpose of this monitoring work is both to verify compliance with the national EIA, the SEER report and the permits, and to ensure that the construction activities do not have a negative impact on the local community.

Airborne noise is regulated by the requirements of SN 2.2.4/2.1.8.562-96 „Noise at workplaces in residential, public buildings and residential areas“.

METHODOLOGY

Airborne noise immissions were monitored with the same frequency used to monitor air quality (see Chapter 3.2.2). Of the total 20 measurements taken, 5 covered the night time and 15 covered the daytime.

Equivalent sound levels and maximum total sound levels where measured for the night time and for the daytime period and were compared to the permissible sound levels for residential areas.

RESULTS

Daytime measurements of equivalent sound levels and maximum total sound levels were below the permissible daytime sound levels for residential areas (respectively <55 dBA and <70 dBA). Similarly, night time measures of equivalent sound levels and maximum total sound levels were also below the permissible night-time sound levels for residential areas (respectively <45 dBA and <60 dBA).

The results of the acoustic monitoring were evaluated by the FPHI "Centre for Hygiene and Epidemiology in St. Petersburg", who provided a positive expert opinion regarding the noise levels originating from the construction activities /11/.

CONCLUSIONS

Noise immissions in 2018 were in compliance with the national EIA and with the regulatory requirements for noise levels in residential areas. The noise immissions have no negative impact on the local community.

3.3 Rosson river monitoring

Water from the construction site and camp is discharged into the Rosson River. For this reason, extensive baseline monitoring of the Rosson river environment, prior to the start of water discharges from the construction camp and site, was carried out in 2018. Gathering of baseline data also took place in 2017. The monitoring work carried out in 2018 was analysed as far as possible to facilitate comparison with the data collected in 2017.

The baseline monitoring covers water and sediment quality as well as the biological river environment, such as benthos and plankton communities and fish fauna. The two monitoring locations are situated 500 m up- and downstream of the discharge point (Figure 10).

Monitoring of the Rosson river will continue throughout the operation of the construction camp and work site and also during decommissioning of the construction camp.

The 2018 monitoring results showed that the water quality of the Rosson river before the start of discharge from the Nord Stream 2 facilities was not in compliance with some national standards (including sanitary standards). However, no epidemiologically significant non-compliance or toxicological manifestations were detected (see Chapter 3.3.1).

The riverbed sediments were classified as "clean" or "low contamination" in accordance with regional standards and no negative trends or pollutant accumulations were found relative to the baseline environmental survey results (see Chapter 3.3.1).

Monitoring of the river's biotic environment was in line with earlier baseline surveys and with the official statistical data from the literature and no objects of special protection were found during the hydrobiological and ichthyological surveys (see Chapters 3.3.2 and 3.3.3).

3.3.1 Water and sediment quality

Monitoring of water and sediment quality in the Rosson river was set up to gather baseline information for later assessment of potential impacts of water discharges from the Nord Stream 2 construction sites into the river (see Figure 10). In addition, the monitoring work also takes into consideration the natural seasonal dynamics of river bodies. All sampling took place prior to the start of the discharges.

METHODOLOGY

Monitoring of water and sediment quality was carried out at 2 sampling locations, during 3 sampling campaigns (end of July, mid-September and mid-November) in order to account for seasonal variability.

Water samples were taken from the top 0.3–0.5 m of the water column. The water samples were analysed by accredited laboratories and included chemical analysis, bacteriological, parasitological, toxicological and microbiological tests.

Sediment samples were taken from the top 0.02 m soil layer. The soil samples were analysed by accredited laboratories including chemical analysis tests.

RESULTS

According to the measurements, the depth of the Rosson river at the two monitoring points ranged from 3.2–3.9 m. The water quality was generally in compliance with the recommended values, with the exception of some pollutants (i.e. phenols, ammonium nitrogen, manganese, BOD5, COD, total iron, aluminium, molybdenum and oil products) for which low and medium[4] concentrations were recorded. The measured pollutant concentrations were generally similar or slightly lower than the baseline data collected in 2017: high concentrations of some pollutants (e.g. iron and manganese) are known to be characteristic of the area and not related to anthropogenic sources.

In general, the chemical indicators of water quality corresponded to the recommended values[5] with the exception of phenols (hydroxybenzene), COD, BOD5, total iron, and for the water colour test. No coliphages, helminths (ascaris, whipworm, toxocar, fasciol), oncosphere taeniidae and viable cysts of pathogenic intestinal protozoa were detected, also in compliance with the recommended values. However, from the bacteriological standpoint, the water quality was found to be unstable, with temporary exceedances of recommended values (for total coliform bacteria and thermotolerant coliform bacteria). According to the biotesting results, the water did not show a toxic reaction to the two applied test objects and were therefore categorised in the lowest categories of hazardous waste.

4 Reference to low and medium category as defined by the Water Quality Standards for Fisheries, approved by Order No. 552 of the Russian Ministry of Agriculture dated 13th December 2016.

5 SanPiN 2.1.5.980-00 (for recreational water use), public health standard GN 2.1.5.1315-03 "Maximum permissible concentrations (MPC) of chemicals in the water of water bodies for household, drinking and amenity water Use", public health standard GN 2.1.5.2280-07 "Maximum permissible concentrations (MPC) of chemicals in the water of water bodies for household, drinking, and amenity water use."

Metal concentrations in the normalised riverbed sediments generally corresponded to the lowest category (class 0), with the exception of Zinc in one sample in a slightly higher category (Class 1). Oil products were observed in low concentrations, where present. According to the monitoring results, the riverbed sediments are classed as follows: 0 („clean" sediments) or 1 („low contamination" sediments) per the Regional Standards /11/.

CONCLUSIONS

The water quality of the Rosson river prior to the start of discharges from the treatment plants was generally in line with the recommended values, however some critical levels were found, such as high concentrations of heavy metals and high bacteriological load. Riverbed sediments were generally considered clean or almost free of contaminants.

3.3.2 Hydrobiological environment

Monitoring of the hydrobiological environment of the Rosson river was set up to investigate the baseline conditions of phytoplankton, zooplankton, zoobenthos and macrophyte communities. The purpose of this monitoring is to gather baseline information for later assessment of potential impacts of water discharges from the Nord Stream 2 construction sites into the river. All sampling took place prior to the start of the discharges.

METHODOLOGY

A hydrobiological monitoring survey was carried out at the two sampling locations in mid-September 2018. In 2018 the data was sampled in a period comparable to that of the data collected in 2017.

Phytoplankton was collected through the trophogenic layer (i.e. the upper portion of the water body where photosynthesis occurs); samples were identified at the species or group level and biomass was measured.

Zooplankton was collected from the surface down to 1 m from the riverbed; samples were identified at the species level and biomass and abundance were measured.

Zoobenthos was collected from the river bed; samples were identified at the species level (except for nematodes) and biomass was measured.

Monitoring of Macrophyte communities took the form of a visual description of the communities within the monitored area and sampling at 4 sites (see Figure 10). Species projective cover and species average height were recorded by visual observation. Species identity and biomass were determined from the data collected at the sampling sites.

RESULTS

The composition of macrophyte communities in the study areas corresponded to the typical plant communities of the water area and shore line of the Rosson river. No rare or protected plant species listed in the Red Data Book of the Russian Federation and the Red Data Book of Leningrad Region were found.

Based on the phytoplankton biomass, the Rosson river is classed as a water body with oligotrophic conditions. The decrease in taxonomic diversity and quantitative indicators of phytoplankton in September 2018, compared with August 2017, is associated with the seasonal change in the temperature regime of the water body. The structure of the dominant microalgae complex has not changed and the development of the phytoplankton community is in line with the measured seasonality of the regional rivers.

The measured species diversity of the zooplankton community showed a natural decline in development and loss of thermophilic species due to the seasonal decrease in water temperature. The quantitative indicators of the zooplankton community were also in line with the literature data for similar river types.

The observed macrozoobenthos community was also typical for the region: according to the abundance of fodder benthos, the study area can be classified as low-nutritional for benthophagous fish. The presence in the benthos of organisms of various sizes and representatives of different taxonomic groups indicates a good quality food supply. The decrease in taxonomic diversity and quantitative indicators of macrozoobenthos in September 2018, compared with the data for August 2017, is due to the different characteristics of the monitored sites in the two years (e.g. differences in depth, proximity to the coast, nature of the ground), /11/.

CONCLUSIONS

The monitored hydrobiological environment appears to be closely aligned with the typical measurement data for rivers in Leningrad Region. Elevated levels of pollutants in water (see Chapter 3.2.1) are within natural variations for the region and do not appear to have major environmental impacts on the biotic life of the river.

3.3.3 Fish

Ichthyological surveys were conducted to investigate the baseline conditions of fish communities in the Rosson river. The purpose of this monitoring is to gather baseline information for later assessment of potential impacts of water discharges from the Nord Stream 2 construction sites into the river. All sampling took place prior to the start of the discharges.

METHODOLOGY

Ichthyological surveys at two sampling locations took place in mid-September 2018. Fish samples were collected with combined gill nets (from 12–60 mm) during 15-hour sampling campaigns. Species composition, abundance and biomass of the catches were calculated.

RESULTS

The observed species composition was in line with the summer-autumn species composition observed for the Luga and Narva rivers. The species distribution was mainly related to the natural feeding movements of the fish.

In 2018, the species observed in the study area were common roach *Rutilus rutilus*, white bream *Blicca bjoerkna*, European chub *Squalius cephalus*, European perch *Perca fluviatilis*, and ruffe *Gymnocephalus cernua*, with ruffe and white bream being the commonest and most numerous species of fish measured at the two sampling stations.

The distribution of fish of the species found and their numerical characteristics during the ichthyological monitoring were governed mainly by natural seasonal climatic changes and observed weather factors /11/.

CONCLUSIONS

Based on the monitoring results, in September 2018 the composition, structure and distribution of the fish population in the surveyed section of the Rosson river corresponded to the background characteristics of the ichthyocenosis of similar watercourses.

4 Monitoring prior to/during onshore construction in Germany

Since the landfall Germany and the PTA are entirely located inside a designated industrial park (see Figure 11), monitoring requirements for onshore construction in Germany are characterised as low complexity compared with the requirements for the landfall Russia.

Figure 11. *Pig Trap Area (PTA) Germany (red box) in the industrial park south of Lubmin industrial harbour in July 2018. The vessel in the foreground shows the location of the offshore exit pit of the shore crossing microtunnel.*

All onshore monitoring activities in Germany were confined to the PTA and its immediate surroundings (see Figure 12).

Continuous environmental construction supervision ensured the implementation and maintenance of various mitigation measures:

- Control of the spatial extension of site preparation works (habitat protection measure);
- Inspection of tree cavities prior to logging and installation of bird and bat boxes in the remaining coastal forest strip (species protection measures);
- Installation of biotope and reptile/amphibian protection fences (species protection measure);
- Implementation of light mitigation measures (species protection);
- Monitoring of airborne noise (human protection);
- Monitoring of groundwater pumping and discharge (water and habitat protection).

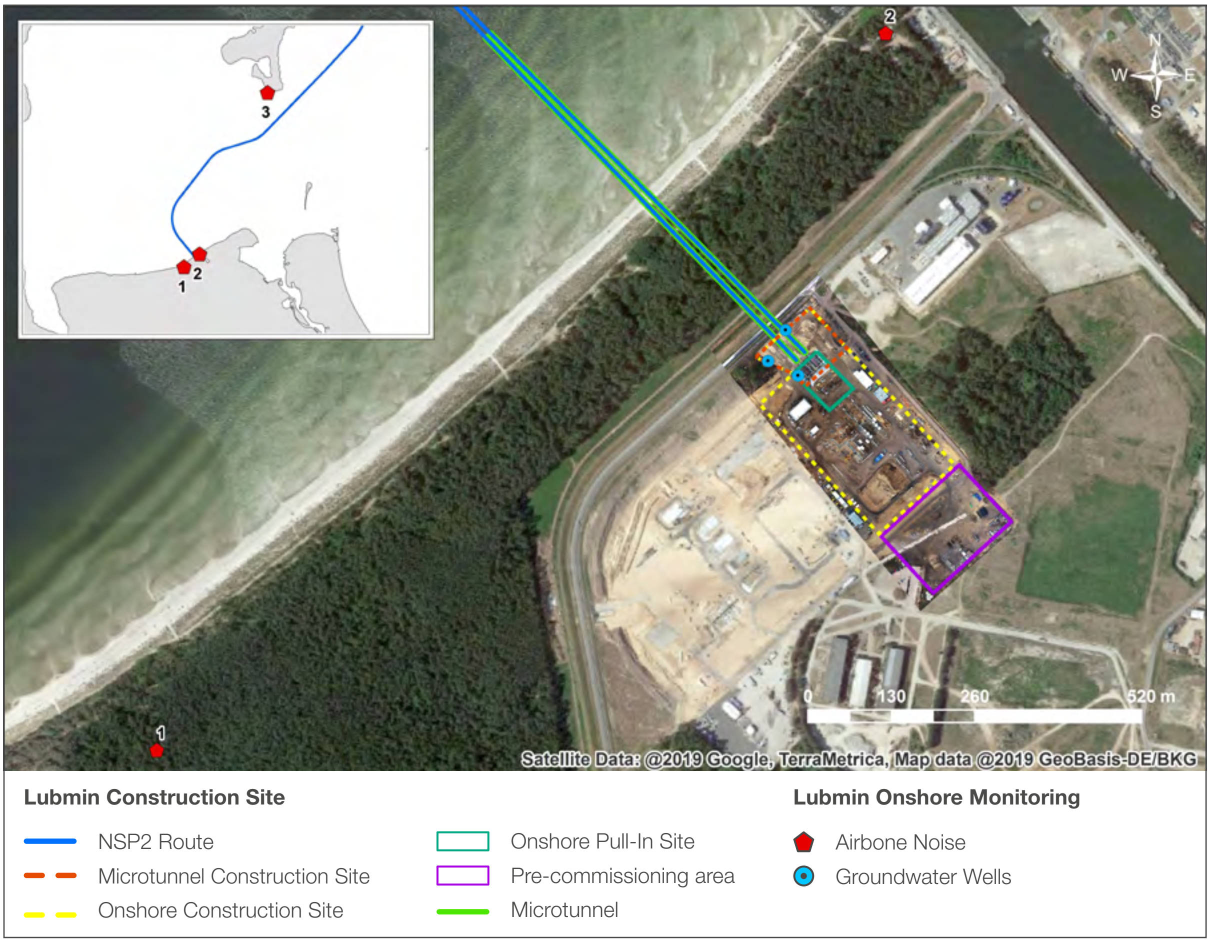


Figure 12. *Environmental monitoring associated with onshore construction in Germany.*

The results of monitoring of construction activities at the German landfall in 2018 showed that no impact on groundwater occurred (see Chapter 4.1.1) and airborne noise levels (see Chapter 4.1.2) were in compliance with the permit provisions.

4.1 Monitoring of abiotic environment

4.1.1 Ground water

METHODOLOGY

Groundwater monitoring at landfall Germany consisted of two elements:

a) Recording of pumping volume

b) Installation/operation of three monitoring wells, one upstream (reference) and two in the vicinity of the tunnelling entrance pit (impact area)

RESULTS AND CONCLUSIONS

The total groundwater volume pumped at landfall Germany in 2018 was 63,000 m³. This was far less than that applied for/permitted: 180,000 m³ /13/. The low pumping volume resulted from the unusually dry weather in Central Europe in 2018. The nearby town of Greifswald received rainfall in 2018 amounting to only 75 % of the long-term average.

The ground water level at the reference site decreased from -4 to -5 m between April and December 2018. The groundwater level at the construction site decreased by about 10 cm as a result of groundwater pumping. The groundwater level at the construction site before and after pumping was -6 m. Hence, the construction-related relative change was only about 1–2 % /14/.

The pumped groundwater was discharged into the nearby industrial harbour of Lubmin after passing through a sedimentation chamber. The low groundwater volume pumped over a period of 9 months did not affect the salinity of the harbour waters in a detectable manner. Any sewage generated at the construction site was discharged to the nearby sewage treatment plant of Lubmin.

4.1.2 Airborne noise

METHODOLOGY

The permit conditions of the German planning approval defined a number of requirements regarding airborne noise emissions. Emissions emanating from the on- and offshore construction sites should not make any relevant contribution to the immission guide values set out in the German General Administrative Regulation for Protection against Construction Noise. The following immission guide values must not be exceeded at the relevant immission sites:

> Industrial areas	day/night 70 dB(A)
> Commercial areas	day 65 dB(A) night 50 dB(A
> Special area (Marina Lubmin)	day 65 dB(A night 50 dB(a)
> General residential areas	day 55 dB(A) night 40 dB(A)
> Exclusive residential areas	day 50 dB(A) night 35 dB(A)

Airborne noise monitoring was implemented at the beginning of the construction works according to German design criteria for construction noise measurements. Permanent sound pressure level recordings were taken throughout the year at three sites: Lubmin village, Lubmin marina (both sites are close to the Pig Trap Area and offshore route/tunnel pit), Thiessow village (Rügen island, close to the offshore dredging and pipelay works, see Figure 11).

RESULTS AND CONCLUSIONS

No sonic impact from construction noise could be detected at any of the three monitoring sites throughout the course of 2018 /15/.

5 Monitoring prior to offshore construction

The purpose of monitoring before the start of construction was to collect baseline information for use in assessing the magnitude of potential changes caused by the project. It will also allow regulatory bodies to evaluate compliance with the relevant permit provisions. Most of the baseline studies along the route were performed during the EIA phase and thus were not included in the monitoring programmes. However, a number of parameters were monitored before construction to collect more information or update existing baseline data. This chapter describes only the baseline information acquired during 2018 as part of approved monitoring programmes. Monitoring prior to construction focussed on the physico-chemical, biological and socio-economic environments in Russia, Finland, Sweden and Germany.

Table 7. *Overview of monitored parameters before construction.*

Parameter	Turbidity and water quality	Seabed sediments	Ecotoxicological effects	Plankton and benthos	Fish	Marine mammals	Cultural heritage	Commercial fishery
2018	R, F, G	R, F, G	S	R	R	R, G	F, S	S

R-Russia; F-Finland; S-Sweden; G-Germany

5.1 Monitoring of abiotic environment

5.1.1 Turbidity and water quality

Monitoring of turbidity and water quality prior to the start of construction activities took place in Russia, Finland and Germany in 2018. Monitoring in Russia and Germany focused on both offshore and near-shore water conditions. Monitoring in Finland focused on water conditions in the locations of munitions clearance and rock placement. Monitoring results for Russia are shown in this Chapter while monitoring results for Finland are shown in Chapters 6.1.2 and 6.5.1 and monitoring results for Germany are shown in Chapter 6.3.3.

The purpose of this monitoring work was to estimate the natural variability of currents, temperature, turbidity and pollutant concentrations before the start of construction. The collected baseline information will be used later to assess potential impacts from construction activities and from the presence of the pipeline on water quality.

METHODOLOGY

Turbidity monitoring was conducted at two near-shore monitoring stations in October 2018. Current speed and direction, temperature and turbidity data was acquired using an Automatic Buoy Station (ABS). Water quality monitoring took place at 11 near-shore stations and at 12 offshore stations in 2018. Water samples were analysed by an accredited laboratory for common physico-chemical properties of the water. A total of 22 near-shore samples and 36 offshore samples were analysed (see Figure 13). In 2018, dredging took place in the study area and the same monitoring locations were used to monitor water quality during and after dredging (see Chapter 6.2.1) and seabed sediment during and after dredging (see Chapter 6.2.2).

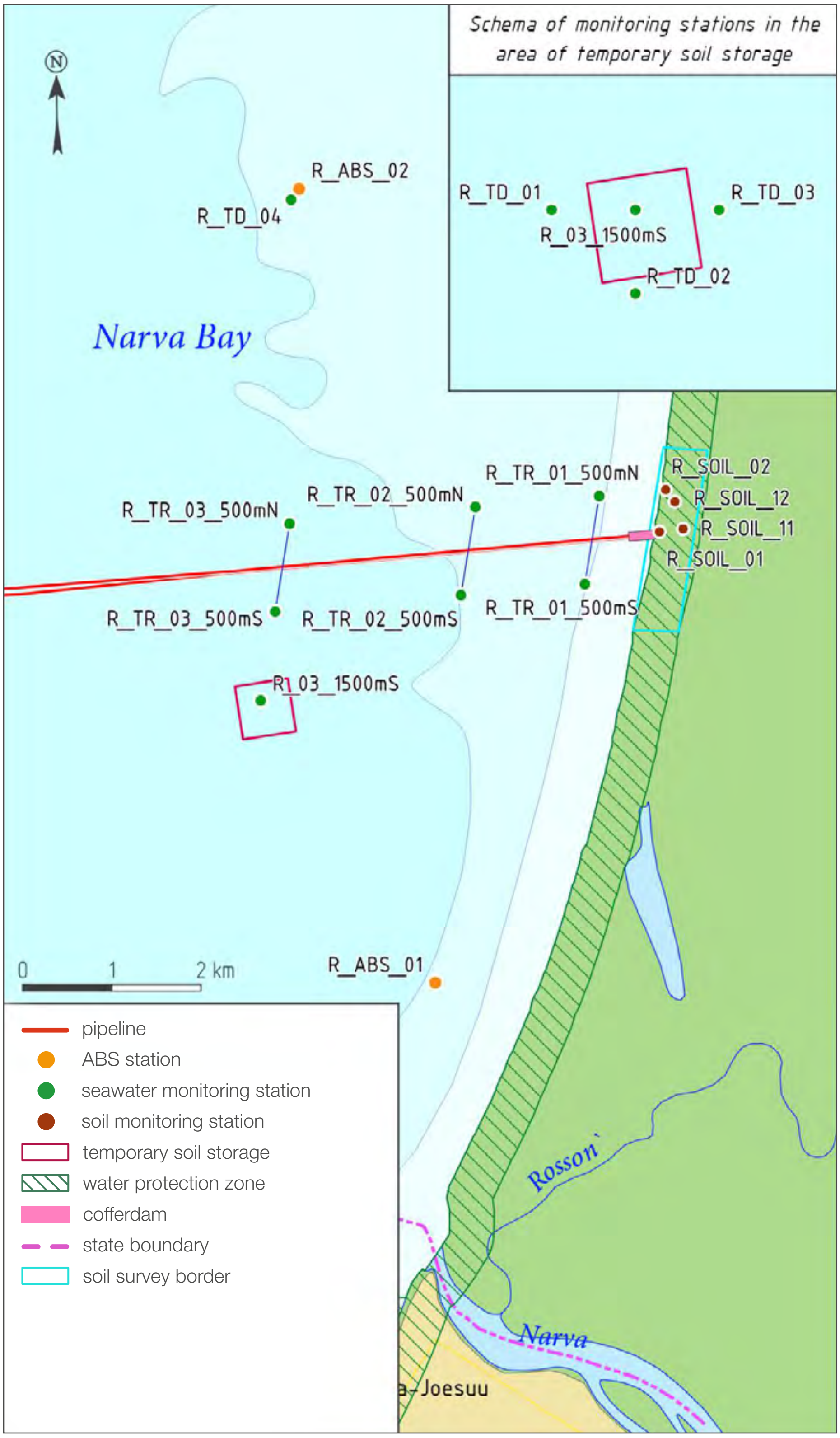


Figure 13. *Monitoring locations set up to monitor environmental conditions prior to the start of construction activities in Russia. The same monitoring locations were also used to monitor environmental conditions (water quality and seabed sediment quality) during and after dredging.*

RESULTS

The monitoring results showed that the currents in the area of interest did not exceed 47 cm/s in summer and 40 cm/s in autumn. These results are in line with seasonal averages reported in the literature. The prevailing current directions are determined by the features of the bottom topography.

On the bottom layers of the shallow-water stations, the maximum turbidity value was 26.4 FTU in the summer period and 67.2 FTU in the autumn, and in the middle horizon the turbidity did not exceed 12.6 FTU[6]. Turbidity in the near-shore area and in the region of Maly Tyuters island was estimated to range between 0–15 FTU, with turbidity peaks up to 20–35 FTU during storm events. Results from water quality monitoring in the nearshore sections showed that the concentration of oil products and suspended solids was in some cases above the Maximum Permissible Concentration (MPC) for water bodies of fishery value (MPC for oil products exceeded in half the samples by 1.0 to 1.9 times and a single exceedance of MPC for suspended solids by 1.03 times). However, since the standard indicator for the content of suspended solids applies to the continental shelf zone of seas with depths greater than 8 m, high concentrations of suspended matter (10.0–12.3 mg/dm^3) recorded at coastal shallow stations with a depth of less than 5 m are not considered an exceedance of the MPC limit. In addition, none of the above mentioned exceedances were recorded in any of the samples recorded a month later during dredging works (see Chapter 6.2.1).

In the offshore section, the concentration of oil products, benzo(a)pyrene, arsenic, and most heavy metals (manganese, zinc, cadmium, chromium, cobalt, nickel, lead, and mercury) were either below the detection limit or present only in trace amounts. At several offshore stations, oxygen deficiency areas were observed in the bottom layer, where its content was below the MPC. For BOD5 and BOD20 indicators[7], a single exceedance of the water quality limit for fisheries in the surface horizon was observed at the station located at KP 43.8 (in the middle of the deep-water section) at a depth of 35 m /16/.

CONCLUSIONS

Measured turbidity levels before the start of construction were in line with expected seasonal values. Concentrations of pollutants were in some cases above the MPC for water bodies of fishery value, however these observations appeared to be related to temporary events since they were not recorded again during Nord Stream 2 construction activities. In the offshore section no pollutants were detected, however some level of oxygen deficiency was observed.

5.1.2 Seabed sediment

Monitoring of seabed sediments prior to the start of construction activities was conducted in Russia, Finland and Germany in 2018. Monitoring in Russia and Germany focused on both the offshore and/or nearshore conditions of the seabed sediments. Monitoring in Finland focused on the condition of seabed sediments at locations of munitions clearance. Monitoring results for Russia are given in this chapter while monitoring results for Finland are given in Chapter 6.1.4, and monitoring results for Germany are given in Chapter 6.3.2.

6 FNU stands for Formazin Nephelometric Units which is a widely used measurement unit for turbidity. FNU is also called FTU (Formazin Turbidity Units) depending on the calibration of the instrument. The concentration of suspended particles in a sample of water is measured as the incident light scattered at right angles from the sample. The extent of scattering when light is passed through an intermediate process stream is related to the level of suspended particulates in the sample. In Russia, the conversion of turbidity expressed in FTU to mg/l was done by two methods: 1) 1.4 mg/l of kaolin corresponds to 2.6 FTU or 1 FTU corresponds to 0.58 mg/l (Russian GOST Standard); 2) according to the linear formula: Turbidity (mg/l) = 0.9453 × Turbidity (FTU) +6.4781 (based on data from EOMAP) /17/

7 BOD Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period (5 days for BOD5 and 20 or more days for BOD20). BOD is used as a surrogate for the degree of organic pollution of water.

The purpose of the monitoring was to collect baseline information for later assessment of potential impacts from construction activities and from the presence of the pipeline on seabed sediments.

METHODOLOGY

Sediment sampling took place in October 2018 at 11 stations located in Narva Bay (see Figure 13). A total of 11 samples were collected (one sediment sample per location). Sediment samples were taken from the top sediment layer. Seabed sediment samples were analysed by laboratories accredited for chemical and analytical testing. Comparison between the monitoring results from earlier baseline studies/literature and the data collected in 2018 was used to calculate the total pollution index. The total pollution index[8] compares pollution levels over time and determines whether pollutants are accumulating in the soil (higher index) or decreasing (lower index). The value of the total pollution index indicates whether special soil management measures need to be put in place due to contamination of the soil.

RESULTS

Generally low concentrations of pollutants were found during the 2018 sampling campaign. Pollution indices were calculated by comparing the 2018 results with 2015–2016 results reflected in the baseline data presented in the EIA and in the Espoo report, and with the 1996 Regional Standard /18/ on seabed sediments. The total pollution indices calculated on the basis of the 2015–2016 baseline studies indicated that seabed sediments in 2018 are in “acceptable” condition. The only exception is the seabed sediments at the station located 500 m south of the pipeline, which were in a “moderately dangerous” pollution category (classification criteria of SanPiN 2.1.7.1287-03).

Total pollution indices calculated on the basis of the 1996 Regional Standard (taking into account the adjustment for standard sediments) also confirms the absence of contamination of the seabed soils. The seabed soils were assessed as category 0 (“clean”). However, the sediment monitoring results showed higher concentrations of pollutants in the offshore sections (water depth >60 m) compared to the results presented in the baseline data and Espoo report. This is explained by the fact that the pollutants are bound to fine sediment particles (i.e. silt/clay soil type) which are common in deep waters. Hence, the offshore areas have shown higher pollutant accumulations over time compared to the 1996 Regional Standards (e.g. copper, zinc and lead content in the offshore area exceeded the regional rate by 1.13–1.46 times).

The total pollution index increased over time, indicating that there is an accumulation of pollutants in the soil. However, pollutant concentrations remained low and the total pollution index did not point to the need for any special soil management measures /16/.

CONCLUSIONS

The seabed sediments showed generally low concentrations of pollutants although, compared to previous studies, the pollutant concentration appeared to be increasing over time in particular in the offshore areas. The increases are marginal however, and mostly related to the natural dynamics of deep waters. No special management of the soil is required.

8 The total pollution index is denoted Z_c.

5.2 Monitoring of the biotic environment

5.2.1 Ecotoxicological effects

The monitoring of ecotoxicological effects was part of the environmental monitoring programme in Sweden to determine whether the construction works (in particular post-lay trenching) could cause a release of anthropogenic and naturally occurring toxic compounds from the suspended sediments. Such compounds could have detrimental effects on the local mussel communities located in the Hoburgs bank and Norra Midsjöbanken and consequently on the birds that feed on them.

