Overall Environmental Monitoring Report 2019

Contents

Abbreviations

ABS	Automatic buoy station
ADCP	Acoustic Doppler current profiler
AIS	Automatic identification system
AWTI	Above-water tie in
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
NSP	Nord Stream project
NSP2	Nord Stream 2 project
NT	Near threatened category group in IUCN red list
NTU	Nephelometric turbidity unit
PTA	Pig trap area
RAM	Ramsar advisory mission
ROW	Right-of-way
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
TBC	Thermotolerant coliform bacteria
TBT	Tributyltin
TC	Total coliforms
TSS	Total suspended solids
TW	Territorial water
TWA	Temporary work area

Summary

The Overall Environmental Monitoring Report 2019 presents the results of environmental monitoring related to construction of the Nord Stream 2 pipeline in 2019. Nord Stream 2 environmental monitoring is based on the five national environmental monitoring programmes for Russia, Finland, Sweden, Denmark and Germany which have been 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 and continued in 2019 in Russia, Finland, Sweden, Denmark and Germany upon receipt of the respective construction permits and start of construction activities.

Construction activities in 2019 comprised the following:

- Russia: onshore construction, above-water tie in (AWTI), dredging, rock placement, cofferdam installation, pipelay and backfilling;
- Finland: rock placement, and pipelay;
- Sweden: mattress installation, rock placement, pipelay and post-lay trenching;
- Denmark: mattress installation, rock placement and pipelay;
- Germany: onshore construction, AWTI and rock placement.

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 sensitivity.

Thus, as part of the permit, 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 physical-chemical, biotic and socio-economic parameters likely to be impacted during various construction activities. The table below lists the parameters monitored in 2019 during certain offshore and onshore Nord Stream 2 construction activities.

Offshore monitoring in 2019

Monitored Parameters	Dredging/ Dredge disposal/ Backfilling/ Nearshore pipe pull	Post-lay trenching	Rock placement	Pipelay	Post-construction
Physical-chemical environment					
Marine sediment quality	R		R		G
Marine water quality (turbidity)	R*	S	F, R	R	
Marine water quality (pollutants)	R			R	
Bathymetry					G
Underwater noise			S	S	
Biotic environment					
Benthic flora and fauna	R				G
Plankton	R				
Fish/Fish migration	R				
Birds	R		R	R	G
Marine mammals	R		R	R*	G
Socio-economic environment					
Cultural Heritage	R*		D, F, R*	D, S, F, R*	G
Munitions (chance finds)			D	D	
Ship Traffic**	R	S	D, S, F, R	D, S, F, R	

* Involves supplementary monitoring measures, beyond those specified as part of national monitoring programmes and permit conditions, to meet additional lender or project requirements
** Monitoring of ship traffic is performed in all countries where relevant construction activities take place; additionally in Sweden, Denmark and Germany monitoring of ship traffic is part of the national monitoring programmes.

Onshore Russia monitoring in 2019

Monitored Parameters	Construction camp & Temporary Works Area (outside Kurgalsky Reserve)	Kurgalsky Nature reserve	Rosson river
Physical-chemical environment			
Soil quality		X*	
Exogenous processes		X	
Air emissions and quality	X	X	
Airborne noise	X		
Water quality – effluent	X*		
Hydrology		X	
Water quality – receiving water			X*
Riverbed sediment quality			X

Monitored Parameters	Construction camp & Temporary Works Area (outside Kurgalsky Reserve)	Kurgalsky Nature reserve	Rosson river
Biotic environment			
Terrestrial flora		X*	
Birds		X*	
Mammals		X*	
Hydrobiology			X
Fish			X

* Involves supplementary monitoring measures, beyond those specified as part of national monitoring programmes and permit conditions, to meet additional lender or project requirements

Onshore Germany monitoring in 2019

Monitored Parameters	Civil works at the PTA
Physical-chemical environment	
Airborne noise	X
Biotic environment	
No monitoring required in 2019	
Socio-economic environment	
Cultural heritage – chance finds	X

CONCLUSIONS FOR OFFSHORE MONITORING

Monitoring associated with the offshore construction activities demonstrated that no impacts other than those predicted occurred in 2019.

No significant impacts on abiotic environment was reported. Monitoring of turbidity and water quality during pipelay, dredging, trenching 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. Installation of the cofferdam in the Russian nearshore section has proven to successfully prevent increase of turbidity and general impacts on water quality during the main construction activities in shallow waters. Analysis of seabed sediments demonstrated no significant increase in pollutant concentrations in the areas where seabed intervention works took place. Underwater noise associated with pipelay and rock placement was comparable in level and frequency to noise radiated from commercial cargo ships in the area as was shown by monitoring in Sweden.

Monitoring of the biotic environment showed that the general conditions of the monitored populations of plankton, benthos, fish, marine mammals and birds were not permanently impacted by the construction activities, which is in line with the EIA reports. Additional monitoring brought additional knowledge to the scientific community, for example the finding of a previously unknown pod of grey seals at the Sommers island rockery and the round trip of a tracked Baltic ringed seal to Estonia. Spawning of Baltic herring as well as the seasonal salmon migrations were not impacted by the project. Generally, ichthyofauna in the project area demonstrated high tolerance of the construction activities which were performed and did not display any specific reaction, as shown by monitoring in Russia.

Monitoring of third party shipping traffic was successfully implemented during construction in all countries, and no incidents were recorded. No disturbance of cultural heritage objects was associated with the project activities. No chance finds of munitions and cultural heritage objects occurred during construction in 2019.

Post-construction monitoring undertaken in German waters showed that the impact on the seabed due to construction (dredging, pipelay, and backfilling) was in line with the assessment. Exclusive use of backhoe dredgers during dredging inside protected Natura 2000 habitats proved to be a successful mitigation measure allowing minimisation of spatial footprint. No contamination of the seabed sediments was observed. The forecast insignificant eutrophication effect through temporary mobilisation of phosphate during works leading to sediment disturbance was lower than assessed. Analysis of benthos revealed an early stage of reinstatement for all benthic communities. Monitoring of seabirds and marine mammals showed that there were no impacts on their abundance and distribution during the first year after construction.

CONCLUSIONS FOR ONSHORE RUSSIA MONITORING

The Kurgalsky Nature Reserve is a highly sensitive area and it has therefore been extensively monitored both in 2018 and in 2019. Monitoring results for 2019 have demonstrated that no significant impacts on the biotic and abiotic environment of the protected area took place. The monitoring of soil quality, exogenous processes and hydrology mostly displayed values within natural variability of the area. The monitoring of the vegetation showed that the impacts were acceptable, although some impacts related to construction activities were recorded (e.g. drying of some species due to the temporary changes in the water regimes and grazing of some areas in proximity of the fences). Also the impacts to local avifauna and terrestrial fauna was in line with the prediction, with minor temporary impacts to the migration of geese and sea ducks and to the feeding behaviour of ungulates.

Construction activities at the construction camp and work areas in 2019 were in line with the EIA assessments. Analysis of the discharged water showed some degree of contamination in the beginning of 2019, but timely mitigation measures which were taken allowed the quality of the water to be improved to meet sanitary requirements. The monitoring of the other abiotic parameters was well in line with the prediction and showed that no impact on the local population was caused by the construction activities at the construction camp and work areas.

Monitoring of the Rosson river was designed to capture the potential impacts caused by the water discharges to the river. Monitoring of different environmental conditions of the Rosson river showed that water discharges did not have any impacts on the abiotic and biotic parameters even when discharged water temporarily did not meet sanitary norms. The registered variation of plankton, benthos and macrophytes communities was explained by natural variability; similarly, the fish communities displayed the expected seasonal variability compared to the data collected earlier.

Monitoring of soil and groundwater quality following a diesel leak at the Landfall Russia accommodation camp in February 2019 showed that implementation of mitigation measures including replacement of contaminated soil resulted in no long-term adverse impacts on soil and groundwater as demonstrated by continuous monitoring over six months after the incident.

CONCLUSIONS FOR ONSHORE GERMANY MONITORING

Onshore monitoring at the German landfall during construction activities in 2019 was focused on monitoring airborne noise. Monitoring was undertaken according to the German legal obligations. It was shown that no acoustic impact from construction noise could be detected at any of the two monitoring sites throughout the course of 2019.

1 Introduction

Nord Stream 2 is a pipeline through the Baltic Sea, which will transport natural gas over some 1,230 km from the Russian to the German coast. The pipelines are built and will be 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, Germany and in 2019 in Denmark upon receipt of the respective permits. Environmental monitoring is carried out before, during and after construction demonstrating 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.