The objective is that the monitoring results will serve as a comparison with the data provided in the Swedish Environmental Study (ES) and provide an answer to the concerns raised by the Swedish Environmental Protection Agency (EPA) and other stakeholders regarding environmental effects from a potential increased concentration of pollutants.

METHODOLOGY

Monitoring of ecotoxicological effects was developed in agreement with the Swedish Environmental authorities (EPA and others) as a 3-stage monitoring programme:

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 the trenching region

The results of each previous stage determines whether or not the monitoring programme should proceed to the next stage.

Sediment sampling and analysis took place on 24th November 2017 at 6 locations. The sampling locations were located outside Hoburgs bank and Norra Midsjöbanken within two planned trenching sections at different depths. Soil samples were analysed by an accredited laboratory for pollutants (metals and organic substances), dry matter, total organic carbon, and loss on ignition.

Based on the results of sediment sampling (no sign of any significant anthropogenic contamination), it was agreed with the authority to not carry out stages 2 and 3.

RESULTS

Most samples were within the guideline values for class 1 (i.e. “very low”) according to the EPA and SwAM classifications /19-20/. The only exception to this was for copper (Cu) where many of the samples had a “natural” concentration slightly above the reference value for class 1, and where the mean concentration for sediment for the planned post-lay trenching section was assigned to class 2 (i.e. “low”). As the copper content is not the result of anthropogenic contamination, and as it is assessed that copper in general is heavily bound to inorganic mineral structures in the glacial till, the amount of dissolved and bioavailable copper from the trenching activities was assessed to be low. Also taking into account the amount of sediment to be handled, the very short duration that the sediment will be in suspension, and the low increased concentration of copper in the sediment, it was assessed that there will be no risk of impacts to marine fauna. The results were also compared to effect-based limit values prepared by the Swedish Agency for Marine and Water Management for lead, cadmium, anthracene, fluorine, TBT (for 2013) and copper (for 2018), /21/.

CONCLUSIONS

The results were presented to the environmental authorities and it was concluded that there is no sign of any significant anthropogenic contamination in the areas where trenching is planned to be performed. There is therefore no risk that polluted sediments will spread to the sensitive mussel banks and it was agreed that the ecotoxicological monitoring did not have to proceed to Stage 2 (Leaching tests on the sediment samples).

5.2.2 Plankton and benthos

Monitoring of plankton and benthos communities took place in Russia prior to the start of the construction activities in 2018. The objective of the monitoring was to evaluate the general condition of the communities in order to later assess potential impacts on marine life related to the installation of the pipeline.

METHODOLOGY

Hydrobiological monitoring in the near-shore section was performed on 13th June 2018 at six locations (1500 m north and south of the pipeline) on profiles crossing the pipeline route. Hydrobiological monitoring provided an assessment of the following communities: bacterioplankton, phytoplankton, zooplankton and benthos. The hydrobiological sampling was accompanied by measurements of hydrological parameters (salinity, temperature) using an oceanological probe.

RESULTS

Bacterioplankton

The monitoring results show that the total bacterioplankton biomass was consistent with similar indicators for this period of the year in the Baltic Sea. The average number of saprotrophs over the entire study area was relatively low for the coastal area of the sea (640 cells/ml of water) and no patterns in the distribution of microbiological characteristics were noted.

Bacterial plankton in Narva Bay was represented mainly by rod-shaped and coccal cell forms. The structure of the plankton bacteriocenosis was dominated by cocci, which constitute an average of 61.7 % of the total bacterial plankton /16/.

Phytoplankton

Phytoplankton in the brackish coastal waters of Narva Bay consisted of 89 taxa in 8 systematic groups of microalgae, with an average number of phytoplankton of 7,246 thousand cells/l. Cyanobacteria displayed the highest taxonomic diversity (34 taxa), followed by diatoms (23 taxa) and green algae (17 taxa). The observed plankton species were typical for the early summer season, with a predominance of freshwater species and ubiquitous species, followed by brackish-water and marine species. The thermohaline regime affected the taxonomic structure of the communities showing increased taxonomic diversity with increasing temperature and decreasing salinity (28 taxa at 14.3 °C and salinity of 3.1 ‰, and 42 taxa at 16.5 °C and salinity of 1.9 ‰). The majority of the observed phytoplankton belonged to the cyanobacteria group (82 % of the observations), of which species of the order Chroococcales were included in the dominant complex. However, the biomass was mainly determined by dinoflagellates (53 %), due to the vegetation of the thermophilic eutrophic species *Oblea rotunda* that was not previously noted. The phytoplankton was in a functionally active state: the concentration of the main photosynthetic pigment of phytoplankton (chlorophyll „a“) in the entire study area of Narva Bay was evenly distributed with an average of 3.20 µg/l /16/.

Zooplankton
A total of 34 species (taxa) of zooplankton belonging to three main groups of the community (Rotifers–15, Cladocera–8, Copepoda–10) were recorded in the entire water area surveyed in Narva Bay. In terms of diversity and number of individuals counted, the community was dominated by eurythermic species of rotifers (average 63.95 %) and cladocerans (21.98 %), occurring in a wide range of water temperatures. In terms of biomass, the community was dominated by cladocerans (72.54 %) and copepods (20.72 %), corresponding to the early summer season. The species structure of the community was formed by euryhaline (gen. *Keratella*) and sea rotifers: *Synchaeta monopus, S. baltica, S. triophthalma*, brackish cladocerans – *Podon polyphemoides, Evadne nordmanni*, single *Cercopagis pengoi*, and also copepods – *Eurytemora hirundoides*, juveniles of *Acartia, Microsetella norvegica, Tisbe cf. furcata*. The freshwater complex included species from the gen. *Daphnia, Bosmina* (Cladocera) as well *Mesocyclops, Termocyclops*, juveniles of gen. *Cyclops* and *Eudiaptomus* (Copepoda). Zooplankton abundance in the coastal (shallow) water area of Narva Bay ranged from 41.53 to 167.05 thousand ind./m³, coupled with biomass ranging from 0.234 to 0.980 g/m³.

The invasive species *Tisbe furcata* was previously encountered in the study area in 2016 and was found again during this study in Luga Bay and the eastern part of the Gulf of Finland. According to the conclusion of the specialised scientific institute (ZIN RAS) there are no other reports on the occurrence of this species in the Gulf of Finland and other brackish waters of the Baltic Sea. The identification of this invasive species is important for the ecological safety of the region and it is recommended that future monitoring studies carried out in Narva Bay should pay special attention to the presence of this invasive species /16/.

Benthos
The diversity of benthic communities was rather low, with a total of 20 benthos taxa observed in the study area. Oligochaeta (9 taxa) and crustaceans (4 taxa) displayed the highest diversity. Benthos biomass was formed by different groups in different parts of the study area: the northern stations were dominated by polychaetes while the southern stations were dominated by oligochaetes *Lumbricillus* sp., and by amphipods *Corophium volutator* and clams.

All taxa encountered are typical for brackish or euryhaline species. The non-indigenous polychaeta *Marenzelleria* sp. were observed with the highest frequency (observed in all stations in almost all samples), followed by the nemertines *Cyanophthalma obscura* which was observed in more than half of all samples. The observed composition of benthic communities is usual for the brackish shallow coastal waters of the eastern part of the Gulf of Finland. The abundance and biomass of benthic communities in Narva Bay averaged 2055 ind./m² and 9.088 g/m².

Low benthic diversity has already been described for the near-shore section in the Espoo report: the presence of unfavourable sand substrate and the active wave regime were cited as the main causes of the low benthic diversity. The absence of significant interannual changes and the wide representation of various groups of benthos in the seabed communities suggests that no significant negative anthropogenic impact currently exists in the water area and benthos are at a stable level above the average for the last 4 years /16/.

CONCLUSION
The observed plankton and benthic communities are generally in line with the literature data for the Baltic Sea and for the monitoring season (early summer). However, an invasive zooplankton species has been observed for the first time in 2016 and was found again during the monitoring work prior to the start of construction activities in 2018.

5.2.3 Fish

Monitoring of fish communities took place in Russia prior to the start of construction activities in 2018. Ichthyological monitoring in the near-shore section included studies of ichthyoplankton and ichthyofauna: the monitoring objective was to evaluate the general condition of communities in order to later assess potential impacts to marine life related to the installation of the pipeline.

METHODOLOGY

Ichthyoplankton monitoring was carried out at two stations located to the north of the pipeline (not along the pipeline route) at the edge of the spawning grounds, approximately 5 km from the shore. Ichthyofauna monitoring was performed at four stations, two of which are located on a profile crossing the pipeline route approximately 2 km from the shore, and two coincided with the monitoring of ichthyoplankton. A total of 40 net fishing sessions were carried out in June 2018.

RESULTS

Ichthyofauna in the study area was represented by 16 fish species belonging to 8 families: Clupeidae, Coregonidae, Osmeridae, Cyprinidae, Percidae, Gobiidae, Zoarcidae and Pleuronectidae. Most of the fish species caught in the survey are typical for the Gulf of Finland, with the exception of the round goby *Neogobius melanostomus*, which is an invader from the southern seas (Black, Azov, Caspian).

The ichthyocenosis was mainly represented by marine species (round goby *Neogobius melanostomus*, Baltic herring *Clupea harengus*, European sprat *Sprattus sprattus*, European eelpout *Zoarces viviparus*) and to a lesser extent by freshwater species (Eurasian ruffe *Gymnocephalus cernua*, common roach *Rutilus rutilus* and European perch). The most common anadromous species was the European smelt *Osmerus eperlanus* followed by the vimba bream *Vimba vimba*. However, the observed species composition differed significantly at the different stations, since the spatial distribution of fish is largely determined by salinity and depth (see Figure 14).

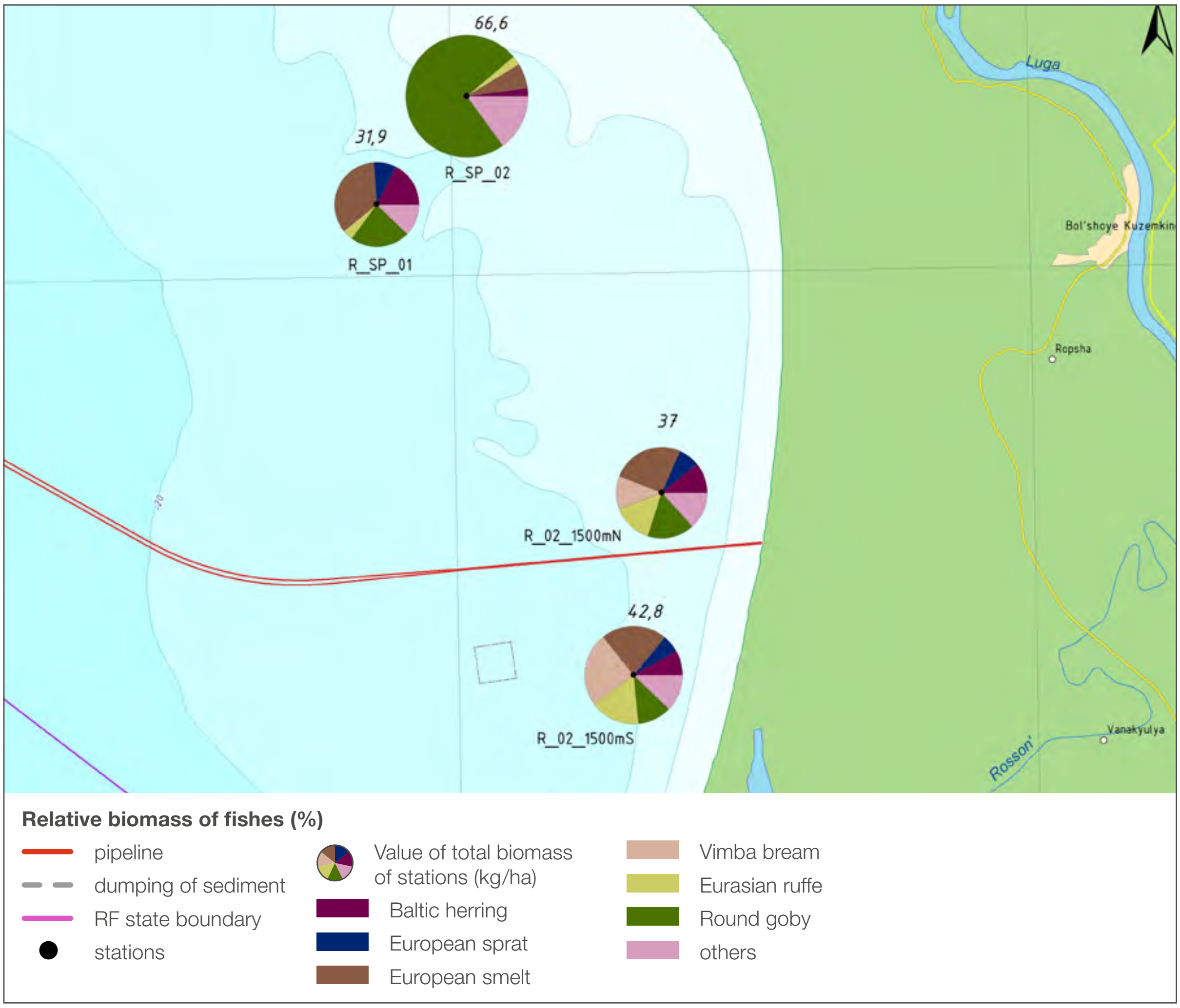


Figure 14. *Fish biomass (kg/ha) in Narva Bay in June 2018.*

The distribution density of the fish population in the near-shore section of Narva Bay was high – from 1.3 to 2.1 thousand ind./ha, and the biomass was 32–67 kg/ha. The highest number of individuals and biomass of fish was formed by anadromous species and marine species, which made up 92.5 % of the number and 82.3 % of biomass.

The monitoring results from August 2016 showed comparable biomass to that observed in 2018 (23–47 kg/ha) but with almost 3 times fewer individuals counted (0.5–0.6 thousand ind./ha). This is due to the fact that in 2018 the dominant species were characterised by relatively low body weight (European smelt, goby, Baltic herring, European sprat).

The structural indices of species diversity indicated stability of the ichthyocenosis at the stations closest to the shore while some level of instability was found at the deeper-water stations. This was due to the significant accumulation of round goby that came to spawn in the deep water areas, causing temporary instability of the local fish community.

As part of the monitoring work, fish larvae were also sampled to assess the efficiency of fish spawning in this section of the Narva Bay. At the monitoring stations closest to the spawning grounds, only Baltic herring and black goby *Gobius niger* larvae were recorded. The distribution density of the larvae measured in June 2018 indicated a rather low efficiency of fish spawning in this area (2018 measured distribution

density corresponded to the minimum values obtained in June 2017, which is an order of magnitude lower than the maximum density recorded the previous year). The condition was potentially exacerbated by the action of wind and currents, which spread the larvae from the spawning grounds throughout the entire water body. It should be noted that the lack of roe and larvae of the round goby which was caught in very large numbers, is due to the particular features of the breeding cycle of this species, with larvae that live in close association with the seabed /17/.

CONCLUSION

The amount of ichthyological material collected allowed us to estimate the size-age structure of the most abundant species that inhabit the water area of Narva Bay in early summer.

5.2.4 Marine mammals

Marine mammals were monitored in Russia by means of aerial surveys and telemetry studies of the Baltic ringed seal population. These studies were not included in the Russian monitoring programmes and are therefore only briefly mentioned in this chapter. Monitoring of marine mammals in Germany is discussed in Chapter 6.3.5.

An aerial survey of Baltic ringed seals was carried out between 14th and 18th April 2018, when seals were expected to be visible on the open ice in the eastern part of the Gulf of Finland. A total of over 900 aerial images were used in the study. The number of ringed seals was counted and used to estimate the expected population size. As a result of the aerial survey the estimated abundance of ringed seals in the Russian sea area was estimated at between 89 and 101 individuals. This is higher than the result from 2012 when the population was estimated at 72–94 individuals. In 2010 the figure was four times lower at about 16–34 ringed seals. Supplementary surveys in Finland and Estonia show that the core distribution of ringed seals is in the Russian waters of the Gulf of Finland due to the limited ice cover in Finnish and Estonian waters /22/.

Two telemetry studies were carried out to monitor the Baltic ringed seal population: one was carried out during 2017–2018 and the other during 2018–2019. Between June and September 2017, 9 seals were captured and tagged in Russian waters. Telemetry data were recorded for a maximum of approximately 6 months, after which the tag fell off due to the moult. The core distribution areas were found to be the reef/islands near Moshchny – Seskar – Kurgalsky, with a secondary distribution area near the island of Maly Tyuters. The main conclusion is that the recorded seal behaviour matches the findings of earlier telemetry studies in the Gulf of Finland. However, the habitat use pattern showed a further reduction in the home range of the species, including the abandonment of some areas in Narva Bay and Koporskaya Bay. The study highlighted the importance of Kurgalsky and the adjacent archipelago area as a core distribution region /23/.

In 2018 two adult female seals were captured (less than the planned 10 individuals, likely due to unfavourable weather conditions for capture) and were monitored for 5 and just under 6 months respectively. The most significant finding was that the seals repeatedly used the central part of the Gulf as foraging grounds in summer. These areas included Estonian and Finnish sea areas where ringed seals used to be common but where they have not been observed in recent times. The monitored seals demonstrated a strong association between the foraging areas and sea floor topography, showing a preference for sloping areas and shoals: this additional knowledge can be used as a valuable tool to assess habitat availability in the Gulf of Finland (results not yet published).

5.3 Monitoring of the Socio-economic environment

5.3.1 Cultural heritage

Monitoring of cultural heritage was carried out in Finland and Sweden based on the results of cultural heritage surveys, as defined in the respective monitoring programmes. Cultural heritage in Germany was monitored prior to construction, however not as part of the monitoring programme (see below). No cultural heritage objects are present in the offshore pipelay corridor in Russia and thus monitoring is focused on archaeological supervision during onshore construction (see Chapter 3.1.6).

The purpose of cultural heritage monitoring is to document the condition of the cultural heritage objects (situated close to the pipeline route) before construction and to verify the condition of these objects after construction.

Mitigation measures to preserve the condition of cultural heritage include a 50 m protection zone enforced during all construction activities. Exceptions are defined and agreed with the competent authorities, for example one object in the Finnish EEZ (see below object S-R09-09806) which is crossed by the pipeline route.

All potential cultural heritage sites in proximity to the pipeline route were surveyed during planning of the pipeline route. The survey material was evaluated by expert marine archaeologists, who identified 2 objects in Finland and 7 potential objects in Sweden. The identified objects included in the respective monitoring programmes were to be surveyed prior to the start of construction activities. It should be noted that the Finnish cultural heritage objects visually inspected and evaluated during the permitting phase, and hence only the objects with confirmed cultural heritage value, were included in the monitoring plan. In Sweden, the monitoring scope was extended to include visual inspection, identification and assessment of the cultural heritage value of the objects.

Based on the monitoring results, it is expected that no impacts on cultural heritage objects occurred in 2018. However, these findings will be confirmed by the post-lay surveys to be conducted in 2019.

METHODOLOGY

Thorough pre-lay surveys were carried out in Finland and Sweden. Monitoring in Finland took place in May, prior to the start of munitions clearance. Monitoring in Sweden took place during the winter of 2018–2019, prior to pipelay at these locations. The pre-lay surveys consisted of Multibeam Echo Sounder sweeps and visual inspection of the objects by ROV (Remotely Operated Vehicle).

RESULTS

The two cultural heritage objects in Finland are a cannon barge and an anti-submarine net. Of the 7 potential targets in Sweden, 2 were subsequently identified as boulders, 3 (described below) were identified as wrecks older than 1850 and 2 were identified as wrecks younger than 1850.

The results of the monitoring of objects of cultural heritage value are presented below:

Cannon barge wreck S-R05-7978 (Finland)

The wreck consists of the remains of a cannon barge with numerous iron cannons (at least 20) which can be seen on each side of the vessel. The cannons are placed side by side along the vessel with alternate positioning of the rear and front ends. Among the iron cannons there is also a well-preserved bronze mortar (see Figure 15). The wreck is considered to be of cultural and historical interest. The cannon barge could provide new insight and information about warfare, engineering and everyday life during the second half of the 18th century in the Baltic /24/.

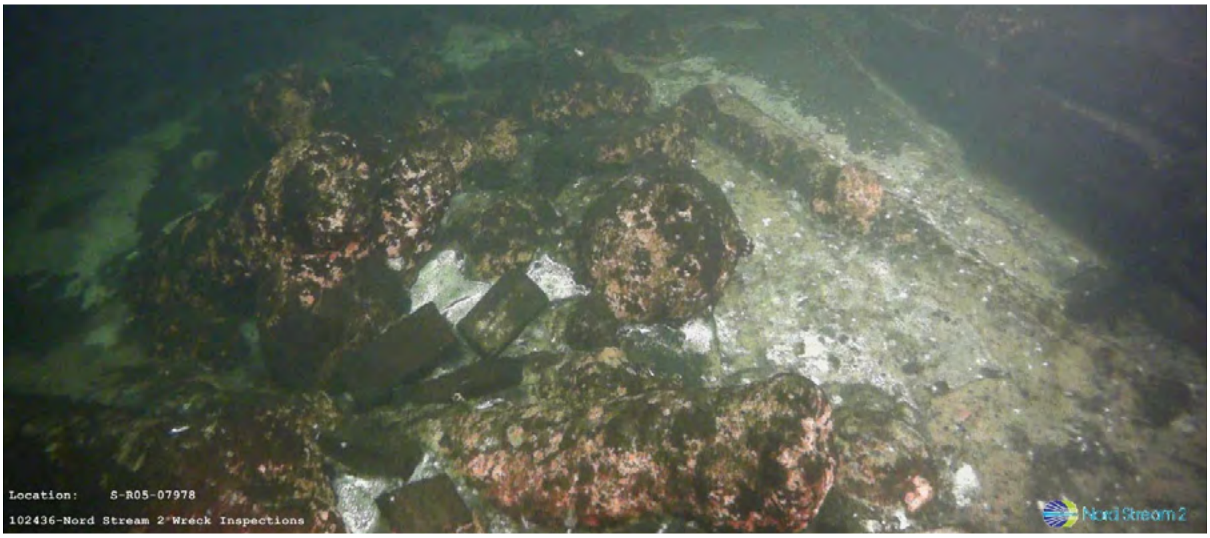


Figure 15. *Wreck mid ship, cannons, cannon balls and debris.*

Anti-submarine net S-R09-09806 (Finland)

The World War II anti-submarine net was laid along a rock outcrop, which dominates the surroundings. The eastern margin of this outcrop forms a steep scarp face with a 33 % gradient. Water depth ranges from 58 m on the plain to 53 m at the top of the rock outcrop.

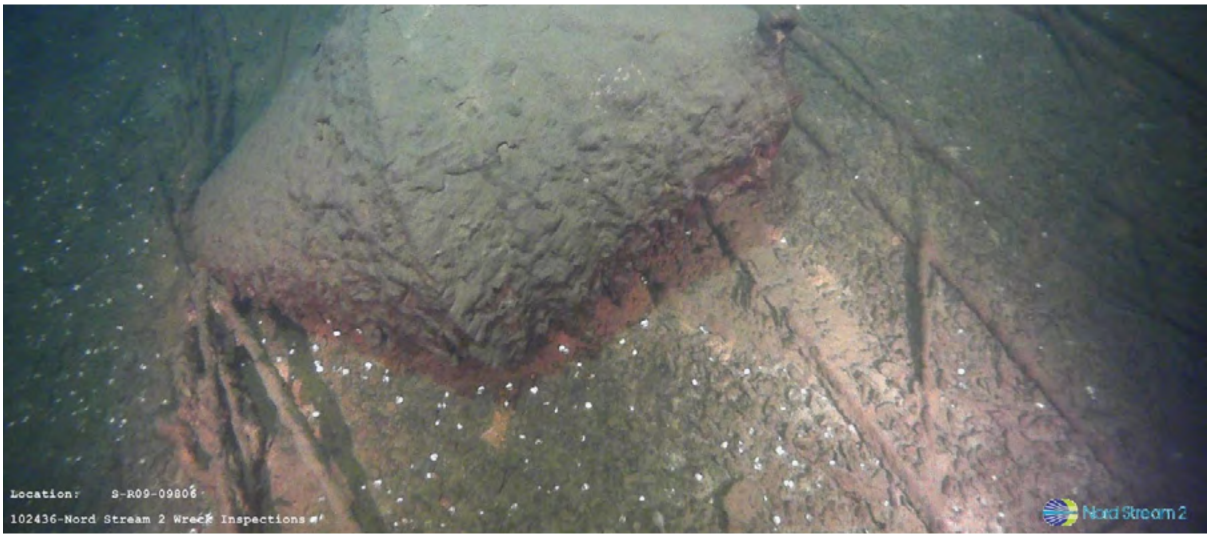


Figure 16. *Buoy attached to submarine net/wires.*

Only the associated floats/buoys and the cable were seen during the survey performed in 2016 (see Figure 16). No munitions or other debris items were visible. Based on the updated set of digital video/photo images taken following the munitions clearance works in 2018, it appears that no changes have occurred at the site since 2016 /24/.

Wooden ship wreck S-R17-4285 (Sweden)

The object is a wooden wreck that is 17 m long and 5 m wide. The construction, anchor, ships boat, capstan, and other details indicate a 17^{th} or an 18^{th} century construction date. 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 another stands on the seafloor just off the bow (see Figure 17). A "ship's boat" lies on deck on the port side. The ships boat has a flat bottom and the sides are clinker built /25/.

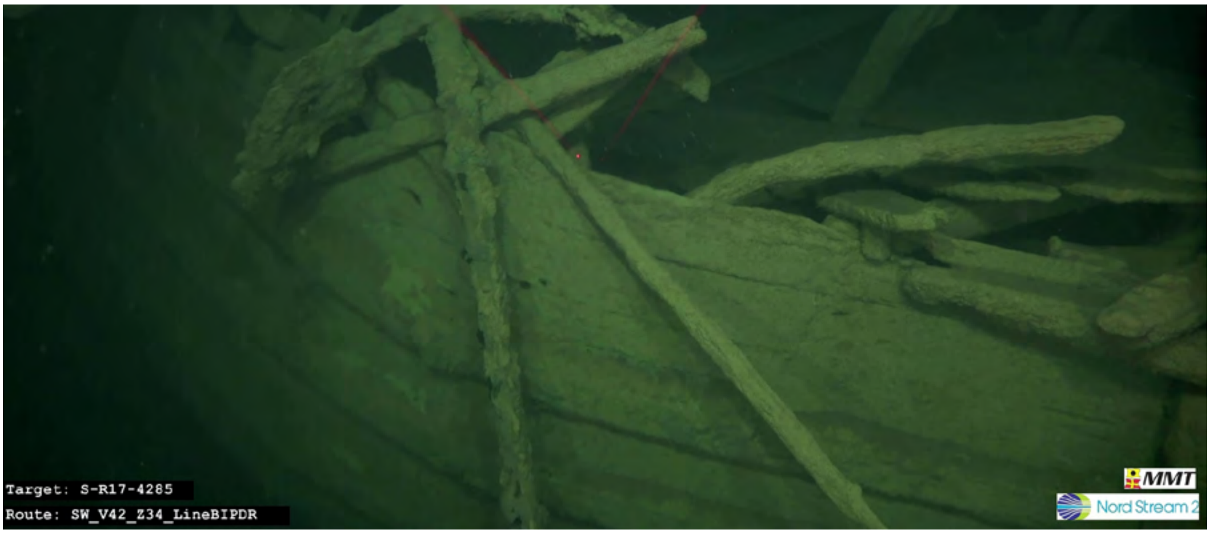


Figure 17. *Anchor hanging on the starboard side near the bow and another stands on the seafloor just off the bow.*

Clinker built ship with cargo S-R28-5046 (Sweden)

This wreck has already been investigated for the Nord Stream project (wreck number S-29-93462). It is a clinker built ship with a cargo (ballast) of limestone and barrels with iron, possibly the so-called Osmund iron that was a common Swedish export commodity in medieval times until the 17th century (see Figure 18), /25/.

Figure 18. *The cargo or ballast stones and an unknown small wheel.*

Wooden ship wreck S-R30-0997 (Sweden)

The object is a wooden wreck, 24 m long and 6 m wide. Based on earlier ROV images and bathymetry, the wreck was provisionally 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 filled 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 /25/.

Figure 19. *The rounded stern. The loose rudder is partly visible on the far lower right.*

Cultural Heritage in Germany

In Germany, the pre-construction survey data was thoroughly reviewed for any archaeological objects of interest. Once identified, exclusion zones were set up around the objects to ensure their safety during the construction works. Some of the objects were selected as diving targets and further investigated. The area around one of the identified wreck site extends over the pipeline route which is why some parts needed to be removed, documented and relocated to prevent any damage during construction works.

As the pipeline route runs through a historical ship barrier which consists of a series of ship wrecks that were sunk around 1715, two wrecks and the ballast stones used to fix them on the seabed were archaeologically recorded, excavated and removed from their original location which is on top of the pipeline route. Post construction the ballast stones were put back in place and the timber parts forming the wreck were buried in the seabed (2019).

During construction works in 2018, a total of 11 chance finds were discovered. The relevant authority was notified in accordance with our chance find procedure and temporary exclusion zones were set up around the objects pending further examination. While the exclusion zones around all objects of cultural heritage value were coordinated with the relevant authorities prior to the construction works, one of the objects of cultural heritage (wood planks) was shown to have moved by approximately 25 m during pipelay activities. The incident is believed to have been caused by vessel movement and respective thruster usage. The relevant authorities were informed accordingly and the site was re-inspected and stabilised with sand bags to prevent further dislocation/ damage.

CONCLUSIONS

Mitigation measures, including a 50 m safety zone around the wrecks during the construction activities, were effectively in place in 2018. Hence, it is expected that no impacts occurred to the cultural heritage objects in 2018. This will be confirmed following the post-lay survey to be performed at the end of the construction period.

The preliminary conclusions are in line with the findings presented in the EIA/ES Reports, Espoo Report and Finnish permit applications.

5.3.2 Commercial fishery

Monitoring of commercial fisheries before the start of construction is planned as part of the Swedish monitoring programme. The purpose of this monitoring is to identify possible impacts on commercial fisheries in the Swedish EEZ due to the presence of the pipeline on the seabed. AIS data will be used to evaluate fishing boat patterns in proximity to the pipeline.

Results from the monitoring of commercial fisheries will be presented for comparison of fishing patterns before start of construction with fishing patterns during operation: therefore the results of the monitoring of commercial fisheries will be presented in the first monitoring report for the operational period (likely in 2023).

6 Monitoring during offshore construction

6.1 Munitions clearance

In order to create a safe corridor for the installation of the pipelines, the route was optimised to avoid unexploded munitions on the seabed. However, some munitions in Finland had to be cleared to ensure safe installation and operation of the pipeline. Munitions clearance in Finland was monitored in 2018 according to the monitoring programme. The monitored parameters defined in the monitoring programme are underwater noise and water quality. Furthermore, additional monitoring of marine mammals and contaminants in the seabed sediments, which were not included in the monitoring programme, were also carried out (see Table 8). The locations of the monitoring stations are shown in Figure 20.

Table 8. *Overview of monitored parameters during munitions clearance.*

	Parameters included in the monitoring programme		Additional parameters monitored	
	Underwater noise	Water quality	Marine mammals	Seabed sediments
2018	F, E*	F	F	F

F-Finland
*Monitoring of transboundary impacts on Estonia from munitions clearance in Finland; no construction activities in Estonia.

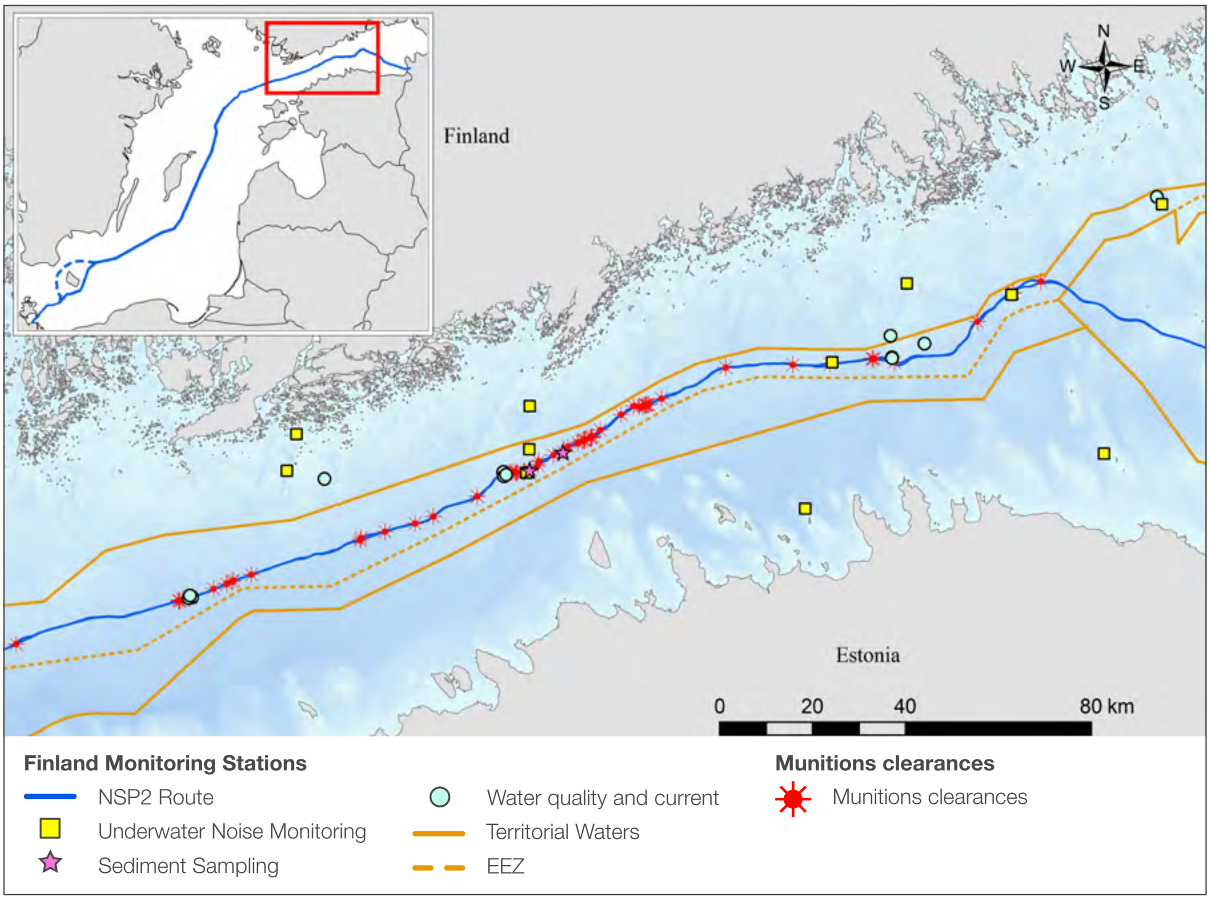


Figure 20. *Environmental monitoring associated with munitions clearance.*

In Finland, the munitions clearance campaign included identification, clearance and/or disposal of unexploded ordnance within the safety corridor of the pipeline. Out of 87 originally planned clearance targets, 15 were found not to be munitions and an additional 2 chance finds were cleared, resulting in a total number of cleared munitions of 74.

A combination of mitigation measures were established in order to ensure that no sensitive receptors were in proximity to the detonation site. For every cleared munition, acoustic deterrent devices, marine mammals observer, passive acoustic monitoring, fish finder and pressure wave sensor were in place, according to the permit application and the JNCC guidelines /26/. Additionally, in order to reduce or attenuate the acoustic noise from the detonation, bubble curtains were used for 58 munitions clearances (see Figure 21). Bubble curtains were used for larger detonations and in all cases in the eastern part of the Gulf of Finland, which is the habitat of the Baltic ringed seal.

Figure 21. *Big bubble curtain was applied to mitigate underwater noise of munitions clearance operations. Photo: ©Nord Stream 2 AG 2018 / Axel Schmidt.*

The potential impacts that were investigated in relation to the detonation of munitions are:

- underwater noise: to determine whether underwater noise has an impact on marine mammals and their environment;
- turbidity and water quality: to determine whether there is increased turbidity as a result of suspended sediment caused by the preparation works prior to the detonation and/ or the detonation itself;
- marine mammals: to determine whether there are behavioural changes for the seals inhabiting the seal sanctuary located closest to the highest density munitions clearance area;
- sediment contaminants: to determine whether toxic compounds contained in the munitions may become available in the seabed after the detonations.

Munitions clearance was carried out in the Finnish EEZ during 2018, a necessary step for safe installation of the pipeline. During the EIA phase and the permitting phase it was assessed that underwater noise from the detonation could cause also severe impacts on marine mammals present in the area. For this reason Nord Stream 2 committed to the use of extensive mitigation measures including bubble curtains. The impacts related to underwater noise were smaller than previously predicted (see Chapter 6.1.1.) and

no impacts on marine mammals were observed at the Kallbådan protected area during the monitoring of munitions clearances (see Chapter 6.1.3). Other impacts, such as increased turbidity (see Chapter 6.1.2) and release of contaminants from the seabed (see chapter 6.1.4) were monitored as well and no impacts on the marine environment were detected.

6.1.1 Underwater noise

Munitions clearance during the construction phase of the Nord Stream 2 pipeline system generates impulsive noise and high peak sound pressure levels, which can have impacts on marine life. According to the EIA Report, the most significant threat associated to munitions clearance was related to the peak sound pressure levels of individual detonations which can cause both temporary (TTS) and permanent (PTS) reduction in hearing sensitivity. Underwater noise monitoring during munitions clearance in Finland took place throughout the entire clearance campaign.

The purpose of underwater noise monitoring was to:

- measure maximum noise levels;
- measure noise propagation from munitions clearance into the most sensitive protected areas;
- compare impacts modelled during the EIA and permitting phases with measured values;
- define potential changes in background noise levels from construction activities.

METHODOLOGY

Monitoring of underwater noise involved 8 fixed long term monitoring stations and 3 vessel based monitoring campaigns. The fixed long-term underwater noise monitoring stations continuously recorded underwater noise throughout the entire clearance campaign (just over one month). In order to provide high resolution information as early as possible (to support corrective measures if required), short-term vessel based monitoring of underwater noise took place during three different munitions clearance events that were cleared at the beginning of the clearance operations. In addition, on-site measurements carried out by munitions clearance contractors took place during most clearance operations.

Data collected from the long-term and the vessel based monitoring campaigns were used to calculate peak and sound exposure levels (SEL) for each munition clearance (in most cases the same clearance event was monitored at several stations). Measured sound exposure levels from the close-range measurements data (i.e. from the munitions clearance vessels and from the vessel-based monitoring campaigns) were used for re-modelling of the PTS area.

RESULTS

A total of 254 peak levels were measured (the same munition was measured at different monitoring locations) and compared to the modelled values in the permit application. This included both measurements from the long-term stations and vessel-based measurements. The variation in measured peak levels increased with the distance to the detonations and distance attenuation was more effective along the Finnish coast due to the low water depth and variable bathymetry when compared to the deeper Estonian coastline with fewer islands (see Figure 22). 253 out of 254 levels were lower than the modelled values in the permit application.

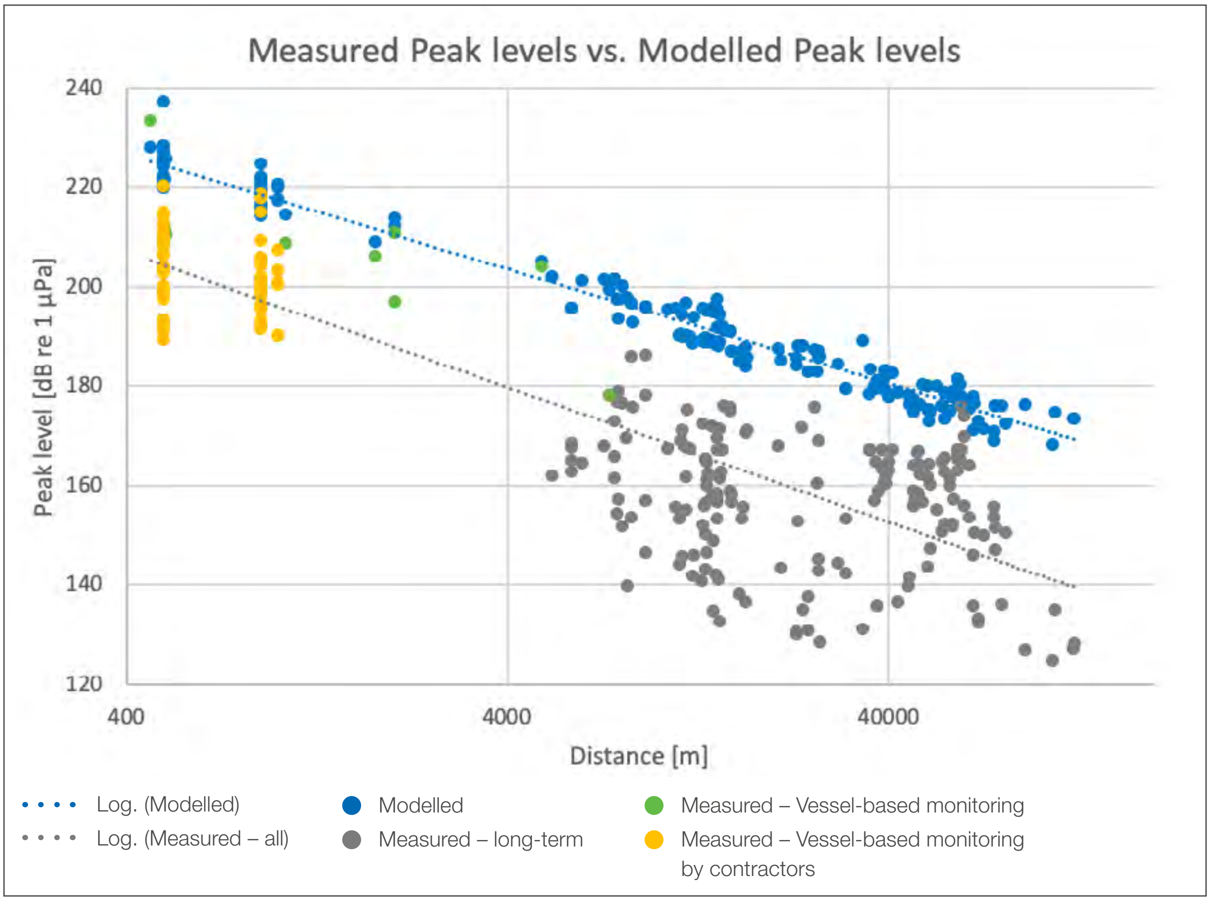


Figure 22. *Peak sound pressure levels (SPL) from munitions clearance events. The SPL levels used in the permit application are based on modelling.*

None of the measured SEL levels measured at the long-term monitoring stations exceeded PTS or TTS levels. The highest measured SEL was 163.3 dB re uPa2s. It was measured near Kallbadan, which is the closest to any protected area with seals as the conservation target and where the munitions clearance density was highest, suggesting that neither PTS nor TTS areas extended into any protected areas with seals as conservation targets.

Based on modelling, which was done for the permit applications, the PTS areas from the munitions clearances did not extend to any of the closest Natura sites included in the Natura assessment and screening studies (see Figure 23). The TTS areas were only modelled to reach one of the Natura sites (Tammisaari and Hanko Archipelago and Pohjanpitäjänlahti Marine Protected Area), however none with marine mammals as designated targets.

The measured and simulated PTS distances were smaller than the modelled average and maximum values in the EIA report. On average, they were as low as 24 % of the modelled areas /24/.

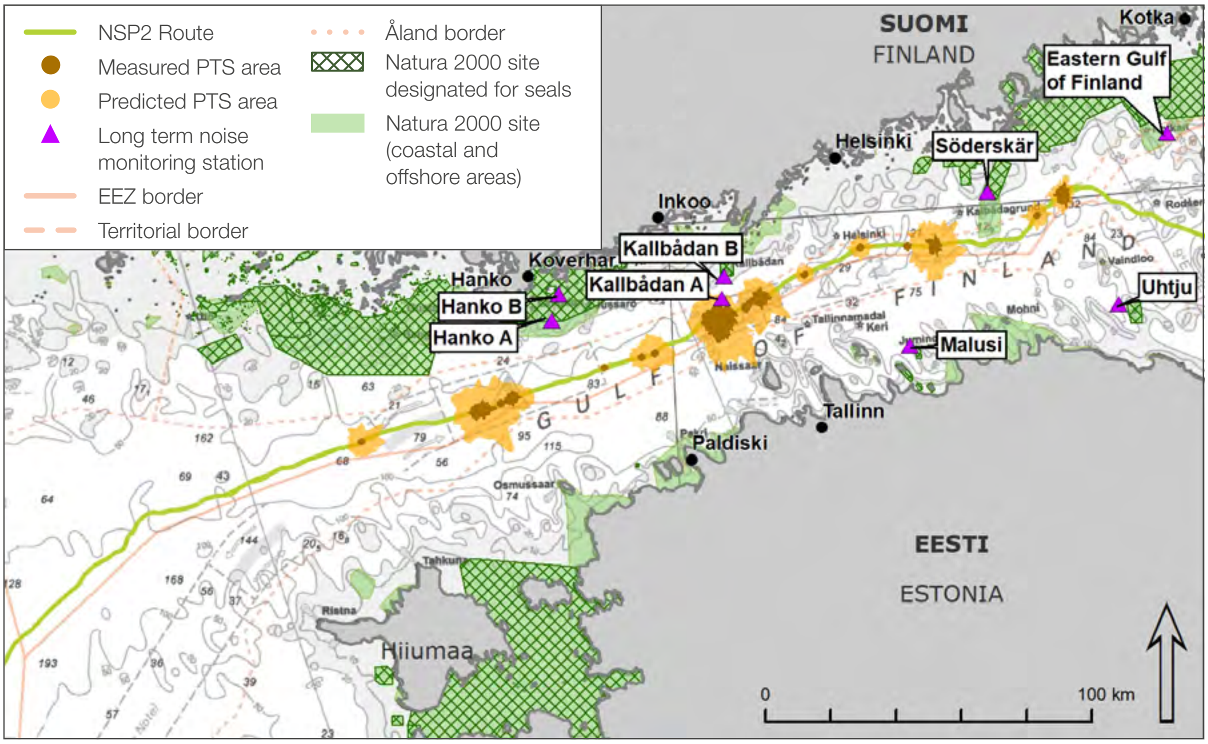


Figure 23. Modelled maximum and measured PTS levels for 62 munitions from 3th May–6th June 2018.

CONCLUSION

According to the noise measurement data, peak sound pressure levels were lower than predicted in the EIA report and the water permit application. In several cases, the total weight charge was smaller than predicted. Similarly, the calculated permanent threshold shift zones based on the measured sound levels were significantly smaller than modelled in the EIA report and the water permit application. Neither the permanent nor temporary threshold shift zones reached any Natura 2000 areas with marine mammals as the conservation target. These results are attributable, at least in part, to the application of mitigation measures, particularly the use of bubble curtains: Nord Stream 2's extensive use of bubble curtains has demonstrated both their feasibility and effectiveness for offshore acoustic attenuation for protection of sensitive marine environments.

6.1.2 Turbidity and water quality

Detonation can cause turbidity to spread into the surrounding water, as the targets to be cleared were in most cases partially buried and pressures associated with the detonation leads to a small seabed crater. Also, activities such as the installation of the bubble curtains and their use may cause resuspension of sediments. Sediment spread can potentially have an environmental impact on marine life.

The main objectives for the turbidity and current monitoring programme were to evaluate:
> How far and for how long the sediments originating from construction operations can travel;
> How high the sediment plume can rise from seabed;
> How high the maximum turbidity readings are;
> How much the construction related sediment spread elevates the background levels in each monitoring location;
> How well the modelled impacts during the EIA phase match the measured values.

METHODOLOGY

Water quality and current monitoring was carried out at 2 munitions clearance locations, at 2 control stations, in proximity to the Sandkallan protected area (to monitor all construction activities) and in the vicinity of 2 rock placement sites (discussed in Chapter 6.5).

Monitored munitions were of medium and large size (115 kg and 350 kg revaluated to 240 kg). At each munitions clearance location, a triple monitoring array was used in a triangular configuration around the munition to be cleared and each array measured salinity, temperature, oxygen and turbidity at three water depths (2,5 and 15 m above the seabed). In addition, one array was equipped with an ADCP current sensor meter which measures current speed and direction across the water column. Also monitoring in the vicinity of the Sandkallan protected area was set up in the same way.

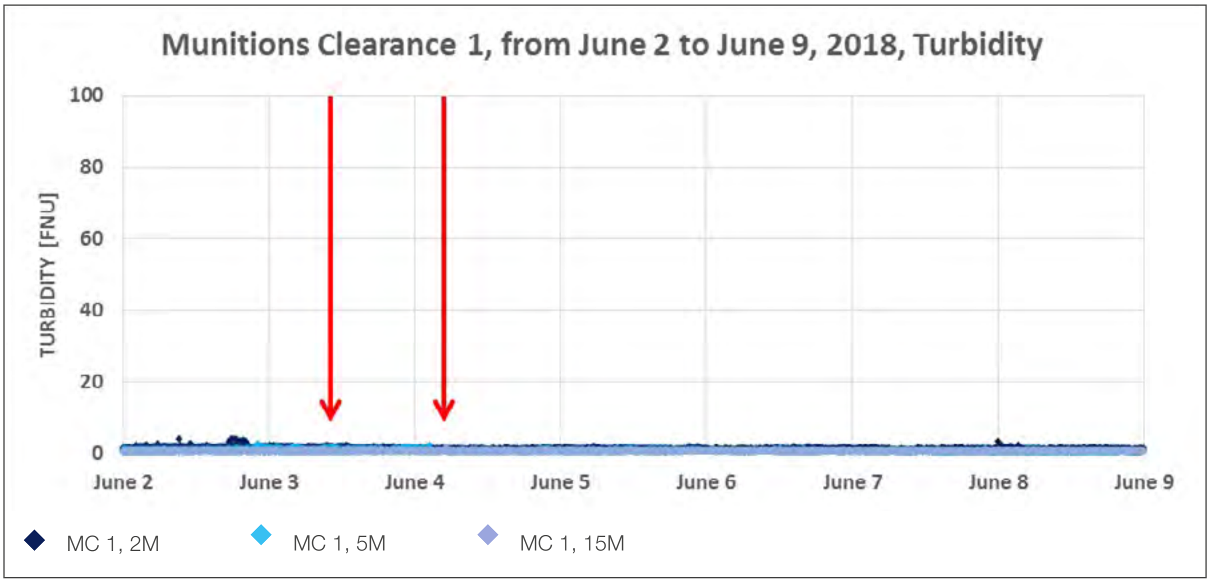
Monitoring at the munitions clearance sites started at least 1–2 weeks prior to the clearance event and lasted until at least 1 week after the clearance. Monitoring at Sandkallan and at the control stations are long term: the control stations are monitored to collect background information on the natural and seasonal variability of turbidity levels, and Sandkallan is monitored to assess the environmental conditions of the Sandkallan reef habitats. Long-term monitoring started 2 weeks prior and will last until 4 weeks after completion of the construction phase.

RESULTS

Measured impacts on water quality were small and correlated more closely with the preparatory activities than with the detonations themselves. The maximum measured turbidity peak value was 9.2 FNU[9], compared with the maximum measured background peak level of 5.8 FNU at the Munition Clearance 2 site (see Figure 24). Turbidity impact was limited to the stratified near-bottom layer measured at 2 m and 5 m above the sea floor. Turbidity in the upper layer measured at 15 m above the sea floor remained below the background levels. At the Munition Clearance 1 site, no clear signs of increased sea water turbidity levels caused by the munitions clearance operation were detected (see Figure 24).

Maximum recorded turbidity values at the control stations were 20 and 24 FNU and maximum recorded turbidity measured at Sandkallan was 12 FNU. Outside storm events, background average turbidity levels remained below 1 FNU at all sites /24/.

9 During the Finnish monitoring campaign, water quality samples were collected at each monitoring station to allow for calibration of turbidity unit versus Total Suspended Sediments in mg/l. Turbidity readings were very low: the conversion factor derived from the measures was established at 1:1. This is applicable for the turbidity measured in Finland as part of the monitoring of munitions clearance and rock placement.



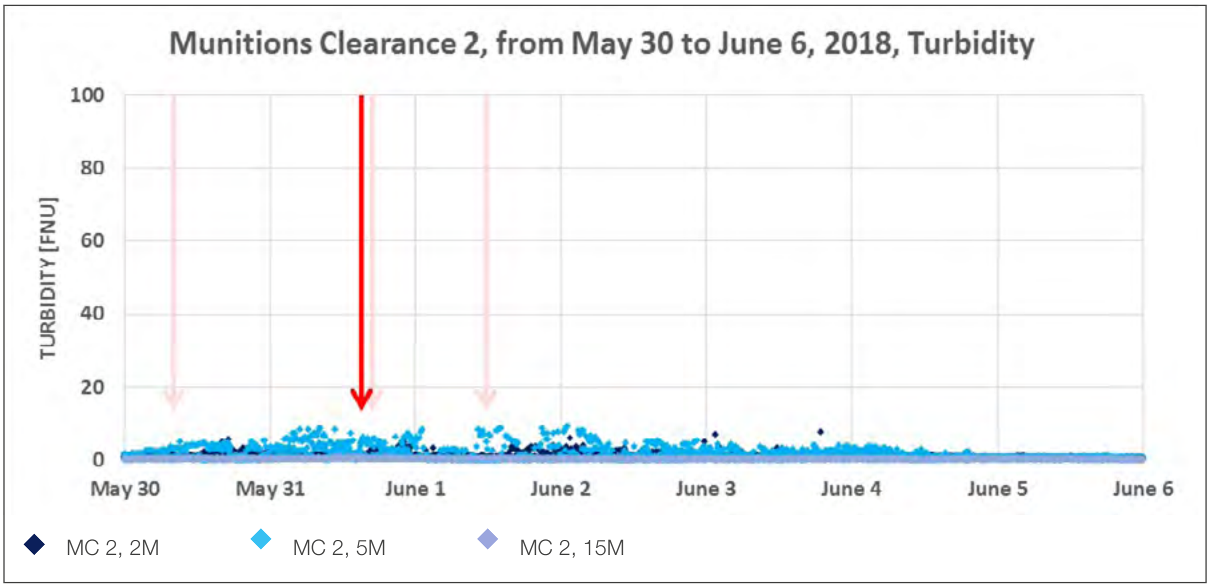


Figure 24. *Measured turbidity during the munitions clearance operation at monitoring sites Munition Clearance 1 (above) and 2 (below). Turbidity readings were taken and 2 m, 5 m and 15 m above the sea floor. The red arrows indicate the clearance time of the main targets, the pink arrows indicate the clearance times of other targets located in the vicinity of the monitoring area.*

CONCLUSIONS

Measured turbidity values from munitions clearance were lower than predicted in the EIA report, but at the same level as those measured during Nord Stream monitoring for similar targets.

In the EIA report, minor impacts from increased turbidity due to munitions clearances were predicted: the modelled maximum turbidity was of 107 FNU and duration of turbidity levels above 2 FNU was estimated at 15–23 hours. The maximum measured turbidity was 9.2 FNU and it was most probably caused by the preparation activities. The detonation itself did not cause turbidity levels to increase above the background variation. The duration of turbidity peaks was typically about 12 h.

In the water permit application, munitions clearance operations were estimated to cause a short-term increase in turbidity values (increased turbidity levels up to 1 km from the clearance and duration of local impact (>10 FNU) was 24 h or less). The maximum turbidity values were similar to those measured during the Nord Stream monitoring (<10 FNU) /27/. No impacts from increased turbidity due to munitions clearances occurred in Finland in 2018.

6.1.3 Marine mammals

Monitoring of seal behaviour in the Kallbadan protected area was discussed between Nord Stream 2 and the Forestry Authority (Metsähallitus) after the grant of the construction and operation permits and is therefore not included in the Finnish monitoring programme. Kallbadan is a seal sanctuary and is part of a Natura area. Natura areas in Finland are managed by Metsähallitus. It was agreed that monitoring would be carried out by Metsähallitus and that the results would be presented in a study and provided to Nord Stream 2.

Metsähallitus monitored seals at the Kallbadan seal sanctuary from 3th May 2018 to 23th August 2018 using remote camera recording equipment. According to the Metsähallitus study, detonations had no impact on the occurrence of grey seals on the islets, even when the detonations were closest to the Kallbadan seal sanctuary. The distance between the detonations and the seal reserve was so great that the seals did not react to the detonations at all /24/.

6.1.4 Seabed sediments

After the grant of the Water and EEZ permit there was a discussion regarding whether the clearance of munitions could release toxic compounds onto the seabed as a by-product of the detonation. Therefore Nord Stream 2 decided to carry out a study of sediment contamination for two munitions events, before and after detonation. Monitoring of sediment contaminants was not included in the Finnish monitoring programme.

A total of 6 + 11 sediment samples were taken in close proximity to two munitions, both before and after clearance. The two target objects were assessed as 25 kg and 300 kg munitions respectively. The sediment samples were analysed by an accredited laboratory for explosive residues and heavy metals.

For both munitions the collected sediment samples showed that none of the analysed samples contained explosive material residues that exceeded the detection limit. Heavy metal concentrations varied randomly and no clear pattern between the location and concentration could be seen /24/.

6.2 Dredging in Russia

In order to protect the pipeline from ice scoring (gouging) in shallow water, dredging is carried out in Russia. Dredging is performed between KP 0.0 and 3.3 (sea depth 13 m). The amount of soil above the pipeLine After backfilling should be at least 2.75 m for the pipeline section with highest probability of ice gouging (approximately 6 m water depth, corresponding to approximately KP 0.85). Backfilling operations are planned for 2019, no backfilling occurred in 2018. An overview of monitoring parameters associated with dredging activities is given in Table 9.

__Table 9.__ Overview of monitored parameters during dredging in Russia.

	Parameters included in the monitoring programme				
	Water quality and turbidity	Seabed sediments	Marine mammals and birds*	Fish migration*	Ichthyoplankton*
2018	R	R	R	R	
2019	R	R	R	R	R

R-Russia
*Seasonal monitoring.

In 2018 monitoring of dredging in Russia focused on water quality and seabed sediments. In addition, seasonal monitoring of marine mammals and birds partially coincided with the dredging activities. Seasonal monitoring of fish migration focused on the migration of salmons. Also monitoring of ichthyoplankton is seasonal, and since no dredging activity took place during the relevant monitored period, this was not monitored in 2018. The monitoring stations are shown in Figure 25.

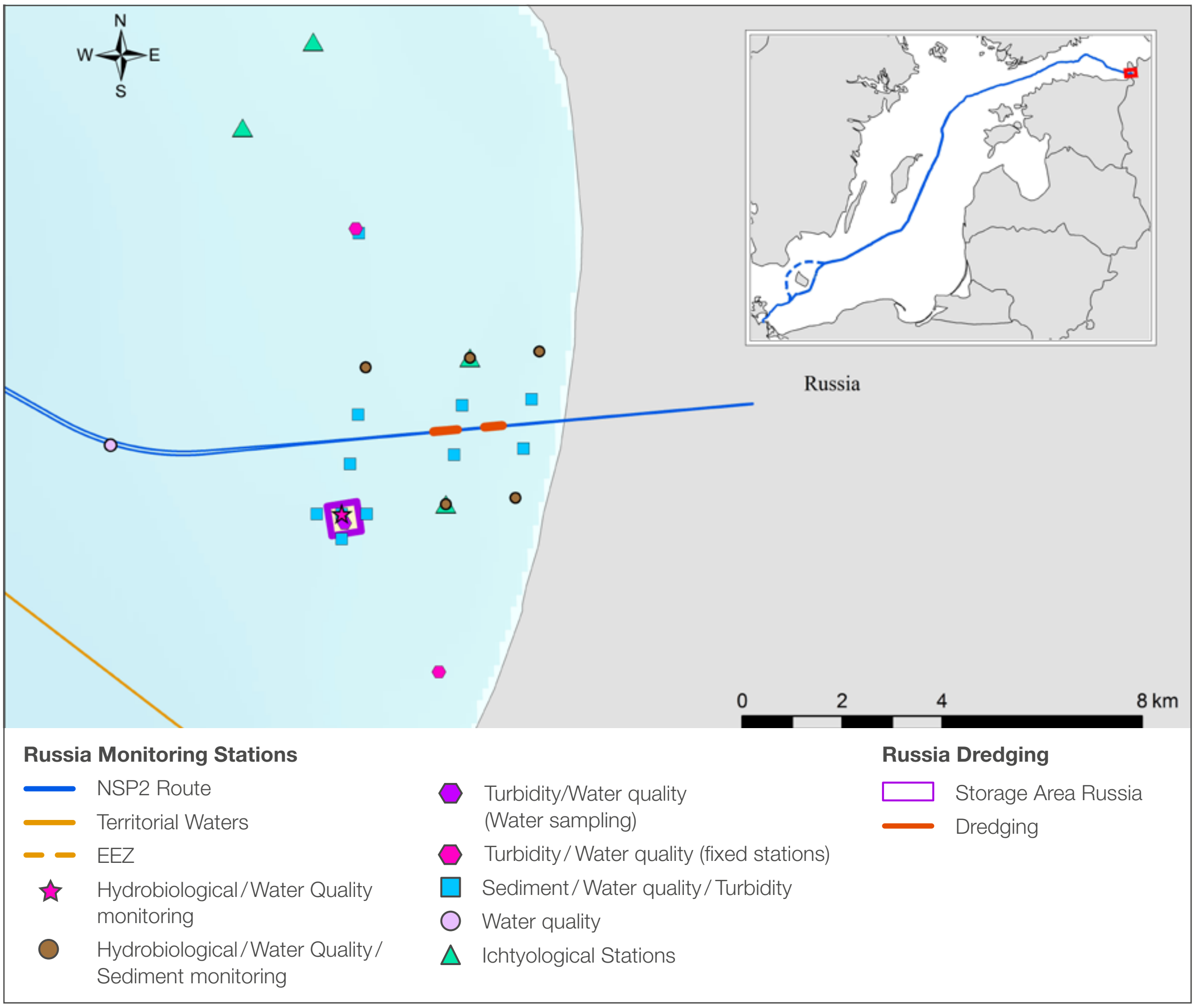


__Figure 25.__ Environmental monitoring associated with dredging in Russia.

Monitoring of dredging activities in Russia showed that the environmental impacts were in line with the predicted values and that no increased turbidity levels above the defined threshold levels (see Chapter 6.2.1) nor pollution of the seabed (see Chapter 6.2.2) occurred in 2018. Seasonal monitoring of marine mammals and birds showed that construction activities did not have an impact on these species: bird migrations occurred prior to the start of dredging activities and no marine mammals were observed in the near shore sections (see Chapter 6.2.3). Monitoring of salmon migration showed that the migration occurred prior to the start of dredging activities (see Chapter 6.2.4).

6.2.1 Turbidity and water quality

Monitoring of turbidity and water quality associated with dredging was developed in order to evaluate changes in the marine environment due to suspended sediments from the dredging activities. The main purpose of the monitoring work was to evaluate changes in turbidity and pollutant concentrations due to sediment suspension from dredging operations.

Water quality thresholds are defined on the basis of Russian legislation, such as SanPiN 2.1.5.2582-10, "GN 2.1.5.1315-03 Maximum permissible concentrations (MPC) of chemical agents in water of water bodies used for public water supply and communal services. Hygiene standards" and "Order of the RF Ministry of Agriculture dated 12.13.2016 No. 552 on approval of water quality standards for water bodies of commercial fishery value including maximum allowable concentration limits of harmful substances in water bodies of commercial fishery value".

METHODOLOGY

Sea water monitoring cycles in the near-shore area were carried out during and after the end of dredging at sixteen multi-purpose monitoring stations located on profiles crossing the pipeline route. The methodology is comparable to that described in Chapter 5.1.1. The monitoring locations are shown in Figure 25.

RESULTS

No negative impact on the condition of the marine environment within the nearshore section as a result of dredging was observed. According to the results of 3 seawater monitoring cycles (background survey, survey during dredging and survey after the end of construction operations) rather low pollutant concentrations were detected, some of which contained quantities of pollutants not exceeding the detection limit of the measurement procedure used (oil products, phenols, benzo(a)pyrene, arsenic, manganese, zinc, cadmium, chromium, cobalt, nickel, lead, and mercury). At the end of the construction operations in the near-shore area, most of the indicators were below background values (results of the survey carried out in 2015–2016). At 6 stations the standard BOD5 and BOD20 limit was exceeded by a factor of 1.0–1.3.

Recorded values of turbidity in the near-shore area during the dredging period did not exceed the background values measured in the previous months. When converting turbidity expressed in FTU to turbidity expressed in mg/l according to the Russian GOST standard, no exceedance of the maximum permissible concentration of 10 mg/l for fisheries was found. When converting turbidity from FTU to mg/l using the data collected from the dredging contractor[10], exceedance of the limit value of 10 mg/l was found at one location (maximum exceedance of 1.5 MPC in the surface horizon and 1.6 MPC in the bottom). However, no exceedance of the autumn background value of 21 mg/l was recorded.

10 Conversion of turbidity values from FTU to mg/l was done by two methods: 1) 1.4 mg/l of kaolin corresponds to 2.6 FTU or 1 FTU corresponds to 0.58 mg/l (Russian GOST Standard); 2) according to the linear formula: Turbidity (mg/l) = 0.9453×Turbidity (FTU) +6.4781 (based on data from EOMAP) /17/

During the background survey in the near-shore section, a single exceedance of the MPC for suspended solids was found (1.03 MPC). Since the standard indicator for the content of suspended solids applies to the continental shelf zone of seas with depths greater than 8 m, high concentrations of suspended matter (10.0–12.3 mg/l) recorded at coastal shallow stations with a depth of less than 5 m are not considered to be an exceedance of the MPC. According to the results of the survey done one month later during dredging works, no exceedance was recorded for any of the samples /17/.

Additional monitoring of turbidity not included in the monitoring programme

Turbidity during the dredging operations was also monitored as part of the dredging contractor's work, to enhance the scientific knowledge related to this activity. The additional monitoring of turbidity during 2018 took the form of collection and analysis of satellite imagery and reactive monitoring of turbidity.

Satellite imagery was collected to assess the water quality conditions both before and during the dredging activities. A total of 43 high and medium resolution satellite images for the period from April to November 2018 were collected: the spatial resolution ranged from 10 m–300 m. The same location was revisited on average every 6 days, which is considered a good rate due to the frequent unfavourable weather conditions in the area. The images were used to calculate turbidity and related total suspended matter concentrations. The measured values ranged between 0.1–9 FTU and 6–15 mg/l, with higher values mainly along the coastline. The results showed that increased turbidity values were mostly related to environmental phenomena such as heavy storms, river inflow during snow melt periods, and algal bloom events /28/.

Reactive monitoring of turbidity was carried out by the dredging contractor in order to allow for continuous adaptive monitoring. In 2018 a total of 5 monitoring locations (2 along the pipeline, 1 near the temporary storage area for dredged soil, 1 near the spawning grounds and 1 near the Estonian border) were installed to continuously upload turbidity values to a specifically designated website. NTU[11] data were uploaded every 15 minutes, with provision for intervention if the recorded turbidity exceeded specific thresholds defined on the basis of general knowledge of the area and experience gathered on the Nord Stream project[12]. During 2018 turbidity levels never exceeded the defined thresholds.

CONCLUSIONS

Turbidity and water quality measurements were in line with the results presented in the national EIA and with the defined requirements. Increased turbidity levels did not lead to the interruption of the work. Elevated turbidity levels were mostly related to natural dynamics.

6.2.2 Seabed sediments

Monitoring of seabed sediments associated with dredging was put in place to determine whether any changes in the quality of the seabed sediments (e.g. pollutant concentrations present in the seabed sediments, soil composition, pH, etc.) are caused by the dredging activities.

11 Water samples were collected on a monthly basis to allow for calibration for NTU and mg/l.

12 Dredging activities must not increase the background turbidity by more than 50 mg/l at the dredge monitoring points (running average). If TSS exceeds 100 mg/l above background levels for 6 hours at one of the dredge monitoring points dredging must be interrupted.

METHODOLOGY

In 2018 two cycles of sea bottom sediment sampling were performed in the near-shore area:

- during the dredging works;
- upon completion of dredging works in 2018.

Seabed sediments monitoring in the near-shore area was carried out at the same stations as for sea water monitoring, with the exception of one station located in the temporary sediment disposal area. The methodology for monitoring seabed sediments was based on the Helcom guidelines for bottom sediment sampling. The monitoring locations are shown in Figure 25.

RESULTS

According to the results of seabed sediment studies at the monitoring site, both during dredging and after the completion of these operations, fairly low concentrations of pollutants were detected. Comparison with the results of engineering and environmental studies conducted in 2015–2016, confirms that the low pollutant concentrations (measured with spatial variation) have not significantly changed compared with the figures from previous years.

No significant increase in the content of pollutants in seabed sediments during the monitoring period was recorded. An increase in iron content, a decrease in the content of arsenic, manganese and cobalt, and a slight decrease in the content of lead and copper in the seabed sediments sampled after dredging, compared with samples taken during dredging, were observed. The changes in the concentrations of lead, copper and cobalt are seen against the background of low concentrations of these elements and are comparable in magnitude with the magnitude of the corresponding measuring errors. The changes in the concentrations of iron, arsenic and manganese are most likely caused not by the influence of dredging, but by natural geochemical and biochemical factors (i.e. these elements are naturally exchanged between seawater and seabed sediments during seasonal variations in hydrochemical and hydro-biological conditions).

The only recorded change in the state of seabed sediments in the survey area, which may be caused by dredging, is the enrichment of seabed sediments with clay particles (1.5–4.8 %). The reason for the observed process of increased content of clay fraction in the surface sediments may be the extraction of clayey soils from the underlying layers during dredging and the subsequent transfer of turbulent clay particles to seabed areas adjacent to the construction site.

Comparison of the monitoring results with known pollutant concentrations typical for the region /18/ confirmed that no additional pollution of the soil was observed during and after the dredging activities. Furthermore, the presence of pollutants in the soil appeared to decrease after the completion of dredging /17/.

CONCLUSIONS

During the EIA phase it was determined that no significant changes in pollution levels were expected after project implementation. Monitoring of seabed sediments during dredging activities showed that the seabed did not contain high level of pollutants and that changes in their concentrations are related to natural geochemical and biochemical factors. The minor increase of clay concentration which may be related to the dredging activities is not an environmental concern.

6.2.3 Marine mammals and birds

Seasonal monitoring of marine mammals and birds was conducted in order to determine whether any behavioural changes in the local and migratory fauna were caused by any construction activity and therefore not strictly correlated to a specific construction activity. In addition, monitoring of birds made it possible to assess the timing of migratory movements and to determine whether the construction activities could have an impact on them.

METHODOLOGY

Monitoring of marine mammals and birds was carried out mainly before the start of construction but also covered part of the dredging activities in Russia. Monitoring took the form of observations from vessels and from near-shore and offshore monitoring stations.

RESULTS

Five surveys took place in 2018 (see Table 10). The results of observations during the summer period showed that the number of seabirds and semi-aquatic birds was highest near the islands of Maly Tyuters, Nerva, Moshchny, and the Birch Islands archipelago. All of the islands were located at a considerable distance from the moving vessel and the construction area.

Table 10. *Results of bird surveys.*

Survey period	Observation duration, h	Number of birds	Number of species/orders
15.07–17.07	32.5	2,909	22 species in 6 orders
26.08–01.09	72	2,284	25 species in 7 orders
02.10–03.10	10	665	8 species in 3 orders
11.10–15.10	56	3,565	23 species in 6 orders
09.11–11.11	27	343	11 species in 4 orders

The groups most represented during the spring and summer surveys were the Laridae (order Charadriiformes) and Phalacrocoracidae (order Pelecaniformes). Charadriiformes and Anseriformes were the group with the highest observed species diversity. Species abundance distribution was different between summer, when fewer birds migrate in the Gulf of Finland, and autumn, which is the active migration season for most birds in the Gulf of Finland. During October, monitoring of birds made it possible to gather information on the largest migratory movements. Bird species most often encountered belonged to the order Anseriformes, accounting for over 80 % of all the species recorded. The most numerous species in this order were long-tailed duck, velvet scoter, common goldeneye and barnacle goose.

Of the total 25 species of birds recorded during the observations, 3 species (little tern, black-throated diver and tundra swan) are listed in the Red Book of the Russian Federation (2001), 13 species in the Red Data Book of Leningrad Region (2018), 11 species in the HELCOM lists of protected species (2013), and 8 species in the IUCN Red List. The final observation cycle in 2018 was carried out during the period of dredging in the nearshore water area. During the observation period in the area of the trench excavation, concentrations of migratory birds were found at relatively low density. No incidents affecting birds were reported and no birds were harmed.

During the surveys, individuals of two species of marine mammals were recorded, namely the grey seal (Baltic subspecies) and ringed seal (Baltic subspecies). Grey seals *Halichoerus grypus macrorhynchus* (family Phocidae, order Carnivora) were encountered on two occasions in July and in August. Both sightings were recorded in the eastern part of the Gulf of Finland near the Berezovye Islands where a total of 9 individuals were observed in open water and on haul-outs near North Birch Island. The discovered haul-outs are of some scientific interest, as there are relatively few documented grey seal haul-outs in this part of the Gulf (Loseva et al., 2014).

The Baltic ringed seal *Pusa hispida botnica* (family Phocidae, order Carnivora) was recorded in October 2018 near Kotlin Island behind a dike. No marine mammals were detected in the near shore areas in 2018 and no incidents with marine mammals were reported by the construction fleet. Both species are included in the Red Data Books of the Russian Federation (grey seal–category 1, Baltic ringed seal–2) and Leningrad Region (grey seal–category 5, ringed seal – 1). The ringed seal is also on the HELCOM list of protected species (VU–Vulnerable).

CONCLUSIONS

The resulting picture of the distribution of regional fauna in different seasons is generally consistent with the reference data. In general, the observed pattern of ornithofauna distribution, including migrants, is consistent with long-term data. However, further studies are needed to assess the impact of construction of the gas pipeline on the region's ornithofauna. Considering that the main migratory events occurred prior to the start of the construction activities, no impacts to birds in Narva Bay were observed due to dredging operations in 2018.

Furthermore, no marine mammals were detected in the vicinity of the dredging operations and therefore no impacts on the resident marine mammal population are likely to have occurred.

6.2.4 Fish migration

During the autumn season, salmon migrate from the sea into the Narva river, with the mouth of the Narva located approximately 5 km south of the Russian landfall. Some salmon migration routes cross the nearshore construction corridor. Salmon migration is monitored during dredging so that the work can be halted to prevent construction-related noise and turbidity from interfering with the migration.

METHODOLOGY

During the expected migration season from August to December, monitoring of salmon catches was carried out using 4 gill nets. Catches were made every 10 days until the first salmon was recorded, and thereafter the frequency was increased to 7–4 days.

RESULTS AND CONCLUSIONS

The actual migration season was shorter than expected, running from the end of October to the first half of November. During October 2018, three salmon were caught in the first session, indicating salmon migration. However, the salmon migration ended before the start of dredging activities in November.

It should be noted that the salmon migration route that crosses the nearshore construction corridor is a fairly minor route, and that the majority of salmon migrating to the Narva river use a migration route parallel to the Estonian border.

6.3 Dredging in Germany

In order to protect the pipeline in nearshore waters, the pipeline was laid into pre-dredged trenches in the German nearshore section from the microtunnel exit pit to a short distance before leaving the territorial waters. To minimise dredging-related environmental impacts, both pipelines were laid in a single trench within Special Areas of Conservation (Natura 2000 areas). The pipelines were laid in separate trenches in the Special Protection Area "Westliche Pommersche Bucht (DE 1649–401)". The depth of the trenches varies in order to meet safety requirements associated with shipping. Dredging and backfilling activities in Germany started on 15th May 2018 and were completed by 31st December 2018.

Table 11 provides an overview of the parameters monitored during dredging activities in Germany. Figure 26 shows an overview of all environmental monitoring activities associated with dredging and backfilling in German waters in 2018. Assessment of impacts on birds from the construction activities is ongoing. The monitoring results will be reported in the 2019 overall environmental monitoring report when construction in Germany is completed to allow representative assessment of the impacts.

Table 11. *Overview of monitored parameters during dredging in Germany.*

	Parameters included in the monitoring programme					
	Ship traffic	Seabed sediments	Turbidity	Underwater noise	Marine mammals	Seabirds
2018	G	G	G	G	G	G

G-Germany

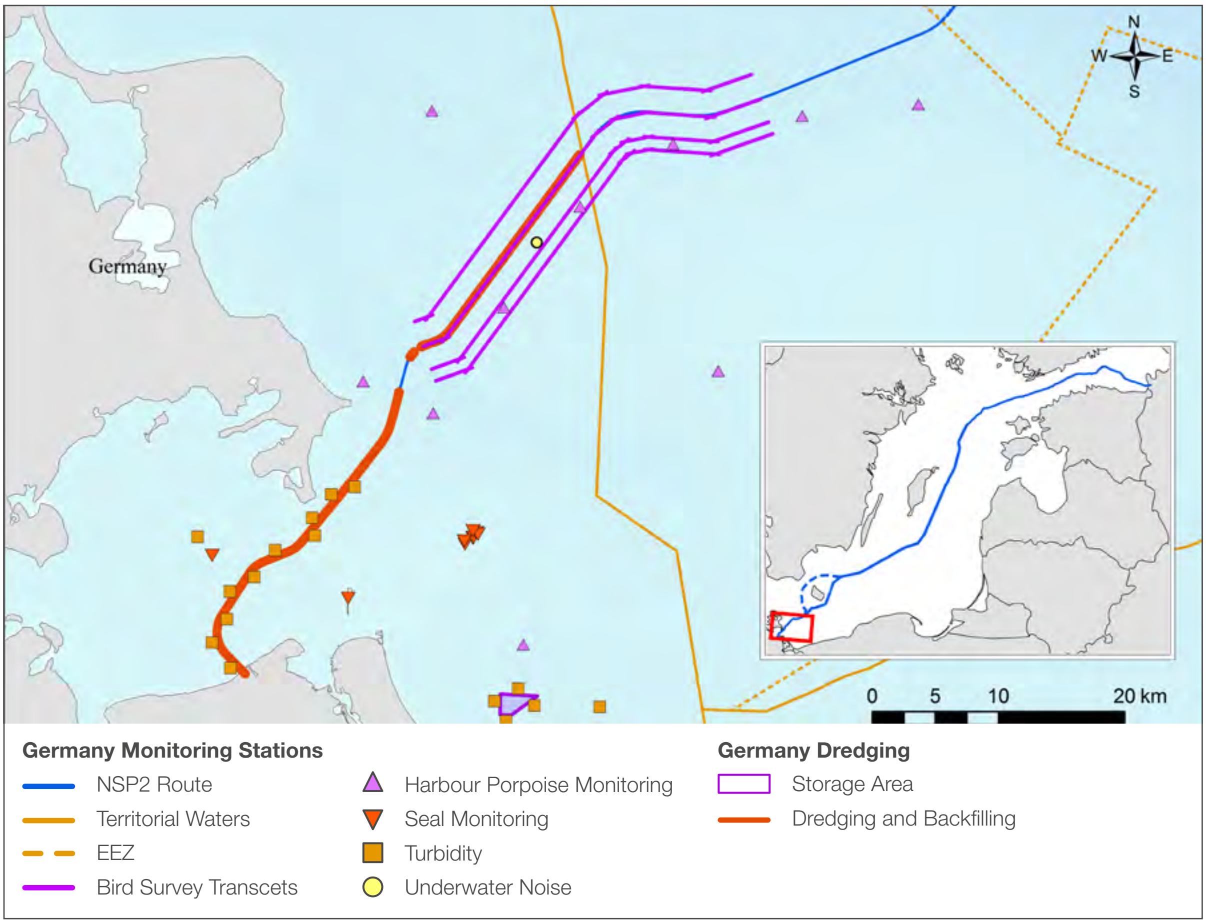


Figure 26. *Environmental monitoring associated with dredging in Germany.*

Monitoring of dredging activities in Germany in 2018 showed that Nord Stream 2 successfully minimised disturbances related to ship traffic (see Chapter 6.3.1). Through the use of extensive mitigation measures, including backhoe dredgers inside Greifswalder Bodden, turbidity remained well below the permitted values (see Chapter 6.3.3) and the quality of the dredging operations is presented in Chapter 6.3.2. The results of underwater noise monitoring indicated that the noise threshold associated with temporary hearing threshold shift (TTS) in marine mammals was not exceeded (see Chapter 6.3.4). However, construction activities may have caused temporary displacement of harbour porpoises in the vicinity of the operating construction fleet (see Chapter 6.3.5).

6.3.1 Ship traffic

METHODOLOGY

Altogether, 88 vessels were involved in the offshore construction works in Germany: a dredging fleet and two pipelay spreads (including the pipelay vessels "Castoro 10" and "Audacia"). More than 50 vessels operated simultaneously during the summer months (see Figure 27).

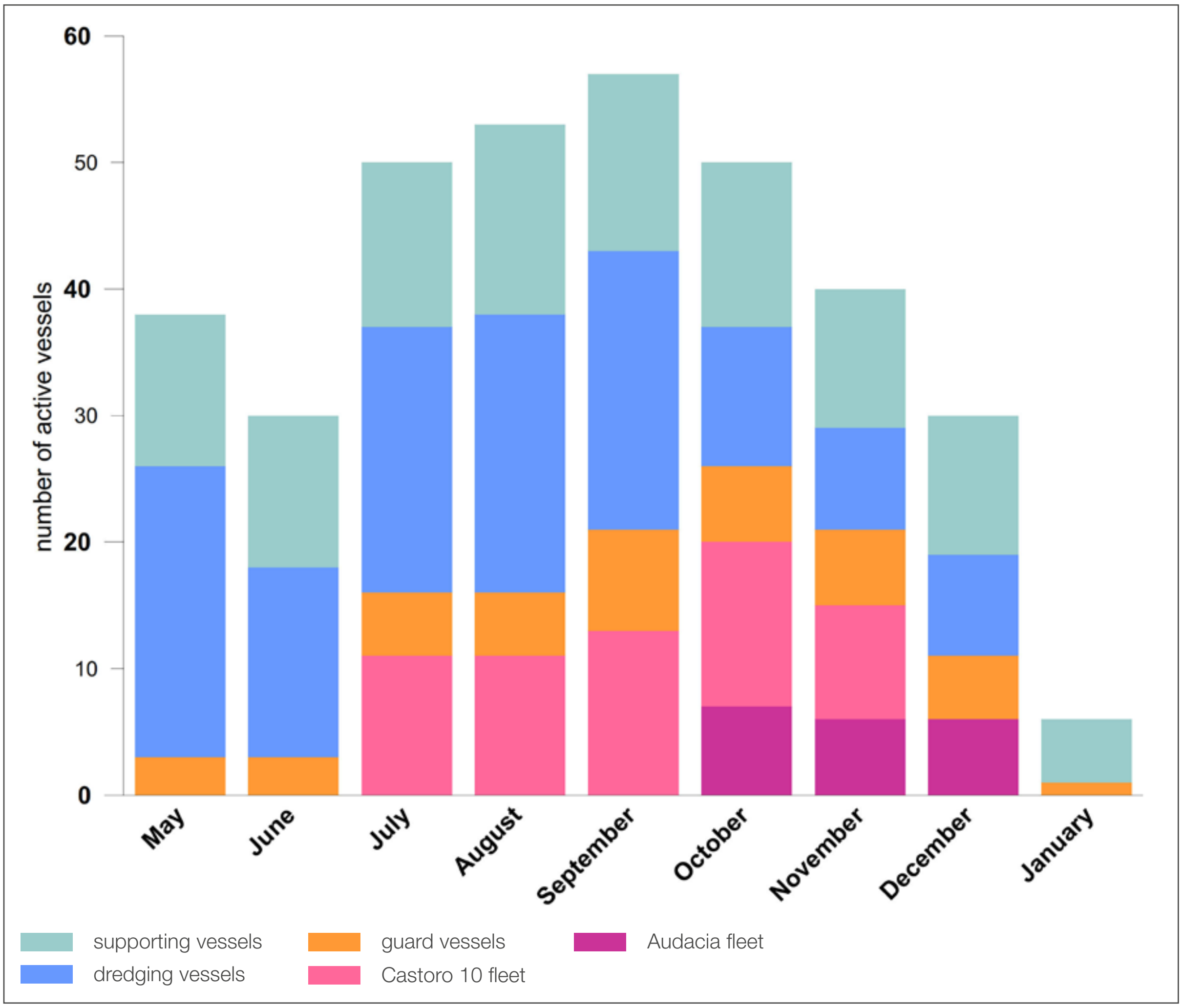


Figure 27. *Number of vessels operating per month during offshore construction in Germany.*

Since the Nord Stream 2 route in Germany crosses Special Protection Areas (Natura 2000 sites) for the protection of seabirds as well as Special Areas of Conservation (Natura 2000) hosting grey seals and harbour porpoises, vessel traffic of dredgers and pipelay spreads was restricted to pre-defined navigation routes (see Figure 28). This mitigation measure was aimed at reducing the displacement of seabirds and marine mammals.

A Marine Coordination Centre was set up to coordinate traffic interactions among construction fleets and third party vessels including leisure boats in close cooperation with the regional administrative maritime traffic centre. All Nord Stream 2 vessels were equipped with GPS-transponders for real time tracking of vessels allowing for permanent real-time control.

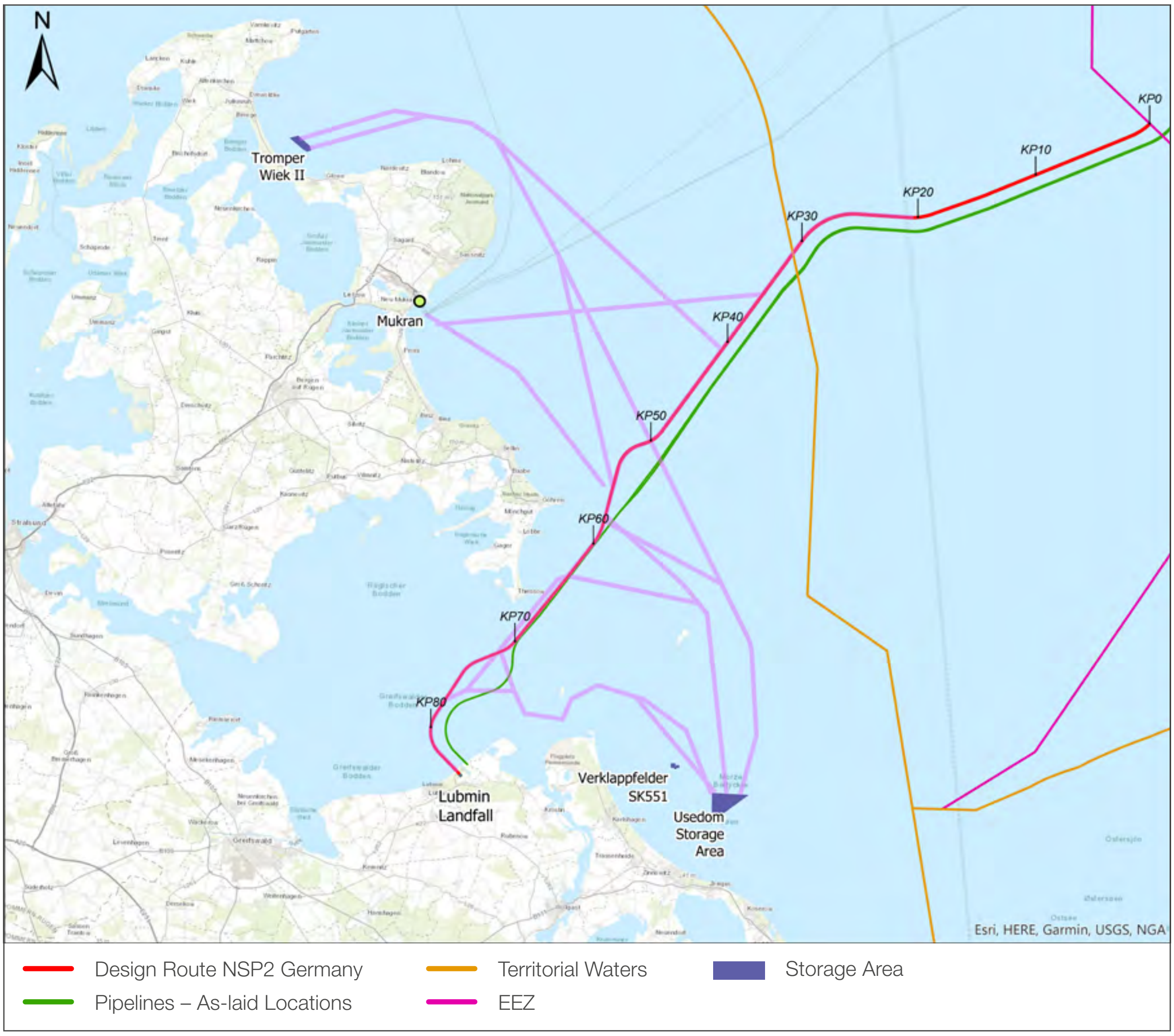


Figure 28. *Nord Stream 2 navigation routes for construction vessels.*

RESULTS AND CONCLUSION

Navigation of dredging fleet vessels was continuously supervised during the offshore construction works from 15th May until 31st December. Necessary route adjustment decisions, required for nautical safety, were taken on a daily basis (see example in Figure 29).

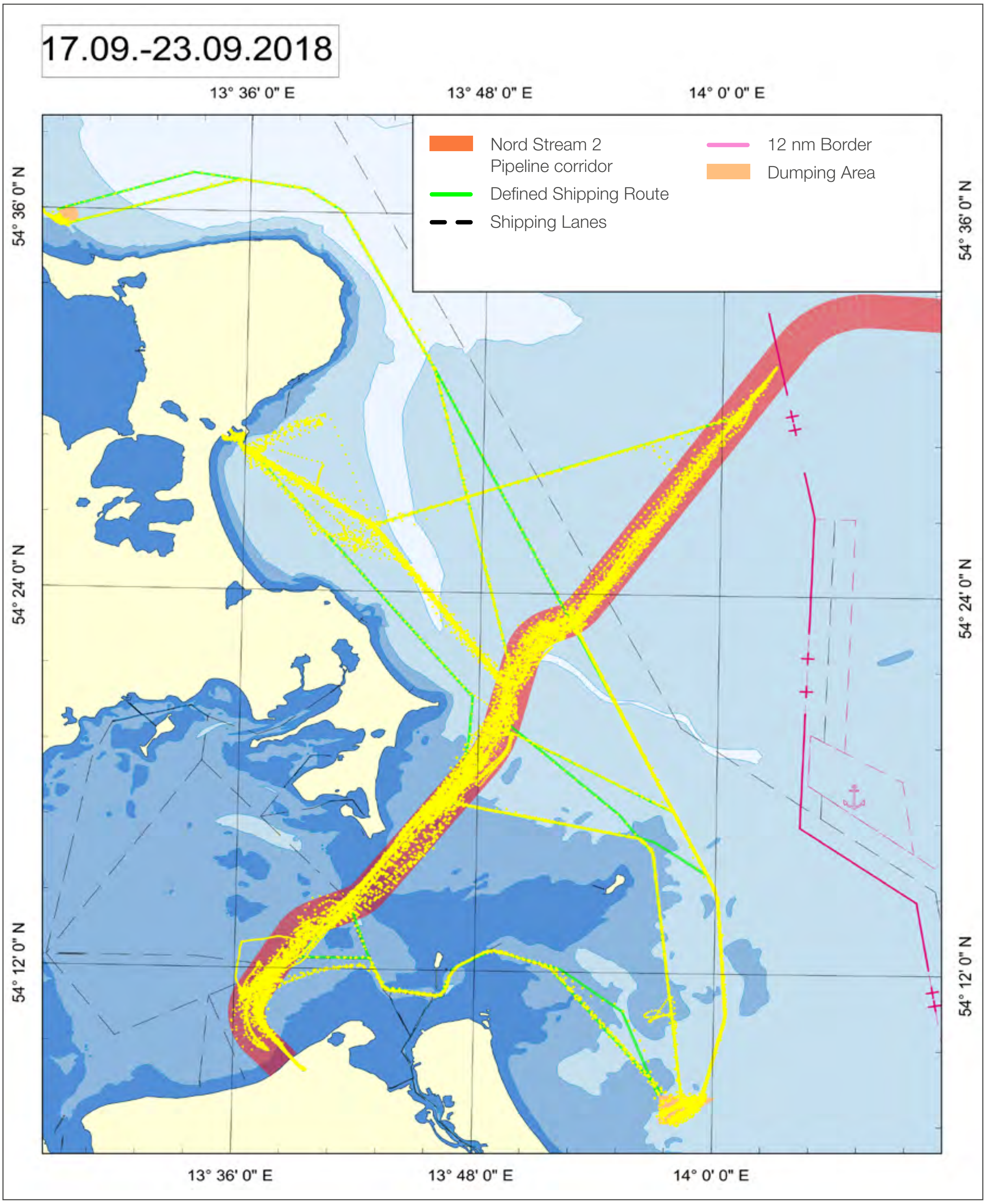


Figure 29. *Nord Stream 2. Tracks of dredging fleet vessels in week 38 of 2018.*

6.3.2 Seabed sediments

METHODOLOGY

Dredging and backfilling aimed at reinstating the seabed to a condition as close as possible to its undisturbed pre-construction status. A number of mitigation measures were implemented as part of a Soil Management Plan in order to achieve this goal:

- Minimisation of the spatial footprint of trenches using optimised trenching technology;
- Establishment of a layer-by-layer dredging plan (see example in Figure 30). Sediment was dredged in two layers: topsoil and deeper strata. Topsoil and sand from deeper strata were stockpiled separately for interim storage. The dredged material was also classified according to its origin. Soil unsuitable for backfilling (marl, very fine sand with higher organic content) was deposited onshore for third party use;
- Backfilling after pipelay to be carried out in three stages: 1) intimate backfill of pipelines with sandy gravel, 2) backfill with suitable sand, 3) backfill with top soil;
- Reinstatement of reefs by dumping suitable rocks and boulders (glacial material of marine origin);
- Bathymetry reinstatement with a tolerance of 0.3 m for trenches and +/-0.5 m for the interim storage area.

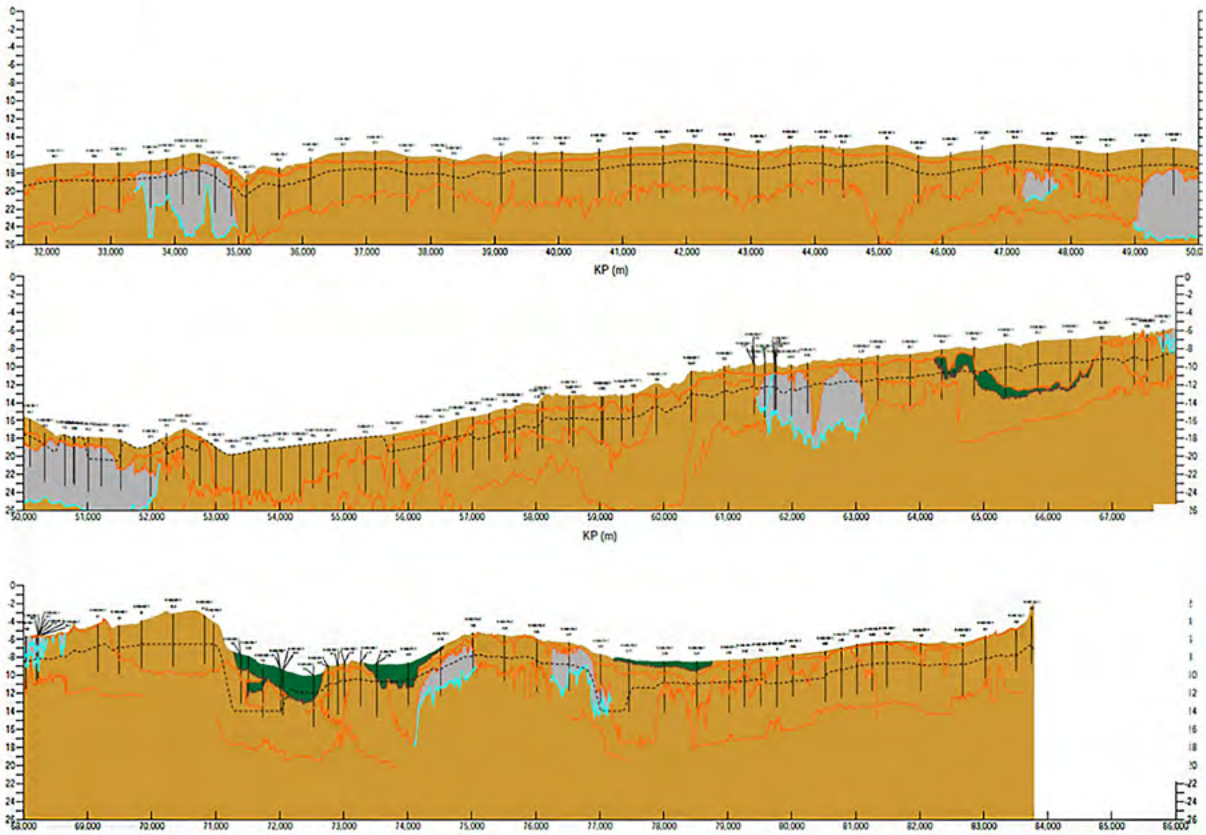


Figure 30. *Soil model as basis for the dredge plan (Soil Management Plan /29/).*

The high complexity of the dredge and backfill plan required real-time monitoring of all dredging and dumping operations together with GPS-tracking. Monitoring of all vessel activities was accomplished by the use of a remotely operated recording system installed on all dredgers and barges. The recorded data was stored in a database. The information was used in combination with bathymetry survey data for daily evaluation of the dredging works and definition of immediate corrective measures in case of unforeseen events and incidents. Dredging, storage and backfilling works were evaluated by bathymetry surveys on a daily basis. This monitoring ensured compliance with defined horizontal and vertical tolerances (see example in Figure 31).

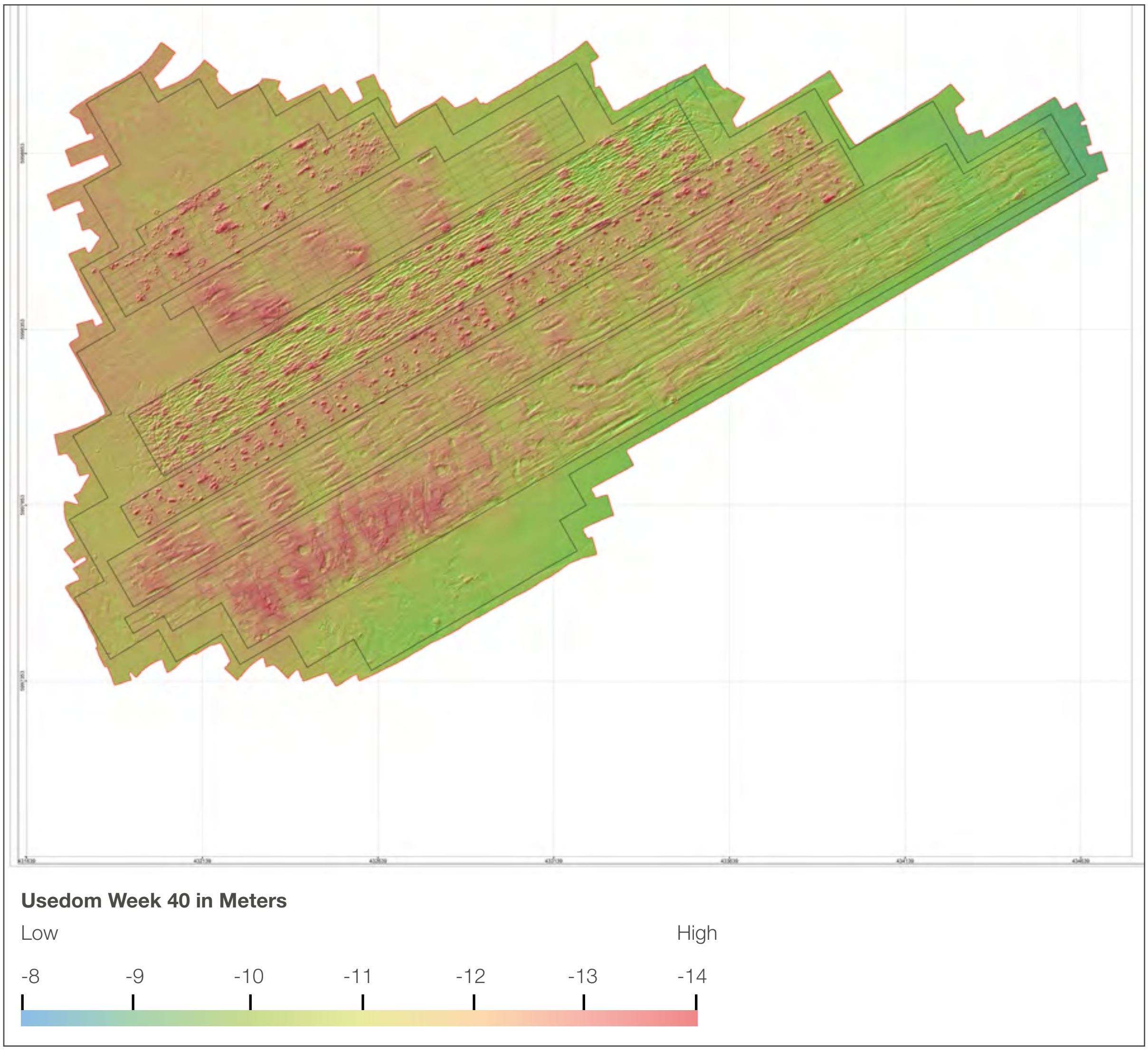


Figure 31. *Bathymetry of the interim storage area in week 40 (near the end of dredging works). The boxes denote specific storage areas for different soil types separated during dredging.*

Additional monitoring surveys to be carried out in 2019 will evaluate the quality of reinstatement:
> Bathymetry survey (integrity of backfill and natural levelling processes);
> Sediment parameters (appropriate reinstatement of grain size);
> Sediment geochemistry (pollutants).

RESULTS

With a total error of 3 % with regard to correct sediment separation during the dredging works according to the soil management plan (see Figure 32), Nord Stream 2 achieved a quality of dredging operations as good as that recorded during construction of the Nord Stream Pipeline in 2010. Based on the experience of recovery monitoring of Nord Stream in 2011–2014, it may be concluded that Nord Stream 2 recovery monitoring will confirm that the trenches and interim storage area of the Nord Stream 2 project will also recover to pre-construction status within 3–4 years.

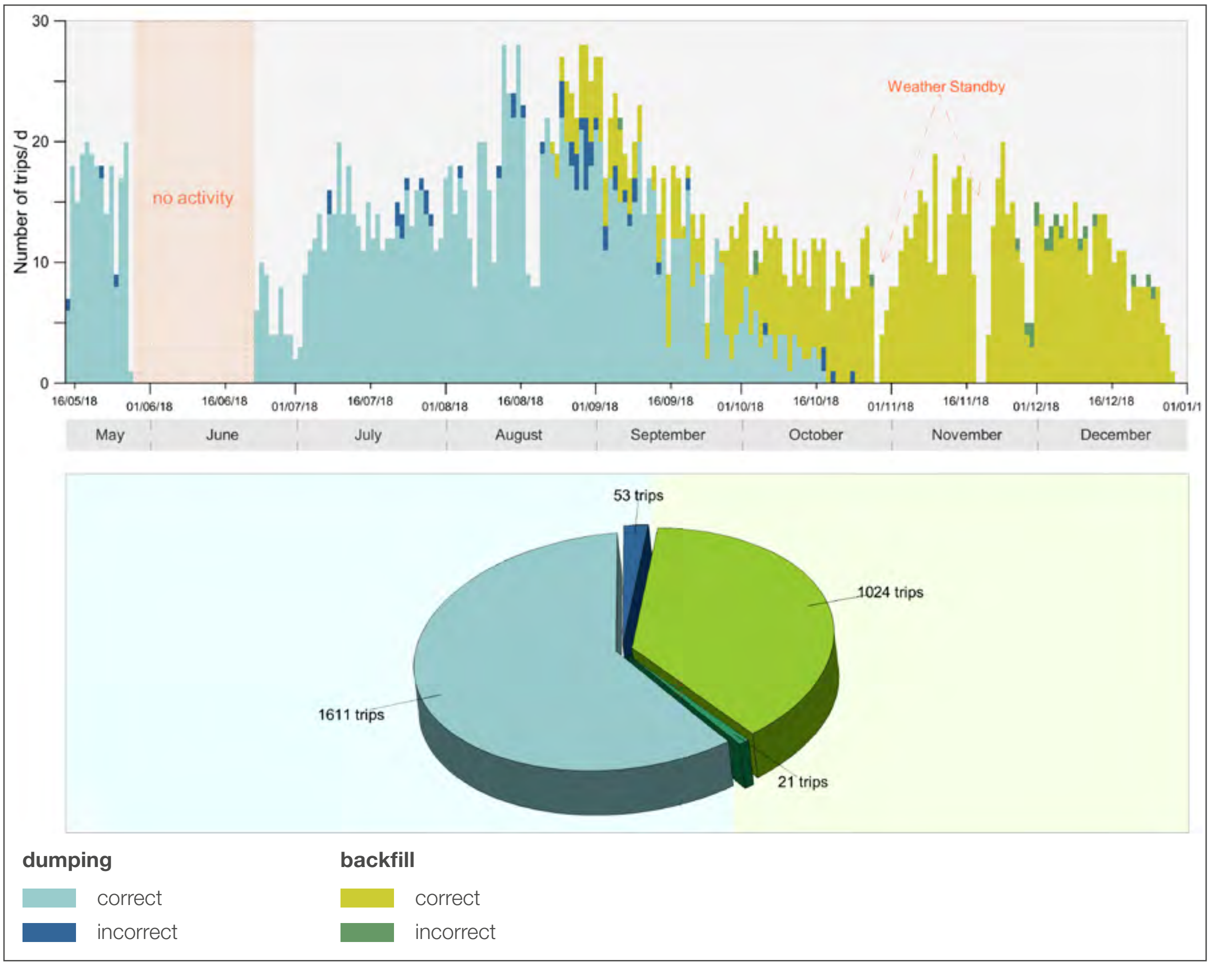


Figure 32. *Results of Soil Management Plan Monitoring: correct/incorrect separation of soil types during storage and backfilling.*

Furthermore, tracking of the dredging operations made it possible to draw up a final balance sheet of soil volumes handled, a condition of the main permit designed to protect the seabed. Nord Stream 2 dredged a total volume of 2.59 million m^3. Of this quantity, 2.12 million m^3 were stored temporarily offshore, 0.23 million m^3 of unsuitable marl and silt were taken ashore, and 0.23 million m^3 were lost through turbidity. During backfilling 2.85 million m^3 of material was handled. A volume of 1.22 million m^3 of sandy gravel was imported for intimate backfill after pipeline installation. Losses through turbidity amounted to 0.32 million m^3.

CONCLUSIONS

Offshore construction supervision, aimed at real-time monitoring of the implementation of the Soil Management Plan, was successful. The quality achieved during dredging and backfilling will ensure the recovery of the benthic flora and fauna.

6.3.3 Turbidity

METHODOLOGY

Turbidity monitoring was carried out during dredging, pipelay and backfilling to provide real-time feedback for direct compliance reporting and operational optimisation of the environmental effectiveness of the works by adjusting the working procedures to comply with the turbidity thresholds stated in the main permit conditions:

> Turbidity, expressed as total suspended solids (TSS), of 50 mg/l above background value at a distance of 500 m from the trench and at the disposal site (Usedom Storage Area) for no longer than 24 hours;
> Temporary and local increase in peak TSS at 500 m distance from work sites is limited to 100 mg/l above background.

Real-time turbidity control was carried out by stationary optical backscatter sensors installed 500 m off the pipeline route and in the vicinity of the interim storage area. Background values were monitored at two stations as a reference for the threshold values (see Figure 26). Stations for background measurements were also equipped with ADCP, waverider, and additional sensors to measure further oceanographic parameters.

Optical backscatter sensors are based on the nephelometric method and measured values are indicated in nephelometric turbidity units, NTU. The verification of a TSS threshold of 50 ml/l required calibration with in situ water samples. More than 500 water samples were collected and filtered (standard DIN 38409-H 2-3) for this purpose throughout the construction period. Measurements began in April, four weeks prior to the start of construction, in order to verify the status of natural variation.

Additional example turbidity measurements were conducted by mobile ADCP (operated from a survey vessel) in order to describe the propagation of turbidity plumes in the immediate vicinity of the dredgers. Acoustic devices are capable of measuring TSS from a distance and at a high temporal and spatial resolution. These measurements were implemented when stationary turbidity monitoring revealed that no increase in turbidity occurred at a distance of 500 m from the dredging works (see Figure 33).

All results were finally compared with the data from governmental oceanographic monitoring.

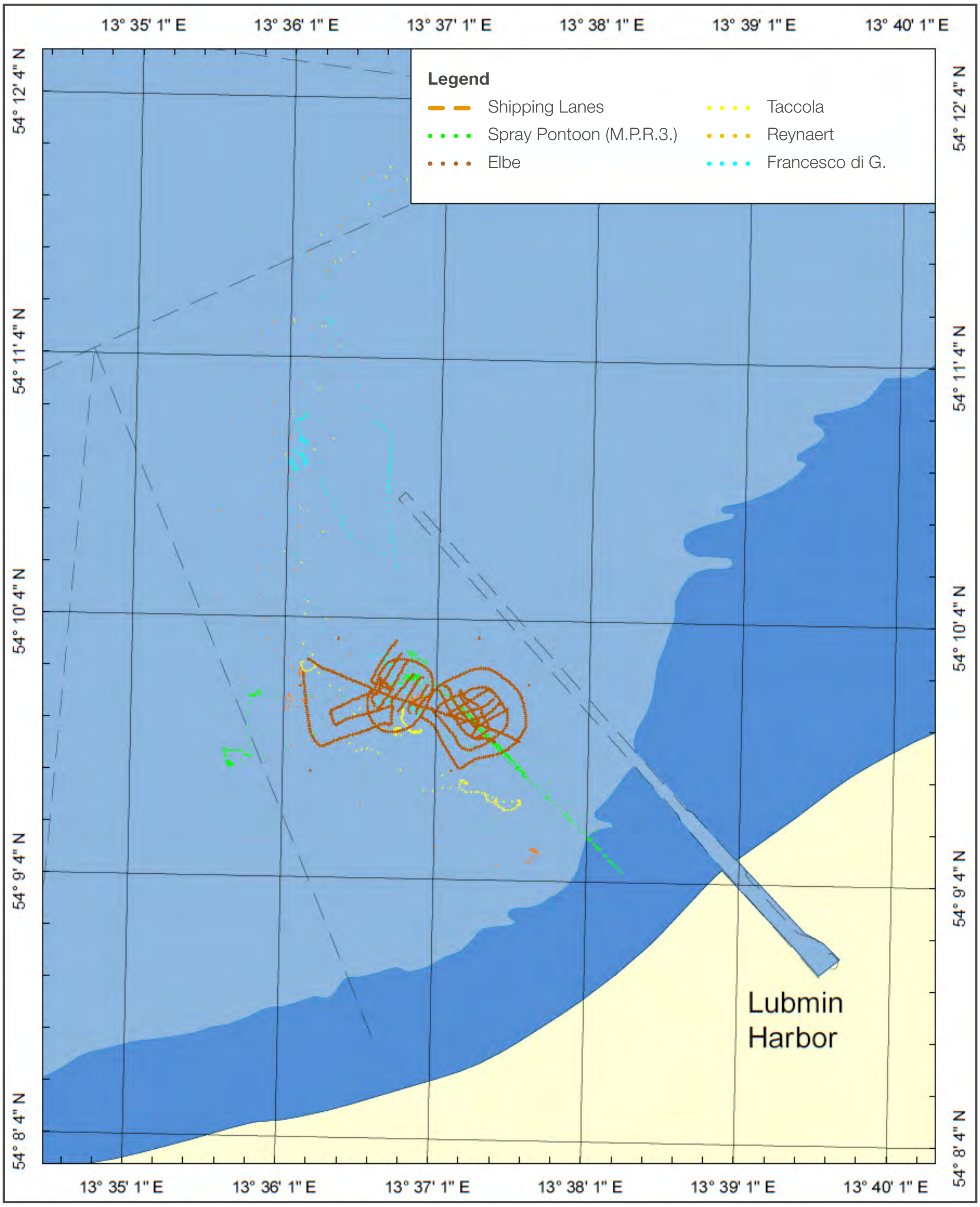


Figure 33. *Navigation tracks of dredgers (TSHDs) and spray pontoon during backfilling and the turbidity monitoring vessel "Elbe" on 29th August 2018.*

RESULTS

Turbidity in the shallow coastal waters of the German landfall is primarily a function of wave height due to natural resuspension. According to wind speed and wave height TSS commonly fluctuates between 5–50 mg/l TSS. During a storm, re-suspension starts within hours, sedimentation lasts for 1–2 days, when calm conditions return. A TSS of 50 mg/l has been set as the threshold for seabed intervention works, because the planktonic and benthic animals which inhabit these coastal waters can cope with short term turbidity of the respective magnitude.

Turbidity values (medians of 15 minute intervals) recorded by the stationary real-time control system never exceeded the threshold value. TSS peaks that could be assigned to the seabed intervention works of Nord Stream 2 ranged between 30 and 40 mg/l (20–30 mg/l above the natural background). For instance, such a peak in turbidity (20 mg/l above the natural background) was recorded at Boddenrandschwelle, when the shallowest route section was being backfilled during the last few days of October (see Figure 34).

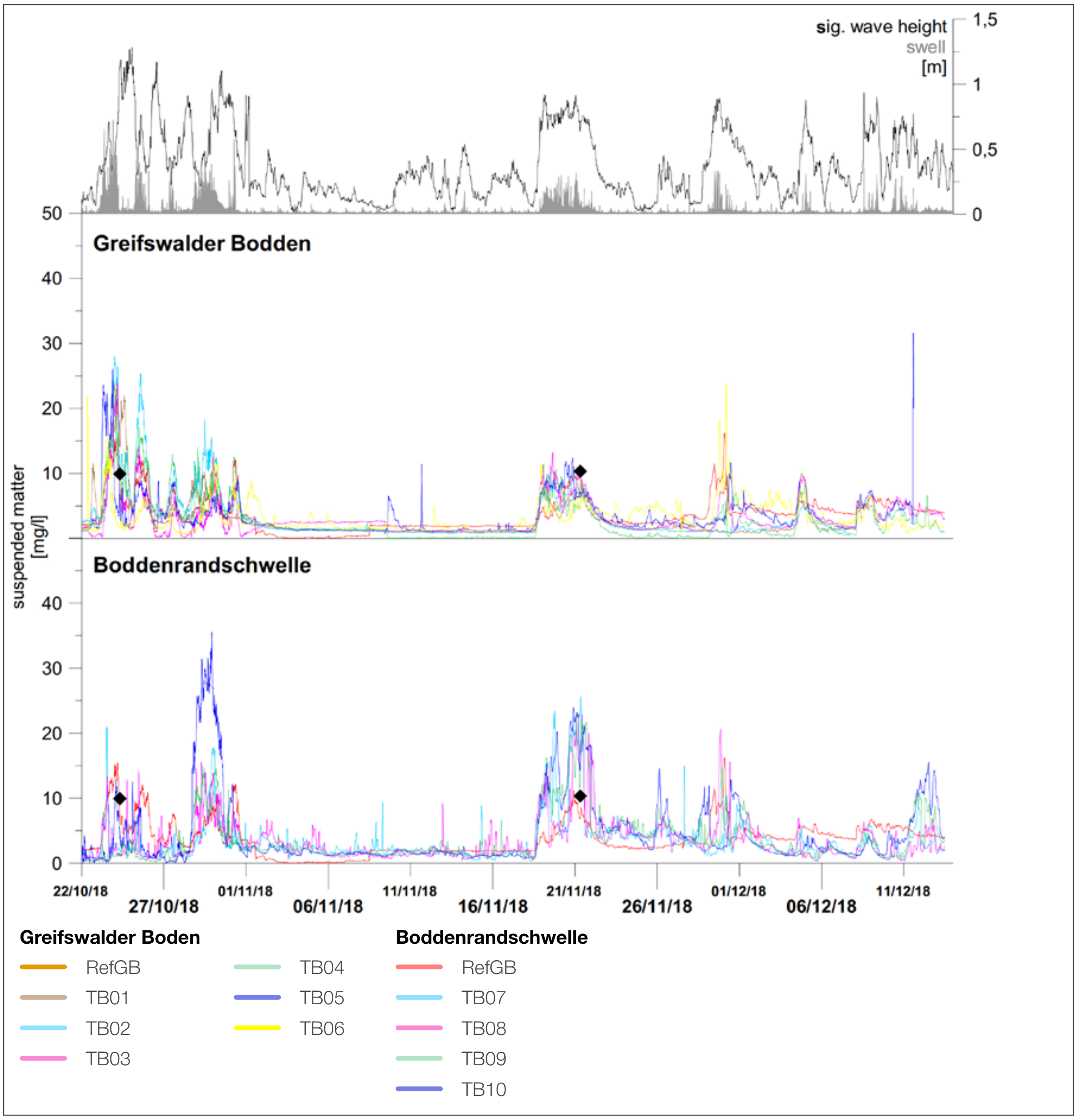


Figure 34. *Total Suspended Solids (mg/l) at 10 monitoring stations in Greifswalder Bodden (lower graphs) in relation to wave height (upper graph) during backfilling in autumn 2018. The peak at station TB10 (blue line lower graph, reference station red line) between 28-31.10.2018 represents a project-related turbidity event (backfilling). See Figure 26 for location of monitoring stations. The black diamonds denote the results of government monitoring*

Comparable results were previously recorded during construction of the Nord Stream Pipeline in 2010. However, the frequency of construction-related turbidity peaks appeared to be significantly lower during the installation of Nord Stream 2. This finding resulted from an additional mitigation measure implemented for Nord Stream 2: dredging inside Greifswalder Bodden was carried out by backhoe dredgers only. As a result not a single turbidity peak was recorded during dredging inside Greifswalder Bodden.

In order to confirm the findings of the stationary monitoring, mobile turbidity measurements were conducted by an independent survey company. All construction activities (dredging, dumping, and backfilling) were investigated. These surveys revealed that turbidity plume extension during dredging by backhoe dredgers never exceeded a range of 150 m from the vessel with peak TSS values of 150-200 mg/l in the immediate vicinity of the shovel. Similar results were reported during backfilling operations (see Figure 35) /30/.

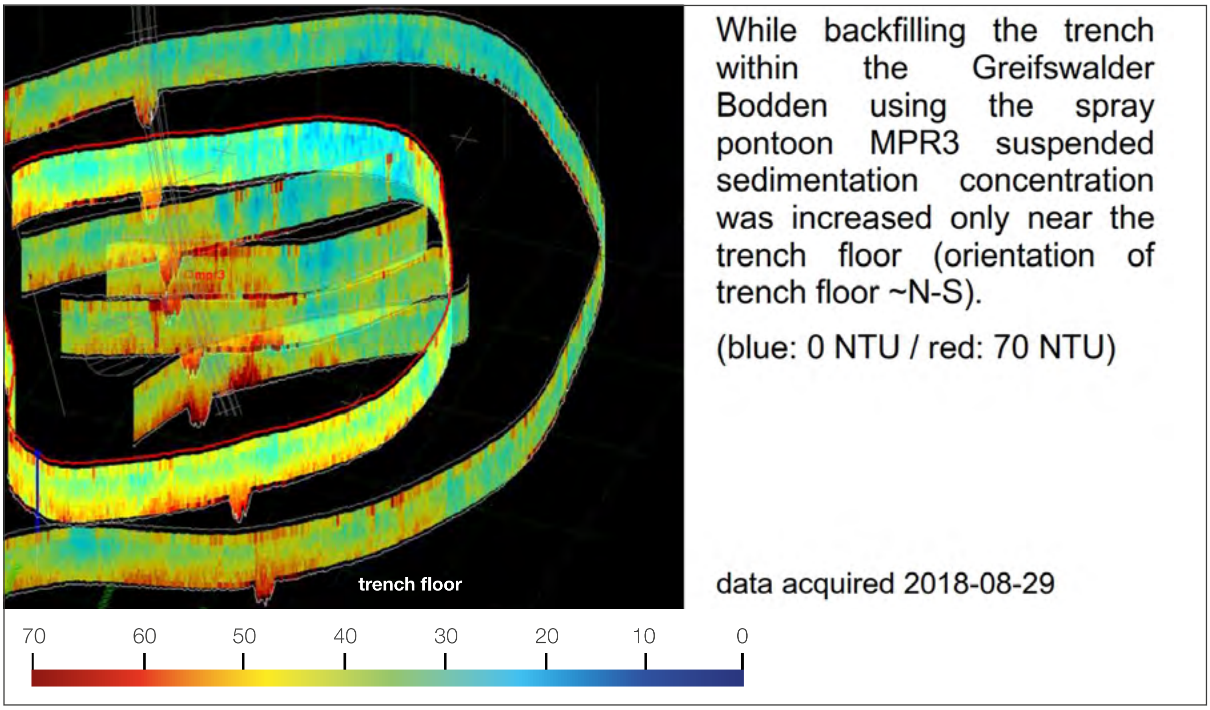


Figure 35. *Navigation tracks of the turbidity monitoring vessel "Elbe" on 29th August 2018 during backfilling of the trench by spray pontoon. The colour scale describes relative changes in turbidity values (blue – 0 NTU, red 70 NTU). Compare with Figure 33 above.*

CONCLUSIONS

Turbidity values resulting from seabed intervention works consistently remained within the threshold defined by the permit condition. By introducing a new approach (dredging inside Greifswalder Bodden by backhoe dredgers only) the extension of turbidity plumes could be kept to a minimum. Monitoring of the sediment management plan together with turbidity monitoring revealed that the overall suspended volume was about 0.5 million m^3. Compared with the Nord Stream offshore installation works in 2010, this represents a reduction in overall turbidity of 50 %.

6.3.4 Underwater noise

METHODOLOGY

Underwater noise immission was recorded at a station 1000 m off the pipeline route in Pomeranian Bay from 15.09.–15.12.2018 (see Figure 26). Measurements and data analysis followed the provisions of the standards StUK (2013) and ISO 18406. Since Nord Stream 2 vessels were operating within a radius of 5 km throughout the period of underwater noise monitoring, no background measurements were carried out. Background measurements were conducted extensively in 2010 and 2011 during installation of the Nord Stream pipeline. Underwater noise recordings were later assigned to specific vessels of the Nord Stream 2 fleet on the basis of AIS data analysis. The AIS data of third party vessels was anonymised prior to analysis.

RESULTS

The median sound pressure level (SPL 24 h) during dredging works was 130 dB re 1 µPa², and 139 dB re 1 µPa² one kilometre off the route during pipelay works, respectively. The median sound pressure level was higher during pipelay due to the longer duration of vessel presence per position (see Figure 36). A maximum sound pressure level (SPL 24 h) of 143 dB re 1 µPa² one kilometre off the route was recorded for both activities. Respective values for background noise were: median sound pressure level 120 dB re 1 µPa², and maximum sound pressure level 126 dB re 1 µPa². The comparatively high background value results from the regular commercial shipping traffic from/to Świnoujście (Poland).

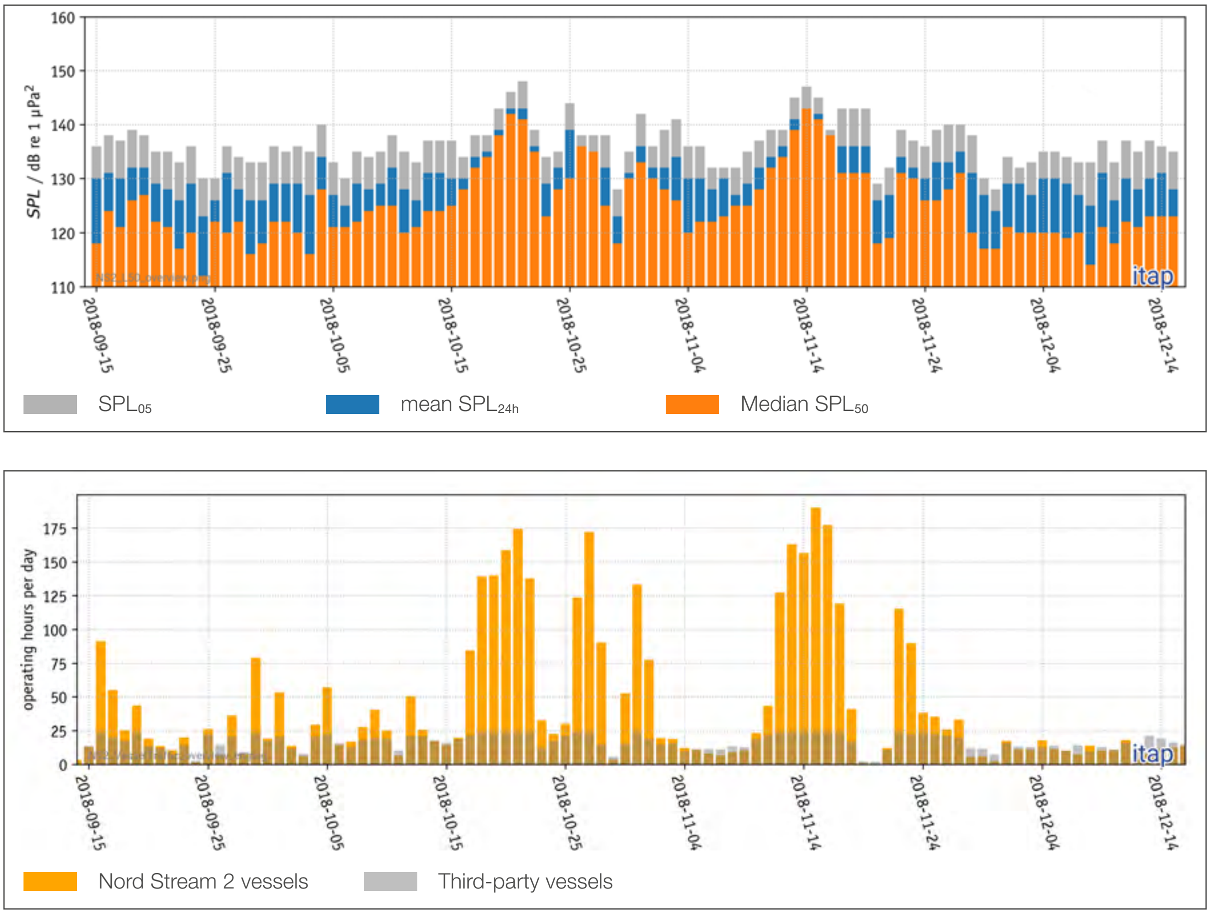


Figure 36. *Above: Mean sound pressure level during 24 hours (SPL 24 h) and 5 % and 50 % percentiles (SPL05, SPL50) one kilometre off the route. Below: working hours per day of Nord Stream 2 construction vessels (orange bars) and third party vessels (grey bars) within a radius of 5 km from the monitoring station.*

Ship-specific analysis revealed highest immission values for trailer suction hopper dredgers (> 130 m in length) and support vessels of the "Audacia" pipelay fleet, operating as anchor handling tugs.

CONCLUSIONS

The results of underwater noise monitoring indicate that the noise threshold associated with temporary hearing threshold shift (TTS) in marine mammals was not exceeded. Sound pressure levels recorded during dredging works and pipelay may have caused temporary displacement of harbour porpoise in the vicinity of the operating construction fleets.

6.3.5 Marine mammals

METHODOLOGY

Two species of marine mammals inhabit the coastal waters of the German route section. Baltic grey seals *Halichoerus grypus grypus* use a number of haul-out sites in the eastern part of the Greifswalder Bodden. They are located in the immediate vicinity of the route and the interim storage area, respectively. Grey seals are quite mobile over the course of the year and the local population uses the entire south western Baltic Sea as its home range /31/. Harbour porpoises *Phocoena phocoena* occur in the northern Pomeranian Bay at low density during summer and autumn only. Due to their seasonal distribution pattern, it is concluded that these animals belong to the western management unit of the Danish Belt Sea /32/. The presence and seasonality of both species were monitored during offshore construction.

Grey seals were monitored by simultaneous monthly counts of individuals in the vicinity of the haul-out sites (see Figure 26). Grey seal haul-out counts were also conducted by local conservation authorities and PhD students, thereby increasing the overall dataset. The number of individuals visible at haul-out sites represent only a portion of the local population. The total number of seals offshore remains vague.

Harbour porpoise monitoring was conducted by passive stationary recording of their echo-location clicks. In total, 13 stations equipped with so-called C-PODs (cetacean porpoise detector) were installed across the Pomeranian Bay, with 7 stations located in the vicinity of the pipeline route (see Figure 26). A similar monitoring programme, using the same spatial layout, was conducted between 2010 and 2013 during the environmental monitoring for Nord Stream. The approach also mirrors the method applied during the SAMBAH project /33/.

C-PODs are capable of remotely recording, extracting and counting porpoise click trains. They do not allow for recognition of individuals. Hence, the monitoring provides information about the presence and relative intensity of use, but not for quantitative analysis. Due to the rare presence and very low abundance of harbour porpoises in the Pomeranian Bay, quantitative survey techniques (ship-based or aerial surveys) are not applicable.

The potential effect of offshore construction work on porpoise presence was analysed by generalised additive modelling taking account of AIS data for dredging and pipelay spreads and third party vessels, passing C-POD stations within a radius of 2 km.

RESULTS AND CONCLUSIONS

Grey seal

More than 800 grey seals were counted during the survey period April 2018 (pre construction) to April 2019 (post construction). The consolidated results and conclusions will be presented in the 2019 report.

Harbour porpoise

The presence, distribution pattern (see Figure 37) and seasonality (see Figure 38) of the harbour porpoise recorded in 2018 mirrored the pattern recorded during Nord Stream monitoring in 2013 (2 years after construction). The highest detection rates were recorded in the north-west of the Pomeranian Bay and in the vicinity of the Nord Stream 2 route. Detection frequency peaked during pipelay in the Pomeranian Bay in October.

Harbour porpoises are exposed to ship traffic in the Pomeranian Bay in general (see Figure 39). The porpoise detection rate per station was significantly affected by vessel traffic. Due to the rarity of harbour porpoises, the displacement effect could not be specifically assigned to Nord Stream 2 traffic or third party traffic (see Figure 40).

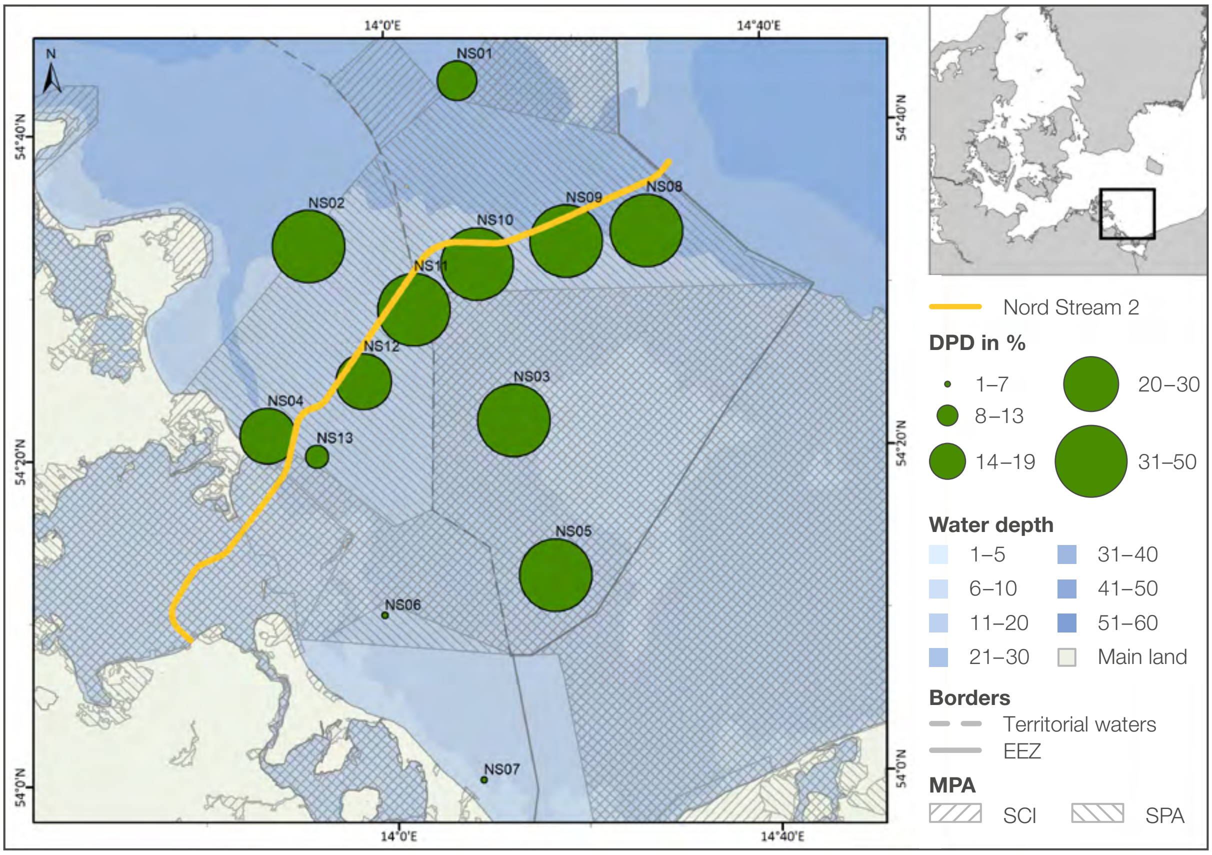


Figure 37. *Mean detection rate per month (%DPD) per station between July and December 2018 in Pomeranian Bay.*

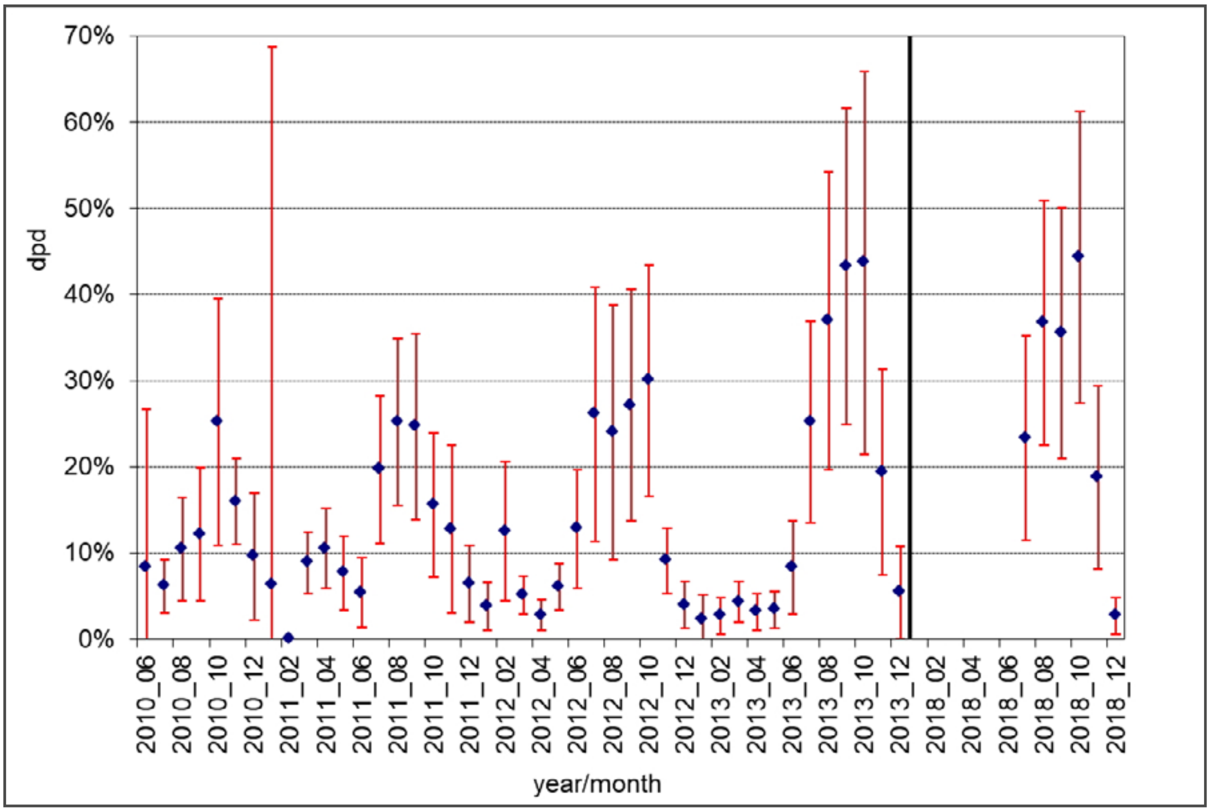


Figure 38. *Trend in mean detection rate per month (%DPD) between 2010 and 2018.*

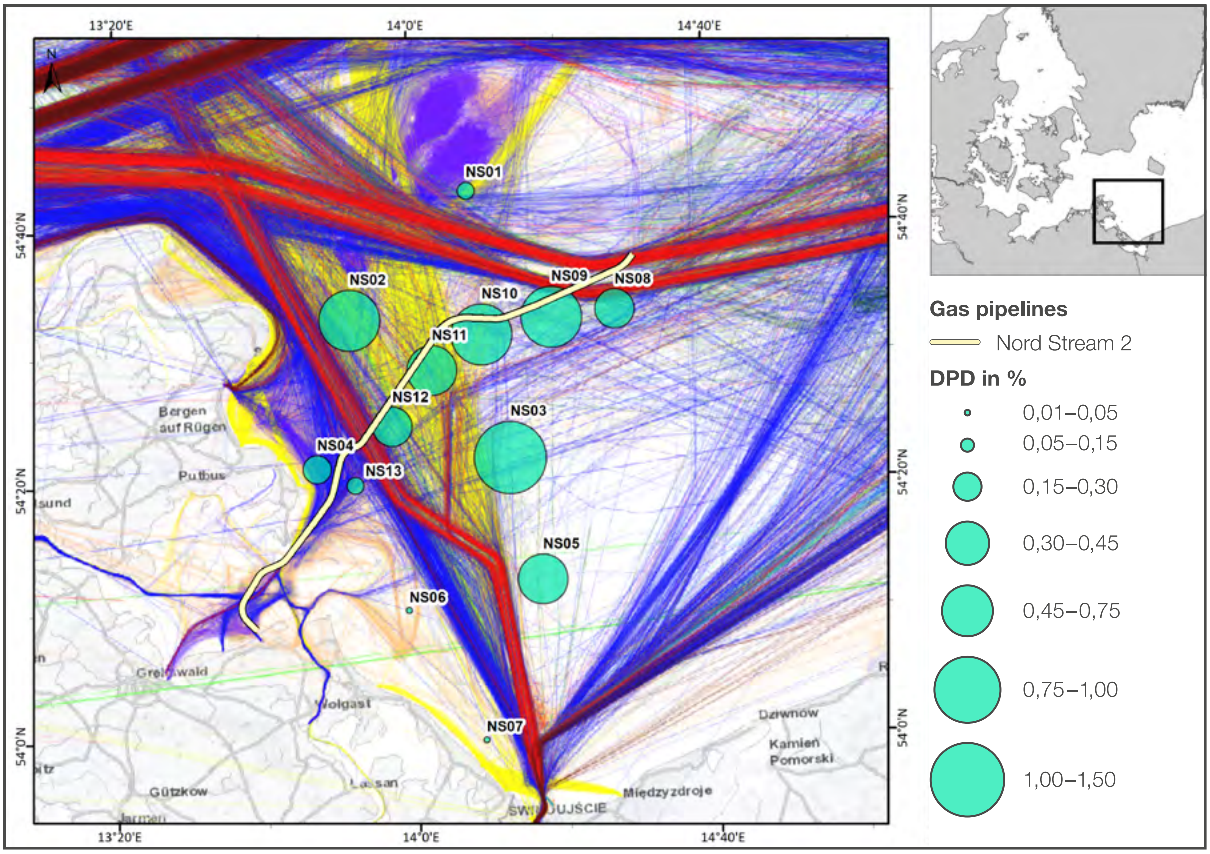


Figure 39. *Mean detection rate per 10 minutes/day (DP10M/d) per station between July and December 2018 in Pomeranian Bay in relation to AIS tracks of vessel traffic (havbase.no, colouration denotes different types of traffic).*

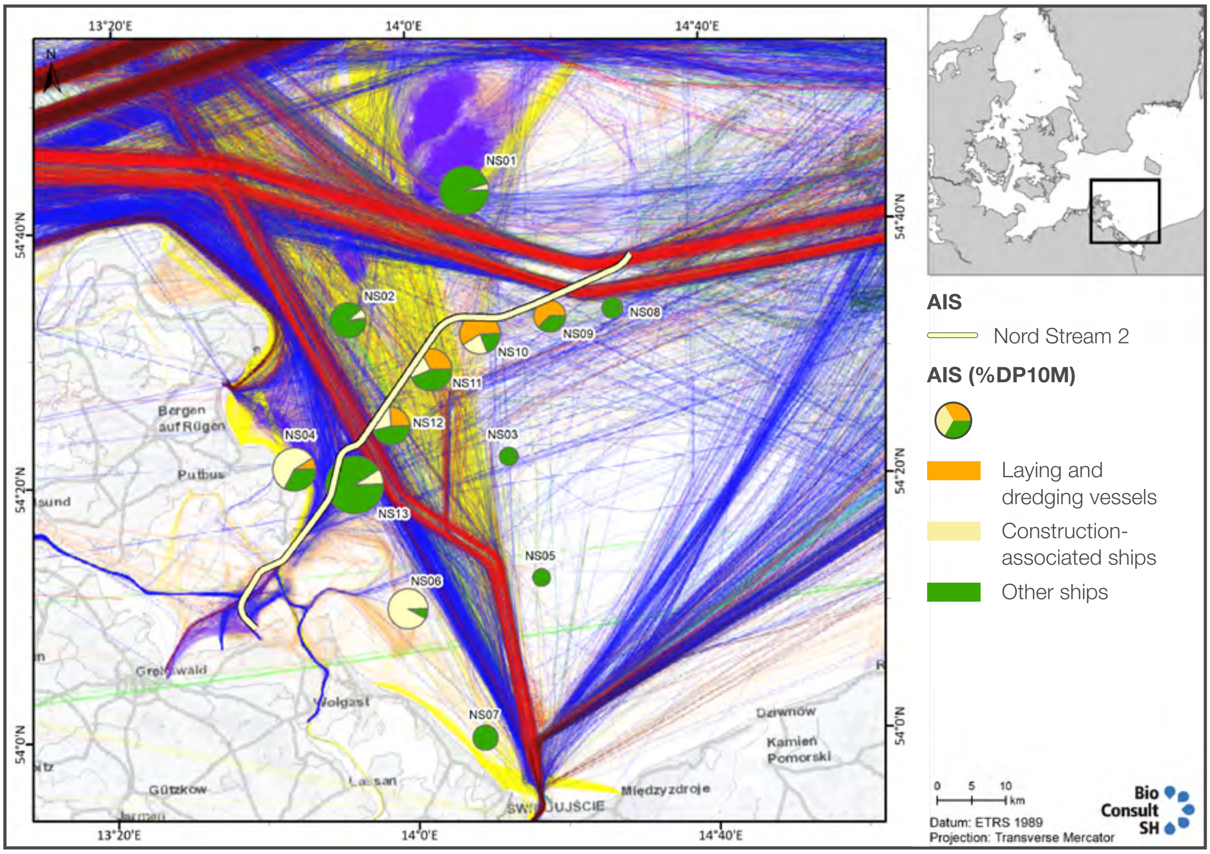


Figure 40. *AIS tracks in Pomeranian Bay between July and December 2018 (havbase.no, colouration denotes different types of traffic). Proportional circles denote the number of AIS tracks recorded within a radius of 2 km around each C-POD (relative numbers). Pie slices refer to NSP 2 dredging and pipelay spreads (orange), associated vessels (beige), and third party vessels (green). DP10M–Detections per 10 minutes.*

6.4 Pipelay

Pipelay of the Nord Stream 2 pipelines is carried out by DP vessels on the offshore sections and by anchor vessel on the nearshore sections of the pipeline.

Environmental monitoring during pipelay is planned in Russia, Germany and Sweden (see Table 12). In 2018 no pipelay occurred in Russia and no monitoring was required during pipelay in Finland. In Sweden monitoring of underwater noise during pipelay is only planned in the Natura 2000 area, scheduled in 2019. Therefore, the section below presents only the monitoring of ship traffic associated with pipelay in Sweden and Germany. Monitoring of seabed sediments, turbidity, underwater noise, birds and marine mammals was undertaken for all construction activities in Germany, including pipelay. Conclusions on monitoring of these parameters are included in Chapter 6.3 (Dredging in Germany) since dredging is considered to cause greater impacts compared with pipelay.

Table 12. Overview of monitored parameters during pipelay.

	Parameters included in the monitoring programme								
	Water quality and Turbidity	Seabed sediments	Underwater noise	Marine mammals and birds	Fish migration **	Ichthyofauna	Ichthyoplankton**	Plankton and benthos	Ship traffic*
2018	G	G	G	G					S, G
2019	R	R	S	R**	R	R	R	R	S, G

R-Russia; S-Sweden; G-Germany
*Monitoring of ship traffic is performed in all countries where relevant construction activities take place; additionally in Sweden and Germany monitoring of ship traffic is part of the national monitoring programmes.
**Seasonal monitoring.

Pipelay and associated monitoring is shown in Figure 41.

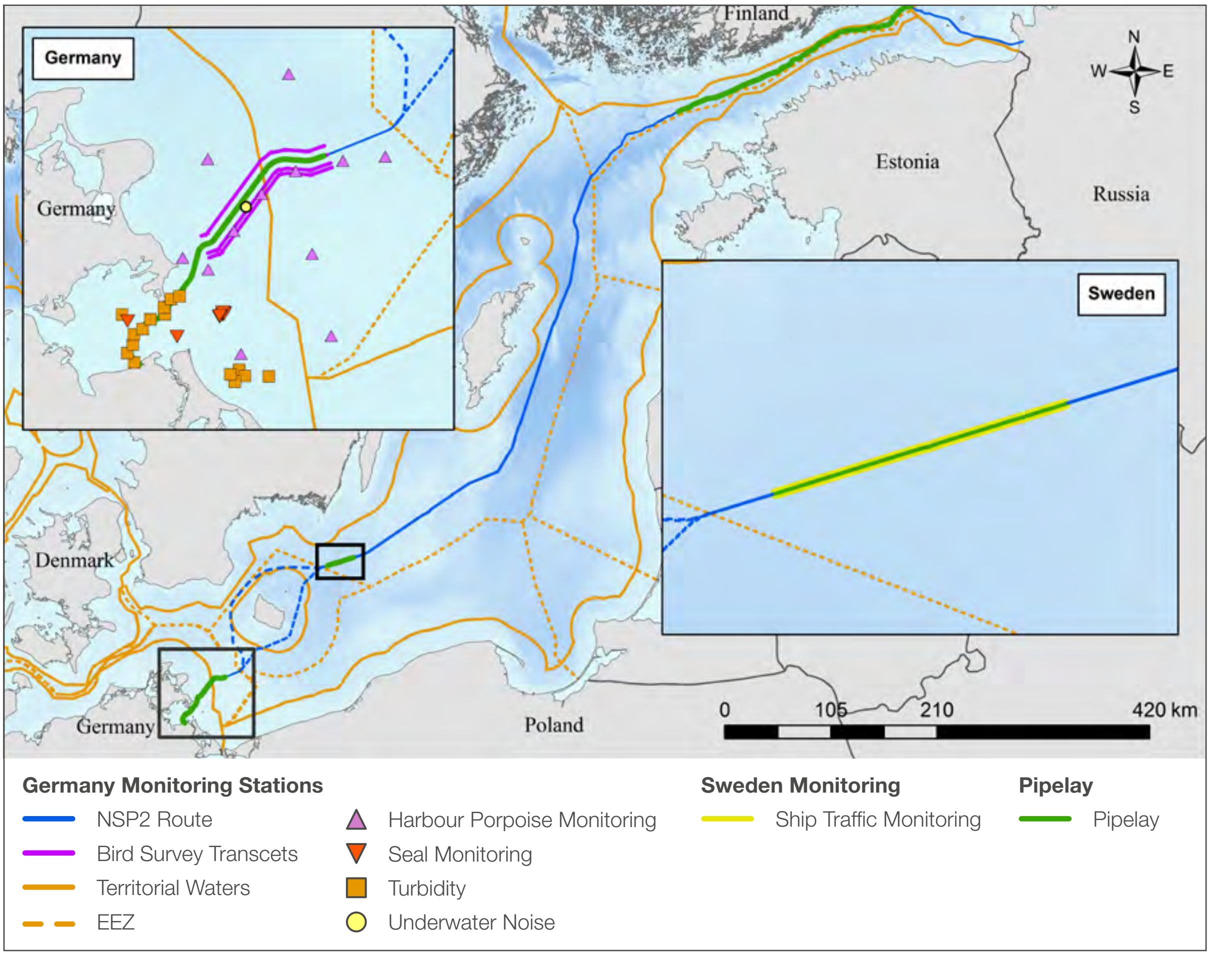


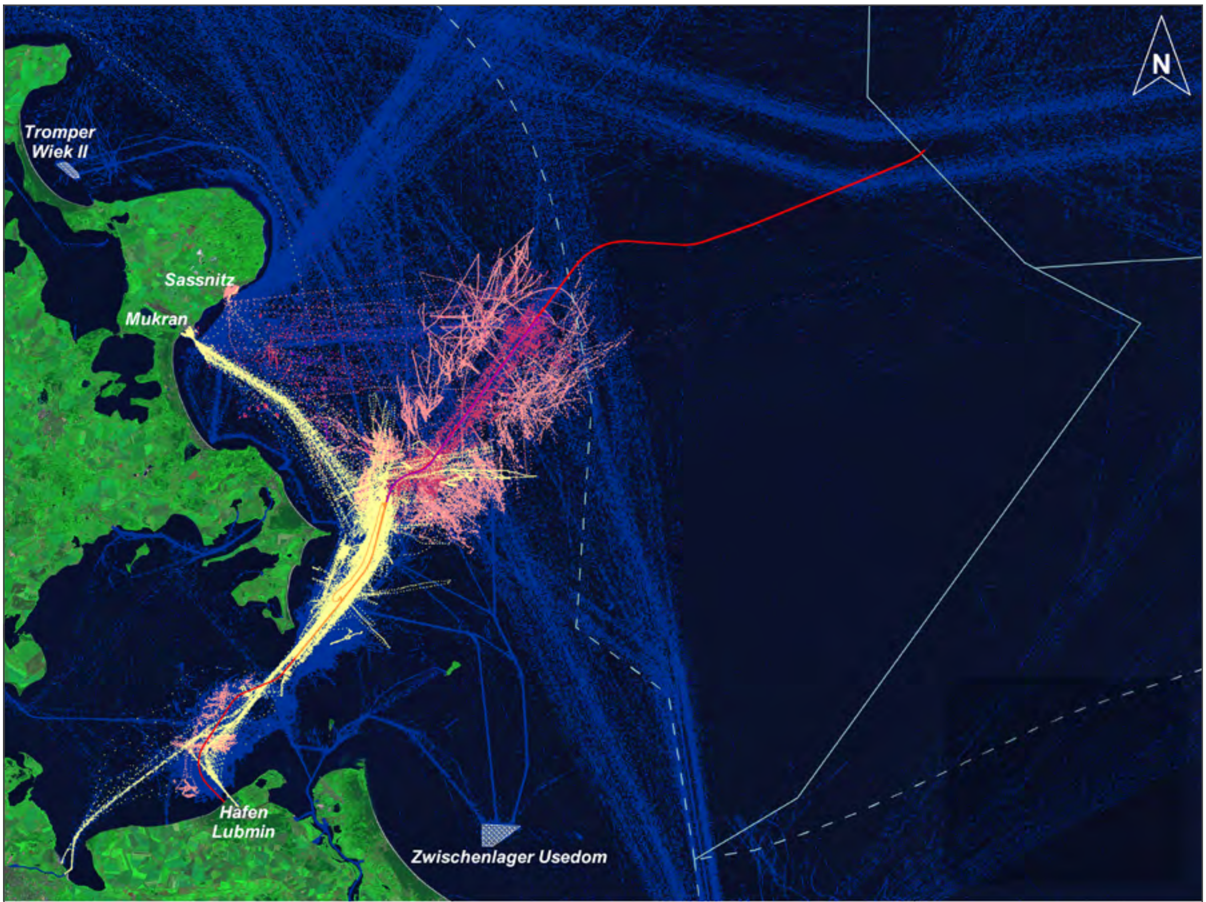
Figure 41. Environmental monitoring associated with pipelay.

In 2018, monitoring of pipelay included monitoring of ship traffic in Sweden and Germany. From the monitoring results it appears that pipelay in 2018 did not cause any hindrance to shipping traffic in the Swedish EEZ (see Chapter 6.4.1). No incidents were recorded and communications to the authorities were in line with the relevant permit provisions. In Germany ship traffic management was handled in close cooperation with the relevant authorities. No incidents were reported (see Chapter 6.4.2).

6.4.1 Ship traffic in Germany

In Germany, vessel traffic was monitored during five months of pipelay (see Figure 42). In order to coordinate traffic interactions among construction fleets and third party vessels (including recreational/leisure boats) a Marine Coordination Centre was established in close cooperation with the regional administrative maritime traffic centre. All Nord Stream 2 dredging vessels as well as the "Castoro 10" pipelay fleet were equipped with GPS-transponders for real time tracking of vessels to allow for continuous real-time control.

The vessel monitoring results (AIS data) were used to verify the displacement effect for marine mammals and seabirds (see Chapters 6.3.4 and 6.3.5), and are therefore not discussed further in this chapter.



Ship traffic – October

Pipeline course	Audacia	Castora 10	third-party vessels
EEZ	support vessels	support vessels	
12-sm border	guard vessels		

Figure 42. *AIS tracks of pipelay fleet vessels and third party vessels in Germany in October 2018.*

6.4.2 Ship traffic in Sweden

In Sweden, during the nine days of pipelay activity in 2018 (23th–31st December) the ship traffic around the pipe lay location and Karlshamn harbour was monitored.

Maritime traffic monitoring in Swedish waters in 2018 included the following activities:

- Notifications to authorities as agreed (Activity 1)[13];
- Monitor construction ship traffic using AIS data (Activity 2);
- Monitor commercial ship traffic passing the slow-moving construction vessels (e.g. the pipelay vessels) using AIS data (Activity 3).

METHODOLOGY

The methodology included gathering and analysis of construction notifications sent by Nord Stream 2 to the authorities as well as daily information sent from the construction ships. Historical AIS data was analysed for confirmation of actual construction activities within the Swedish EEZ as well as movement to and from the construction locations.

RESULTS

Activity 1

The results showed that Nord Stream 2 complied with the permit commitment to notify the shipping authorities at least one month before the start of construction works. Analysis of the correspondence between Nord Stream 2, the authorities and other stakeholders indicates that the information was provided as agreed. In most cases the construction vessels did send notifications to the authorities 24 hours before the work was scheduled to commence in the Swedish EEZ (and in all cases before any work was started).

Meetings with the shipping authorities were held on a regular basis and the authorities confirmed during these meetings that they felt that the communications from Nord Stream 2 and the respective vessels worked well.

Activity 2

Analysis of historical AIS data gathered from the Swedish Maritime Administration confirmed that the movements of the construction vessels were within the reported areas and that official shipping lanes were used for transportation to and from the construction locations.

The work was carried out as follows: the activity log of the construction vessels was compared with reconstructed routes of these vessels from the recorded AIS data. The purpose of this analysis was to determine whether the activity log was consistent with the reconstructed routes based on the locations and times of the ships‘ movements.

The monitoring shows only a few minor discrepancies between the reported construction vessel behaviour, for example the linepipe was delivered to the correct locations but on slightly more days or at different times than previously communicated in the notifications to the authorities. Overall, there was a good match between the notification information and the actual work performed.

13 Monitoring of shipping traffic is performed in all countries where relevant construction activities take place; in Sweden monitoring of shipping traffic is part of the national monitoring programme.

Activity 3
The purpose of this activity was to document that commercial ship traffic had safe and free navigation when passing the construction vessels and that the safety exclusion zone around the Nord Stream 2 construction vessel was respected. Navigation safety was confirmed by monitoring of third-party vessel movements.

Given that the pipelay vessels have the biggest safety zones (1 nm) to be avoided by third party vessels, this report concentrates on the traffic around these particular vessels. During 2018, pipelay activities took place from 23th–31st December and were carried out by the vessel Solitaire. The vessel's crew reported that there was very little shipping traffic in the construction area and that no commercial ships came close to the pipelay vessel or entered its safety zone. This was confirmed by reviewing the routes reconstructed from the AIS data of all vessels in the area during the period 23th–31st December. The replay provides an animated view of the shipping traffic, showing that most commercial traffic passed by in the deep-water shipping lane to the north. The conclusions are, however, restricted by the limited AIS data coverage in some areas /21/.

CONCLUSIONS
There were no accidents or incidents involving maritime traffic, including fishing vessels. The impact on maritime traffic due to pipelay is thus confirmed as minor, localised and short-term in nature.

6.5 Rock Placement

In order to provide support for the pipelines and ensure their long-term integrity, rock is placed by means of a fallpipe to locally reshape the seabed before or after pipelay. Rock placement is required for free-span correction and for the crossings with other pipelines. The size and shape of each rock berm are individually designed to ensure the required pipeline support and/or protection.

Environmental monitoring during rock placement is planned for Finland, Sweden and Russia (see Table 13). In 2018, no rock placement took place in Russia; monitoring of underwater noise in Sweden is only planned during rock placement in the Natura 2000 area scheduled for 2019. Therefore, this chapter presents the results of monitoring of rock placement in Finland. The monitoring stations are shown in Figure 43.

Table 13. *Overview of monitored parameters during rock placement*

	Parameters included in the monitoring programme					
	Water quality and Turbidity	Seabed sediments	Underwater noise	Marine mammals and birds*	Fish migration*	Ichthyo-plankton*
2018	F					
2019	R	R	S	R	R	R

R-Russia; F-Finland; S-Sweden

*Seasonal monitoring.

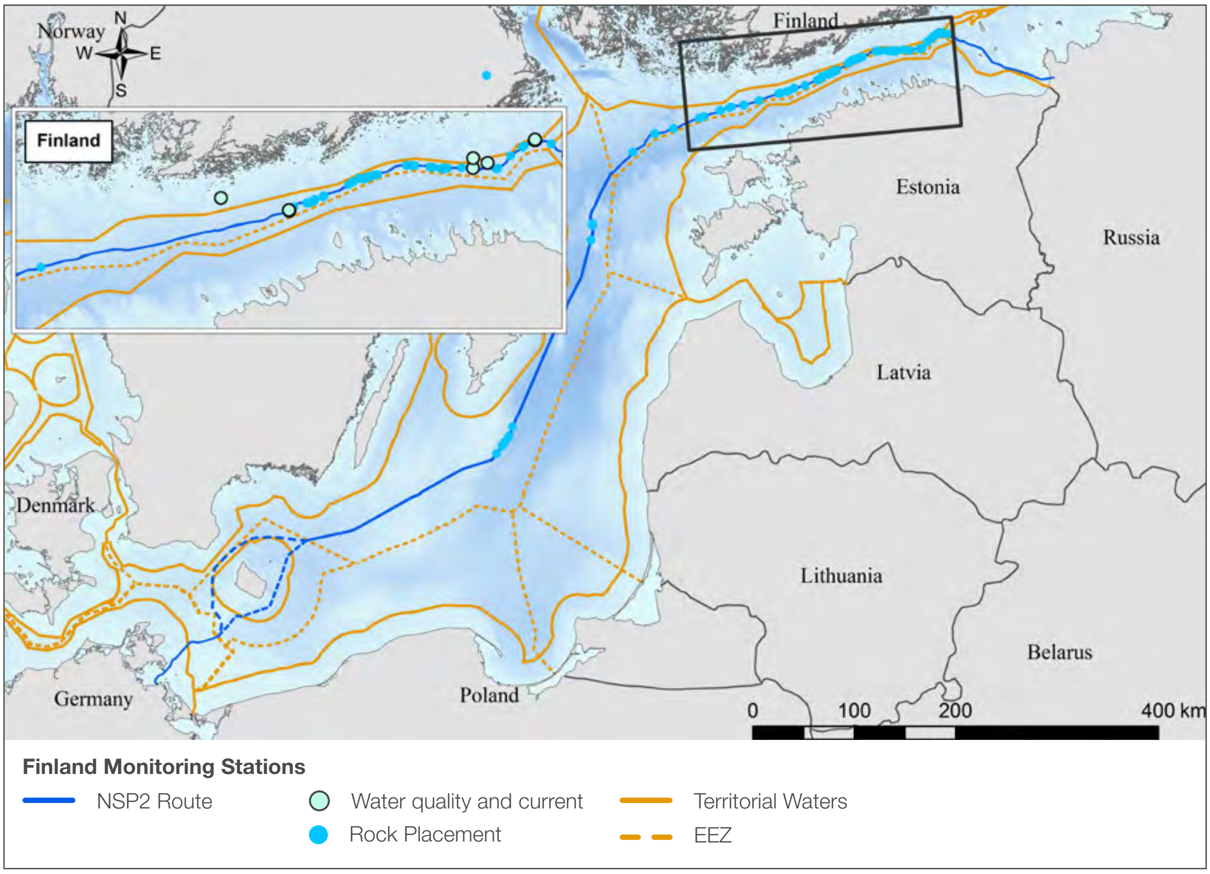


Figure 43. *Environmental monitoring associated with rock placement.*

The rock used for rock placement in Finland was clean, fresh unweathered granite. The rock material is chemically stable for the 50 year lifetime of the pipeLine And does not contain any pollutants such as heavy metals and plastics that can be released into the water environment. The rock material is transported from the port to the rock placement site by a fall pipe vessel. These are dynamically positioned vessels that load the rock material by conveyors on the vessel and use their fall-pipe, which extends through the water column, to precisely place the rock on the seabed.

Rock placement activities in Finland in 2018 caused increased turbidity levels comparable to the modelled values presented in the EIA. Measured impacts were limited both in terms of space and duration: the temporarily increased turbidity levels were unlikely to cause any impacts on the marine environment (see Chapter 6.5.1).

6.5.1 Turbidity and water quality

The local placement of rocks on the seabed, especially when placed on seabed characterised by soft sediments, can cause sediment resuspension which may have some impacts on the marine environment. The purpose of monitoring turbidity and water quality is to evaluate:

> How far and for how long the sediments originating from construction operations can travel;
> How high the sediment plume can rise from seabed;
> How high the maximum turbidity readings are;
> How much the construction-related sediment spread elevates background levels at each monitoring location;
> How well the impacts modelled during the EIA phase match the measured values.

METHODOLOGY

Water quality and current monitoring was carried in the vicinity of 2 rock placement stations, 2 munitions clearance locations (discussed in Chapter 6.1), 2 control stations, and near the Sandkallan protected area (to monitor different construction activities).

The monitored berms were selected on the basis of size (a medium sized berm and one of the largest berms constructed in Finland) and location on the seabed (located on soft seabed). At each rock placement location, a triple monitoring array was used in a triangular configuration around the berm and each array measured salinity, temperature, oxygen and turbidity at three water depths (2,5 and 15 m above the seabed). In addition, one array was equipped with an ADCP current profiler that measures current speed and direction through the water column. Monitoring near the Sandkallan protected area was also set up in the same way. Only one monitoring array was installed at the control stations.

Monitoring at the rock placement sites started at least 1–2 weeks prior to the construction operation in the area and lasted until at least 1 week after the operations were completed at each monitoring location. Monitoring at Sandkallan and at the control stations is long term: the control stations are monitored to collect background information on the natural and seasonal variability of turbidity levels, and Sandkallan is monitored to assess the environmental conditions of its reef habitats during construction activities. Long-term monitoring started 2 weeks prior and will continue for 4 weeks after the end of the construction phase.

RESULTS

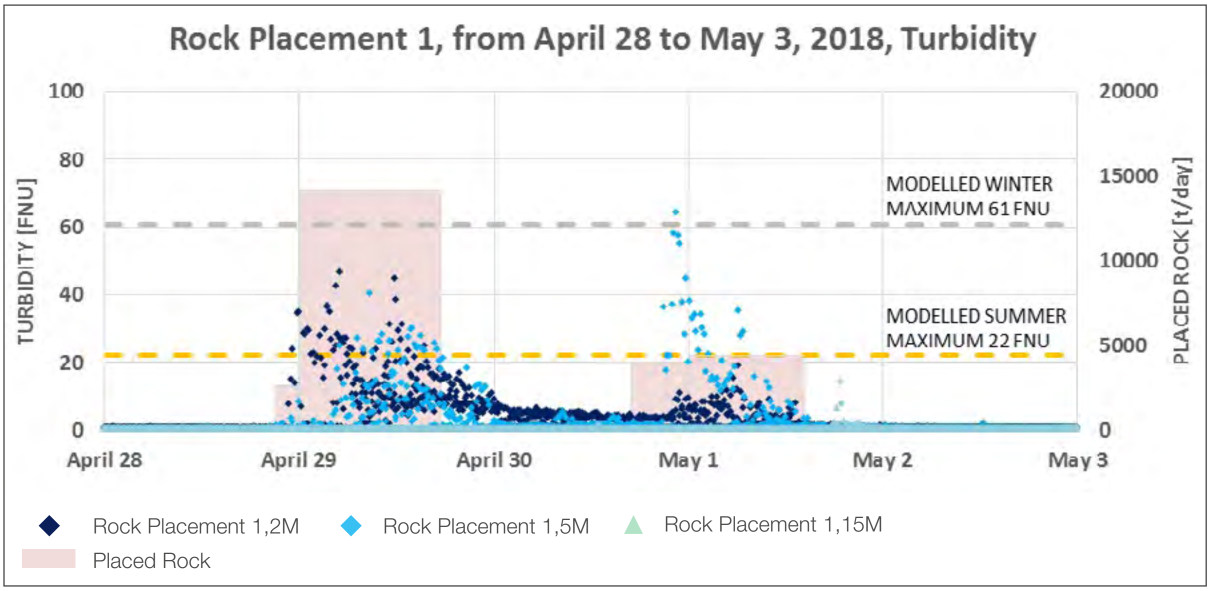
A total of 25,000 tonnes of rock were placed at the largest monitored berm and 9,000 tonnes were placed at the medium-sized monitored berm.

The impact of rock placement on turbidity was clearly detected by the network of turbidity sensors for both monitored berms (Figure 44). However, the turbidity measurements were significantly lower for the second berm compared to the first.

Turbidity measurements from monitoring the largest monitored berm (top graph in Figure 44) were generally in line with the modelled data presented in the EIA (model for summer conditions) with only one record of measured turbidity above the maximum modelled value of 61 FNU[14]. All the high values were measured close to the bottom at distances of 2 and 5 metres. Turbidity values decreased below 10 FNU in 6.5 hours and below 2 FNU in 44 hours after the rock placement operation was completed (measured at 200–300 m from the berm).

Turbidity measurements from the medium-sized berm were never above the modelled turbidity values presented in the EIA report. The highest single measured value was 13 FNU while all other measurements were below 10 FNU (see bottom graph in Figure 44). Turbidity plumes were visible only during the rock placement operation and turbidity values decreased to background levels below 1 FNU immediately after completion of the rock placement operation /24/.

14 During the Finnish monitoring campaign, water quality samples were collected at each monitoring station to allow for calibration of turbidity unit versus Total Suspended Sediments in mg/l. Turbidity readings were very low: the conversion factor derived from the measurements was established at 1:1. This is applicable for turbidity measured in Finland as part of monitoring of munitions clearance and rock placement.



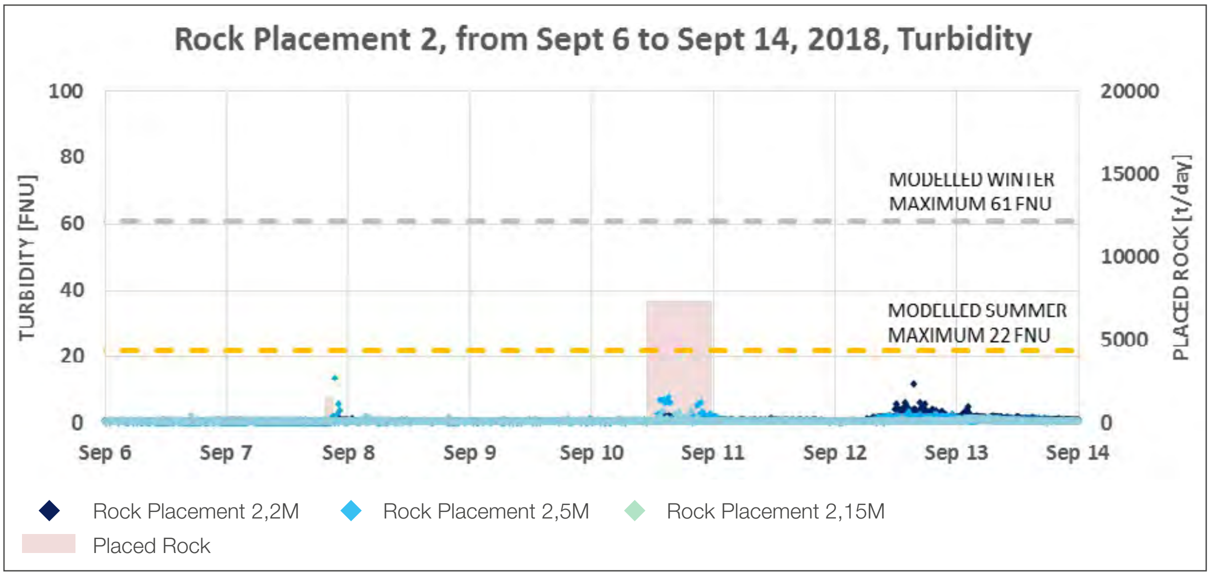


Figure 44. *Measured turbidity data recorded at 2 m, 5 m and 15 m above the sea floor during the rock placement operation at the monitoring sites Rock Placement 1 and 2. The pink colour indicates the total amount and duration of rock placement.*

CONCLUSIONS

Two turbidity models were presented in the EIA report: one based on summer weather conditions and one based on winter weather conditions: the measured turbidity values relating to rock placement activities were a better match with the EIA phase model for winter conditions than for the summer model. The highest turbidity values were measured in May, when the stratification structure is still weak and closer to the modelled winter conditions than strong summer stratification, which correlates with stronger current conditions in the bottom layer. The highest measured values were also at the same level with Nord Stream monitoring of similar construction sites (the highest recorded turbidity in the Nord Stream monitoring was 53.8 FNU).

Also, the duration of the impacts was less than assessed both in the EIA (concentrations above 2 FNU were modelled to last 24 h in winter conditions) and in the permit application (concentrations above 10 FNU were modelled to last a maximum of 19 h). The measured turbidity was generally comparable to or below the predicted values, leading to the conclusion that no impacts from increased turbidity due to rock placement occurred in Finland in 2018.

6.6 Dredged soil storage (Ust-Luga bay)

The soil excavated during dredging activities in Russia is stored in temporary and permanent storage areas. Monitoring of the temporary storage area is discussed as part of the monitoring of the dredging activities in Russia (see Chapter 6.2) while the monitoring of the permanent storage area located in Ust-Luga Bay is discussed in this chapter. Monitoring of dredged soil management in Germany is discussed as part of the monitoring of dredging activities in Germany (see Chapter 6.3).

Monitoring of dredge spoil placement in Russia included monitoring of water quality, seabed sediments and hydrobiology: the purpose of the monitoring was to evaluate the impact of construction activities on the environment and allowed for remedial actions to be put in place.

The monitoring stations are shown in Figure 45. Dredge spoil placement took place approximately 400 m north of R_PD_01.

Table 14. *Overview of monitored parameters during dredge spoil placement.*

	Parameters included in the monitoring programme		
	Water quality	Seabed sediments	Plankton and benthos
2018	R	R	R
2019	R	R	R

R-Russia

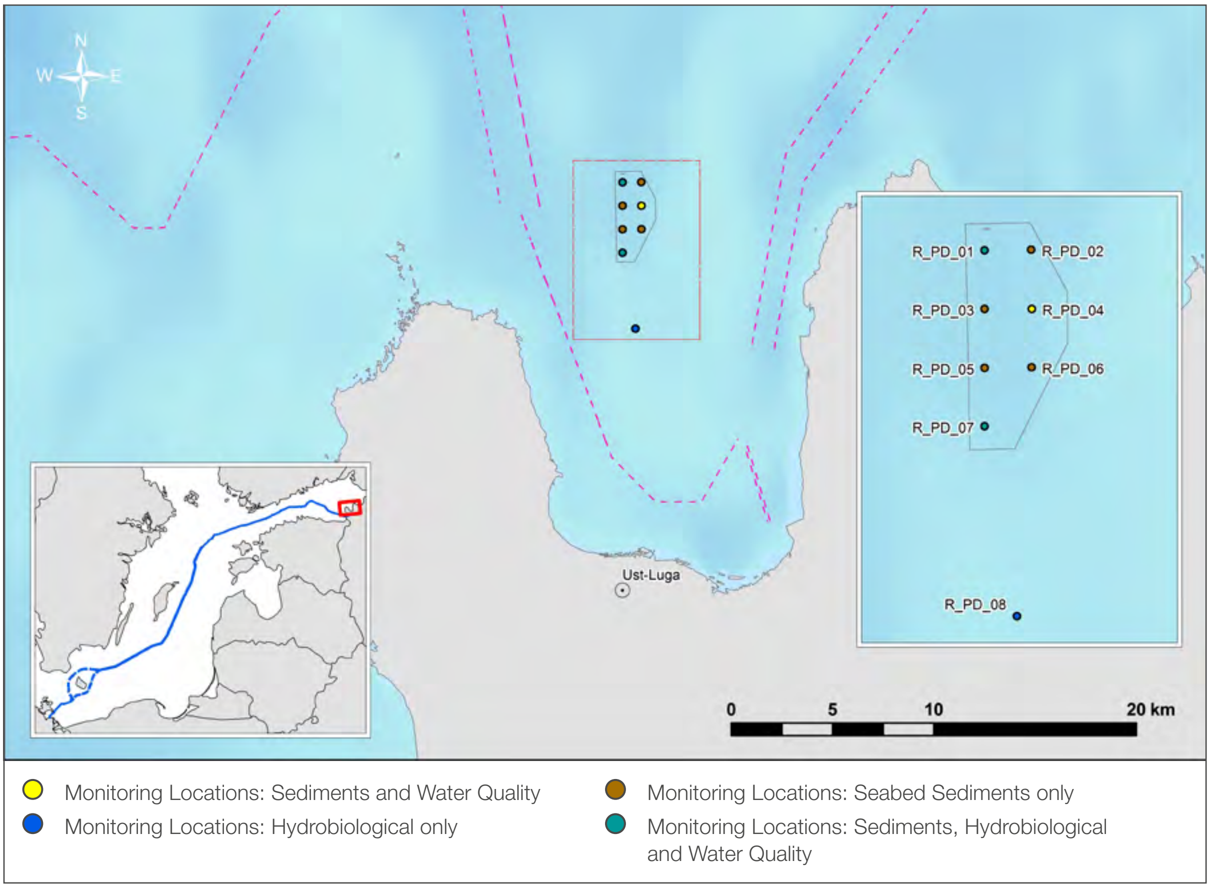


Figure 45. *Environmental monitoring associated with dredge spoil placement (permanent storage) in Russia.*

Monitoring of the abiotic and biotic environment in the area affected by storage of dredge spoil showed that the construction activities did not have a detrimental effect on the environment. Water quality (see Chapter 6.6.1) and sediment quality (see Chapter 6.6.2) were not affected by the construction activities and the measured pollutant concentrations, which are generally low, are not attributable to the Nord Stream 2 project and are in line with the literature data. Neither was the biotic environment affected by the construction activities (see Chapter 6.6.3).

6.6.1 Water quality

Monitoring of water quality associated with the placement of dredge spoil material was undertaken in order to evaluate changes in the marine environment due to resuspended sediments originating from the construction activities. The main purpose of the monitoring was to evaluate the changes in turbidity and pollutant concentrations due to sediment resuspension. Water quality thresholds are defined on the basis of Russian legislation, such as the SanPiN 2.1.5.2582-10 standard.

METHODOLOGY

Water sampling was carried out in the surface and bottom horizons at 3 stations coinciding with the bottom sediment monitoring points (see Chapter 6.6.2). Monitoring took place prior to and after the dredge spoil placement. A total of 12 water samples were analysed by an accredited laboratory for common physico-chemical water properties.

RESULTS

Overall, no negative impact on seawater quality within the dredged spoil placement site in the Ust-Luga Bay Bank area was revealed. According to the results of 2 monitoring cycles (prior and post soil placement), fairly low concentrations of pollutants were detected, some of which were present in amounts not exceeding the detection limits of the laboratory methodology used (anionic surfactants, benzo(a)pyrene, arsenic, manganese, zinc, chromium, cadmium, nickel, lead, mercury, copper). For most parameters, similar results were obtained in the baseline studies presented in the EIA in 2016.

At the station closest to where the sediments were placed (R_PD_01 in Figure 45) no changes in the concentrations of the majority of pollutants after soil placement were noted. Concentrations of toxic and non-toxic substances were comparable for the entire study area.

The results of the monitoring cycle carried out after the completion of dredged spoil placement showed an increase in the concentration of oil products in the surface horizon at all stations. A single exceedance of the statutory limit (MPC for fisheries) was detected at the station located furthest away from the disposal point (1.06 MPC). The study site is located within an area of active navigation, which was most likely the cause of the local increase in the oil products measured at the water surface /34/.

CONCLUSIONS

The monitored results highlighted that water quality was not affected by dredge spoil placement in 2018. Water quality was comparable prior to and after the soil placement and only limited amounts of pollutants were detected. At one monitoring site, oil product concentrations were elevated in one instance, probably due to the presence of the shipping lane located nearby.

6.6.2 Seabed sediments

Monitoring of bottom sediment quality associated with the placement of dredge spoil material was undertaken to determine whether changes in seabed quality (e.g. pollutant concentrations in the seabed sediments, soil composition, pH, etc.) are caused by the construction activity.

The quality of seabed sediments is regulated by the provisions of Government Decree No. 2753-p dated 30th December 2015.

METHODOLOGY

Seabed sediment monitoring was carried out at 7 stations (Figure 45). Soil samples were collected prior to and after dredge spoil placement. In addition, two soil samples were also collected from the dredging site to compare pollutant concentrations in the soil before and after its transfer to the storage site. The soil samples were analysed by laboratories accredited for chemical and analytical testing.

RESULTS

According to the results of seabed sediment analysis, relatively low concentrations of pollutants were found in the seabed sediments in the placement area as well in the dredged sediments from the construction site: the differences in pollutant concentrations between the different stations is attributable to the heterogeneity of the seabed sediments in the area of the permanent storage site[15].

15 It should be noted that the Valshteyn bank area is constantly used for dumping of dredged sediments, which is the cause of its heterogeneous grain size composition.

There are no significant exceedances[16] of the content of pollutants such as lead, cadmium, mercury, radioactive isotopes and oil products in the dredged sediment samples in comparison with those taken in the storage area (see Table 15). The content of organochlorine pesticides, polychlorinated biphenyls and terphenyls, as well as organostannic compounds in all studied samples was at a level below the detection limit.

Table 15. *Concentration of pollutants presented as ranges (minimum, maximum and average values). The following pollutants are not included because they are present in concentrations below the detection limits: organochlorine pesticides (<0.0001 mg/kg), polychlorinated biphenyls (<0.0001 mg/kg), terphenyls (<0.005 mg/kg) and organostannic compounds (<0.01 mg/kg)*

Measured parameter	Pb (mg/kg)		Cd (mg/kg)		Hg (mg/kg)		Total oil products (mg/kg)		Cs-137 (Bq/kg)		Sr-90 (Bq/kg)	
	concentration	standard deviation	concentration	standard deviation	concentration	standard deviation	concentration	standard deviation	specific activity	standard deviation	specific activity	standard deviation
Monitoring prior to start of placement of dredge spoil												
Min	4.08	±1.22	<0.05	–	<0.015	–	<5.0	–	5	±2	<4.0	–
Max	12.82	±3.85	0.182	±0.055	0.069	±0.014	8.83	±3.53	37	±11	<5.9	–
Average	7.63	–	0.097	–	0.037	–	6.90	–	19	–	–	–
Sediment excavated from the dredging site												
Min	7.70	±2.31	0.111	±0.033	0.016	±0.003	5.00	±2.00	6	±2	5.3	±2.8
Max	8.38	±2.51	0.210	±0.053	0.084	±0.017	9.53	±3.81	18	±5	6.6	±2.4
Average	8.04	–	0.161	–	0.050	–	7.27	–	12	–	6.0	–
Monitoring after placement of dredge spoil												
Min	2.07	±0.62	0.030	±0.009	<0.015	–	<5.0	–	6	±2	4.0	±4.0
Max	5.02	±1.51	0.150	±0.045	0.073	±0.015	19.58	±7.83	40	±2	8.0	±4.0
Average	4.08	–	0.084	–	0.034	–	10.60	–	17	–	5.2	–

Comparison of pollutant concentrations measured in the dredged sediments at the construction site and in the dredged sediments at the placement site showed that sediment disposal had no significant effect on the content of pollutants in the dumping area. In addition there was no significant increase in the content of the clay fraction in the sediment samples taken at the station R_PD_01 (see Figure 45) which is located closest to the dredge spoil placement site. The dredged sediments were characterised by high clay content. Thus the monitoring results reveal that no significant change in the chemical composition of the seabed sediments at the dumping site resulted from sediment disposal near the station R_PD_01.

The total pollution index was calculated for the collected soil (see Chapter 5.1.2 for the methodology for calculation of the index). The total pollution index relative to the literature values from 2010 and the values from the storage site before the start of placement activities revealed no pollution and the soil

16 Beyond the detection limits of the corresponding measurement method.

was categorised as „acceptable“ in accordance with the criteria of SanPiN 2.1.7.1287-03. However, taking the 2016 survey results as background values, the calculated total pollution index for the sediment sample collected at station R_PD_04 prior to dumping, as well as in one sample collected from the dredging area corresponded to the „moderately dangerous“ pollution category. In general, higher values of the total pollution index are observed when comparing the monitoring results with the results of the 2016 surveys, which are characterised by the lowest detected concentrations of pollutants compared with other studies /34/.

CONCLUSIONS

Analysis of the sediment samples collected after dredge spoil placement shows that the content of pollutants has not increased and remains within the range of low concentrations.

The monitoring results indicate that the placement of seabed sediments extracted during dredging in the construction area of the Nord Stream 2 gas pipeline was in compliance with the specified requirements.

6.6.3 Plankton and benthos

Monitoring of the hydrobiological environment in proximity to the placement of dredge spoil material was undertaken in order to determine whether the viability of plankton and benthos communities could be affected by the construction activity.

METHODOLOGY

Hydrobiological monitoring in the dump area was carried out at 4 stations. Three stations coinciding with the bottom sediment and seawater monitoring points were located in the impact area (R_PD_01, R_PD_04 and R_PD_07), and 1 station (R_PD_08) was considered as background (see Figure 45). Phytoplankton was sampled throughout the trophic layer, zooplankton was sampled with a plankton net and benthos was sampled from the seabed. Sampling took place in November 2018, after the completion of sediment placement.

RESULTS

In general, plankton and benthic communities in Ust-Luga Bay were characterised by rather poor species composition. Quantitative parameters (abundance and biomass) were lower than those observed in the background survey near the placement area in May 2015, but were within the range of seasonal variation and comparable to the average indicators typical of the eastern part of the Gulf of Finland. Impacts on aquatic organisms as a result of soil placement were not detected: the station closest to the sediment placement site (R_PD_01) displayed similar species composition and quantitative characteristics to the other monitoring stations.

Phytoplankton was represented by 46 species from 8 divisions, of which the greatest species diversity was found in green algae and diatoms. In terms of the number of species, freshwater species predominated, followed by brackish-water and marine forms. The number of phytoplankton varied from 74.5–189 th. cells/l and averaged 132.4 th. cells/l. Biomass varied from 67.6–159.3 mg/m^3 and averaged 112.7 mg/m^3. The pigment composition was mainly represented by chlorophyll „a“ (which plays the most important role in the process of photosynthesis). The quantitative indicators of phytoplankton development (abundance, biomass, concentration of photosynthetic pigments) in the Ust-Luga bank were within the seasonal variation. A characteristic feature was higher quantitative indicators of phytoplankton development (2–2.5 times in abundance, 1.3 times in biomass, as well as in the concentration of photosynthetic pigments) at the storage site compared with the background station, primarily due to the more intensive development of blue-green algae.

Zooplankton was represented by 9 species and taxa of a higher rank, characteristic of the late autumn period. *Eurytemora affinis, Keratella quadrata*, polychaete larvae (Polychaeta) and Cyclopoida juvenile stages dominated. In abundance and biomass, copepods dominated, polychaetes were subdominants, which is typical of the studied water area in the autumn and winter periods. Zooplankton abundance varied from 154–864 ind./m^3, averaging 487.9 ind./m^3, biomass – from 4.97–60.75 mg/m^3, averaging 18.97 mg/m^3. The values obtained for the abundance and biomass of zooplankton were within the limits characteristic of Luga Bay in the autumn-winter period.

Macrozoobenthos was represented by only 7 taxa, including oligochaete, polychaete, crustaceans, and bivalve molluscs. In the storage area, the abundance (33–150 ind./m^2, average 90 ind./m^2) and biomass (3.87–30.09 g/m^2, average 13.29 g/m^2) of macrozoobenthos was higher than at the background station (17 ind./m^2, 2.86 g/m^2). The biomass of macrozoobenthos was dominated by Baltic tellin *Limecola balthica* /34/.

CONCLUSIONS

The measured species diversity and biomass of phytoplankton, zooplankton and benthos were rather low, which was attributable to the general environmental characteristics of the area and to the monitored seasons. Species viability was considered to be good.

Monitoring of the hydrobiological environment showed that the placement of dredge spoil in the permanent storage area did not have a negative effect on the plankton and benthos communities.

7 Unplanned events

To prevent or mitigate potential impacts from accidents and unplanned events during construction, Nord Stream 2 has developed a mitigation strategy which ensures compliance with international requirements and follows best practice. Measures to reduce or avoid any unacceptable risks have been explored and incorporated (e.g. implementation of a safety zone around vessels and careful route planning). Nevertheless, the following unplanned events happened in 2018: water treatment plant incident in Russia, 4 minor oil leaks in Finland and a grease incident in Germany.

The water treatment incident in Russia is discussed in Chapter 3.2.1.

The oil leaks in Finland were very minor: 3 of the 4 spills involved less than 4 litres of biodegradable oil, and one spill consisted of approximately 150 litres of gearbox lubricant oil from the Solitaire. The oil leak from the Solitaire is also expected to biodegrade and not to bio-accumulate through the food chain. Remedial actions were taken immediately by the vessel crew. None of the oil spills that occurred in Finland were assessed as having a detrimental effect on the environment.

An accidental release of grease occurred during the start of dredging operations in the Greifswalder Bodden in Germany in mid May 2018. Up to 145 kilograms of grease were released by a backhoe dredger at night due to a defective seal. Since its density is lower than sea water, the vast majority of the grease was washed up along the nearby coast in the Bay of Greifswald. As soon as Nord Stream 2 became aware of this incident, dredging was suspended and beach cleaning work was instigated. The beach clean-up operation carried out by a specialist contractor recovered 105 kg of the grease over a period of three weeks. It was estimated that approximately 80–90 % of the spilled grease was recovered. Beach monitoring continued for another four weeks without any further findings. In addition to the clean-up, sediment samples were collected from the vicinity of the offshore construction site of the respective dredger as well from affected beaches and analysed for their content of pollutants, principally medium and long-chain hydrocarbons, the main component of grease. No indications of elevated pollutant concentrations were observed in relation to pre-construction values and values from unaffected reference sites.

Dredging was suspended for a period of four weeks in order to analyse the causes of the grease incident and implement lessons learnt. During this time Nord Stream 2 took all necessary measures, in close consultation with the authorities, to prevent similar incidents throughout the remaining offshore construction works. The vessel responsible for the grease spill was removed from the construction fleet on a permanent basis. All remaining vessels were examined and all grease and hydraulic oils liable to come into contact with sea water were substituted with biodegradable environmentally acceptable lubricants (EALs). Targeted offshore environmental supervision measures were established and implemented from June onwards, ensuring that further incidents were successfully prevented.

Following the grease incident the use of biodegradable EALs was not only restricted to the dredging operations in German waters but was also targeted for use in relevant construction activities across the Project. To mitigate potential impacts from such unplanned incidents, Nord Stream 2 has ensured that, where highlighted through risk assessments, lubricants were replaced with biodegradable EALs for both offshore and onshore construction operations. Mitigation measures are applied to a wide range of machinery used in the project, from chainsaws used for vegetation clearance, to heavy equipment such as excavators, hydraulic vibratory pile drivers and cranes for onshore construction, as well as dredgers and other vessels for the offshore activities.

The use of EALs is a voluntary commitment by Nord Stream 2 that goes beyond statutory requirements.

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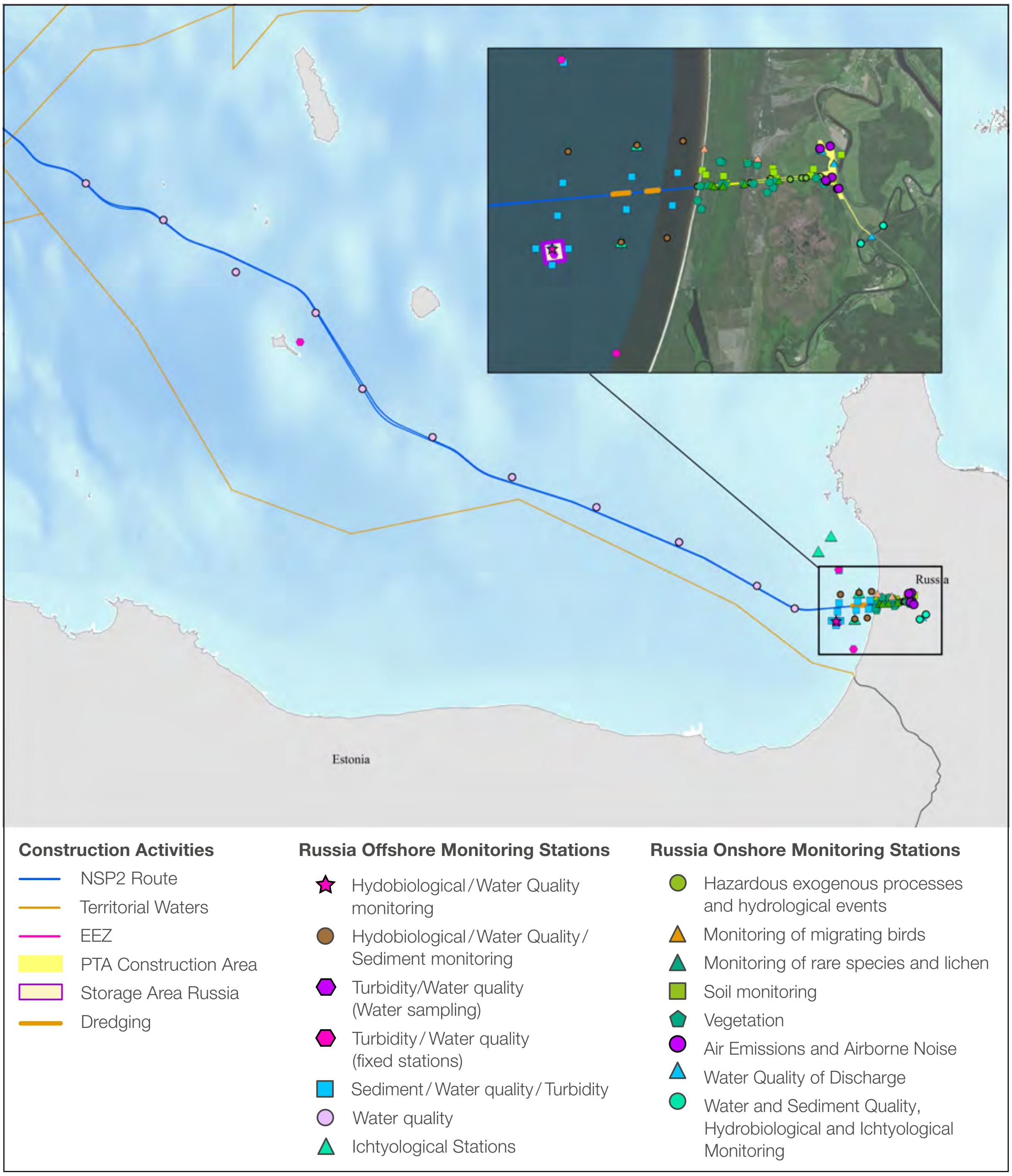
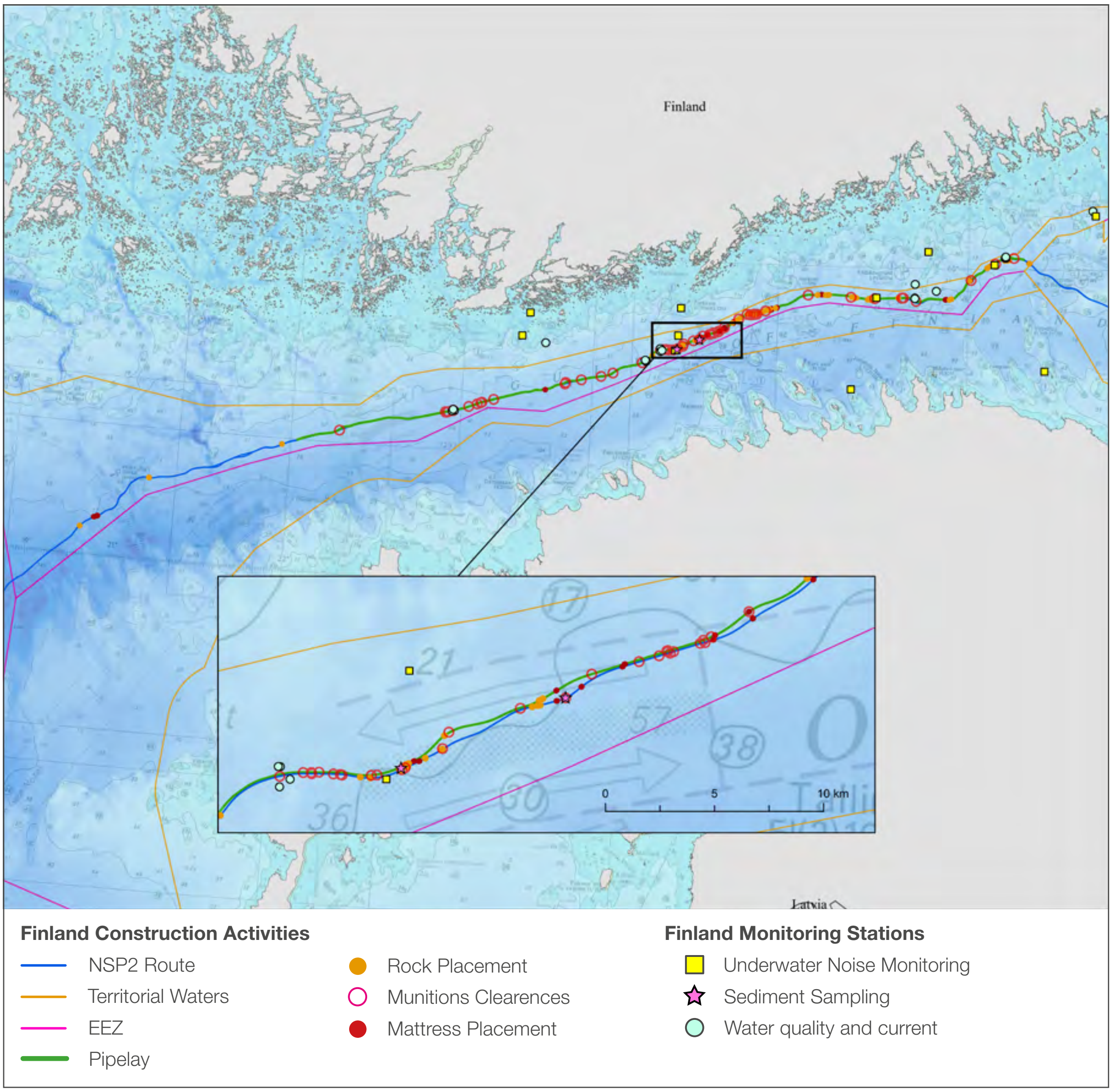
9 Appendices A–D

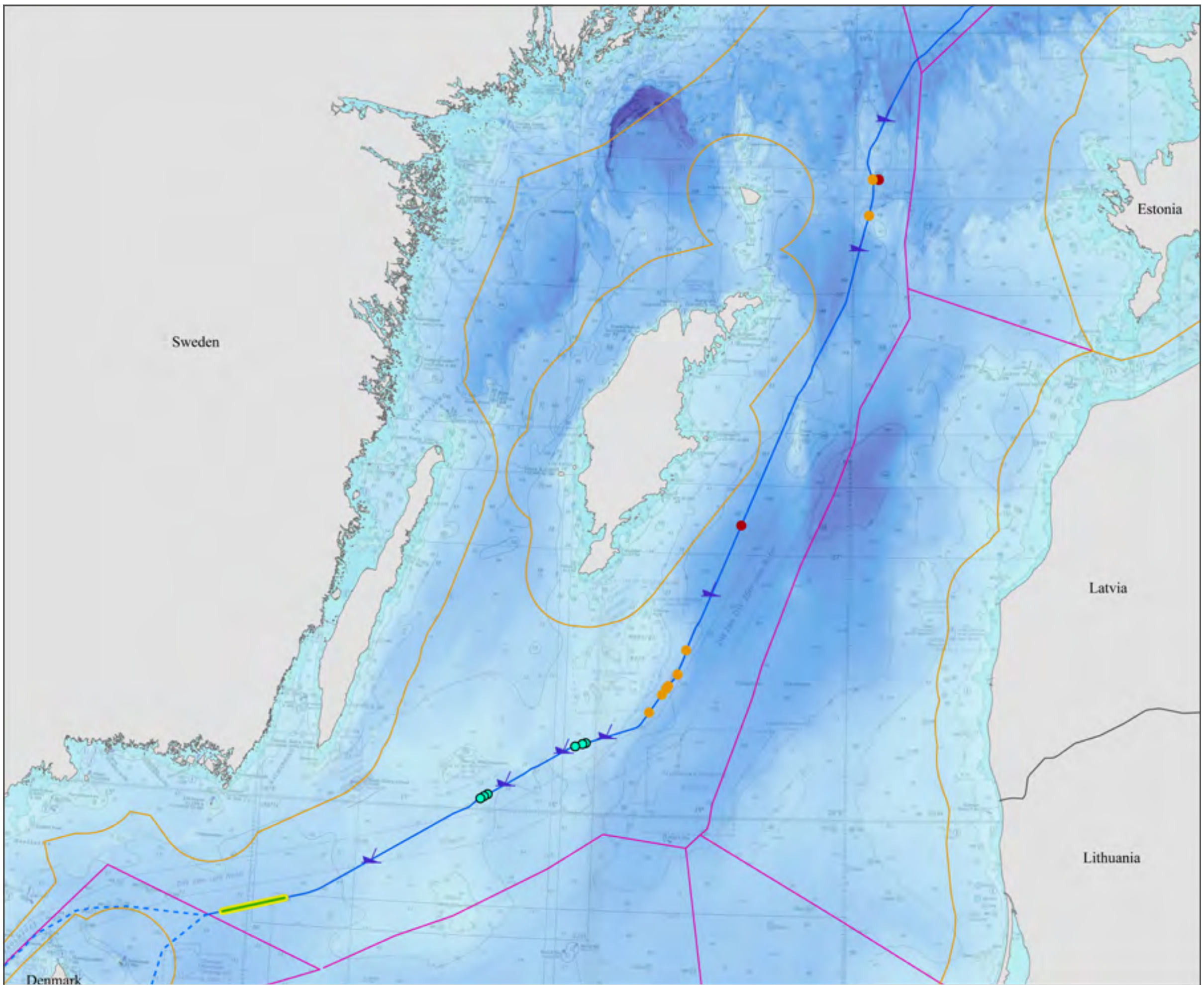
Appendix A: Construction activities and environmental monitoring in Russia



Appendix B: Construction activities and environmental monitoring in Finland



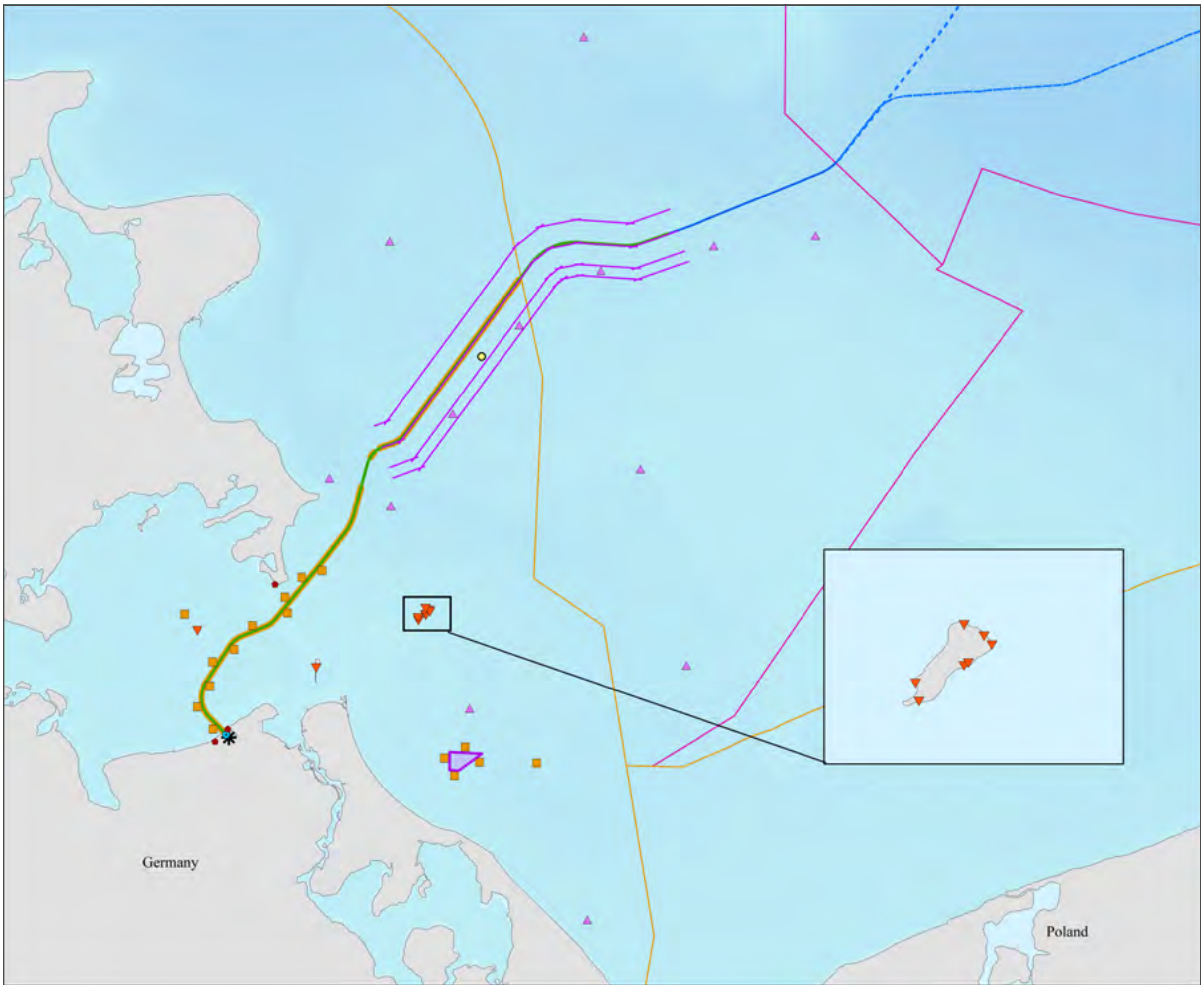
Appendix C: Construction activities and environmental monitoring in Sweden



Sweden Construction Activities
- NSP2 Route
- Applied Routes in Denmark
- Territorial Waters
- EEZ
- Pipelay
- Rock Placement
- Mattress Placement

Sweden Monitoring
- Monitoring of Ecotoxological Effects
- Cultural Heritage Monitoring
- Ship Traffic Monitoring

Appendix D: Construction activities and environmental monitoring in Germany



Landfall Construction Activities
- NSP2 Route
- Applied Routes in Denmark
- Territorial Waters
- EEZ
- Deforestation, facility preparation, sheet pilling, tunnel drilling, pipe pull-in, sheet pile removal, civil works

Germany Offshore Monitoring
- Harbour Porpoise Monitoring
- Seal Monitoring
- Turbidity
- Underwater Noise
- Bird Survey Transects

Germany Onshore Monitoring
- Airborne Noise
- Groundwater Wells

Germany Offshore Construction Activities
- Dredging and Backfilling
- Storage Area
- Pipelay

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