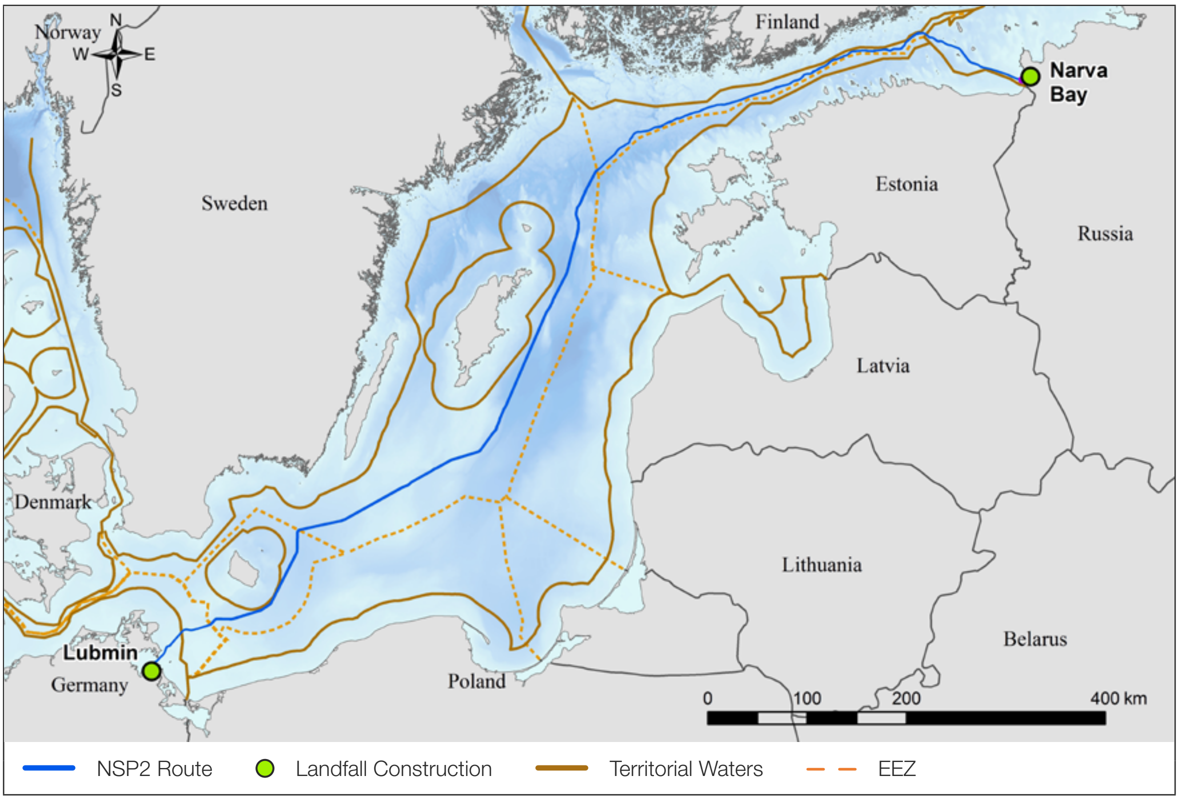


Figure 1. *Nord Stream 2 pipeline route.*

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 2019 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. Following the ratification of the EEZ border agreement between Denmark and Poland, the construction permit was granted for the South-Eastern route within the Danish EEZ. The EEZ border shown on the maps in this report reflects the agreed border as ratified in 2019.

Overview of the received permits is shown in Table 1.

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 government	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	30 October 2019

Country	Regulation	Permit granted
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. In addition, 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. seal telemetry study in Russia.

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/–/06/ 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 through whose waters the pipeline passes, as well as through consultation with the relevant national authorities. Depending on the 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 do not cause unforeseen environmental impacts or impacts that are 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 /07/–/12/. 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, to enhance scientific knowledge of the Baltic Sea environment and/or to demonstrate adherence to lenders' standards or other standards adopted by NSP2. These studies include:

- Telemetry studies and aerial surveys of the Baltic ringed seal in the Gulf of Finland (2017–planned 2020);
- Monitoring of sediment toxicity in Finland after munitions clearance (2018);
- Additional monitoring of marine mammals as defined by Finnish authorities (2018);
- Satellite monitoring of turbidity during dredging/backfilling activities in Russia (2018–2019);
- Increased frequency of wastewater discharge monitoring at the Russian landfall (bi-weekly rather than quarterly as required under national monitoring) to enable a more rapid response to deviation from performance (2019–2020);
- Monitoring for emergence of invasive species at the Russian landfall, to prevent spread of or introduction of such species (2018–2020);
- Implementation of a watching brief for cultural heritage in the vicinity of the designated archaeological site at the Russian landfall (2018);
- Enhanced biodiversity monitoring (additional to that required under the national approvals/permit) notably in relation to birds in the vicinity of the project footprint in the Kurgalsky nature reserve (2018–2020);
- Reinstatement of the onshore Russian landfall site (planned for 2020);
- Monitoring the implementation of conservation measures for peat, forest and sandy soils at the Russian landfall to promote retention of natural habitat (2018–2019);
- Hydrological monitoring in the vicinity of the construction footprint within the Kurgalsky nature reserve at the Russian landfall (2019).

In addition, 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 in five countries is given in Table 2.

Table 2. *Overview of monitored parameters before, during and after construction/during operation in Russia, Finland, Sweden, Denmark and Germany defined in the national monitoring programmes.*

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

Parameter	Before construction	During construction	After construction
Cultural heritage	F, S, D, G		F, S, D
Munition object	D		D
Ship traffic****		S, D, G	
Pipeline footprint			R, F, S, D, 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; D – Denmark; 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 during Operation phase was cancelled in agreement with the Swedish authorities based on the baseline results.
**** Monitoring of ship traffic is performed in all countries where relevant construction activities take place; additionally in Sweden, Denmark 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 3–5. Maps showing construction activities in each country and monitoring locations are provided in Appendix A–E.

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 2019 included onshore activities in Russia and Germany and offshore activities in Russia, Finland, Sweden, Denmark and Germany, see Figure 2.

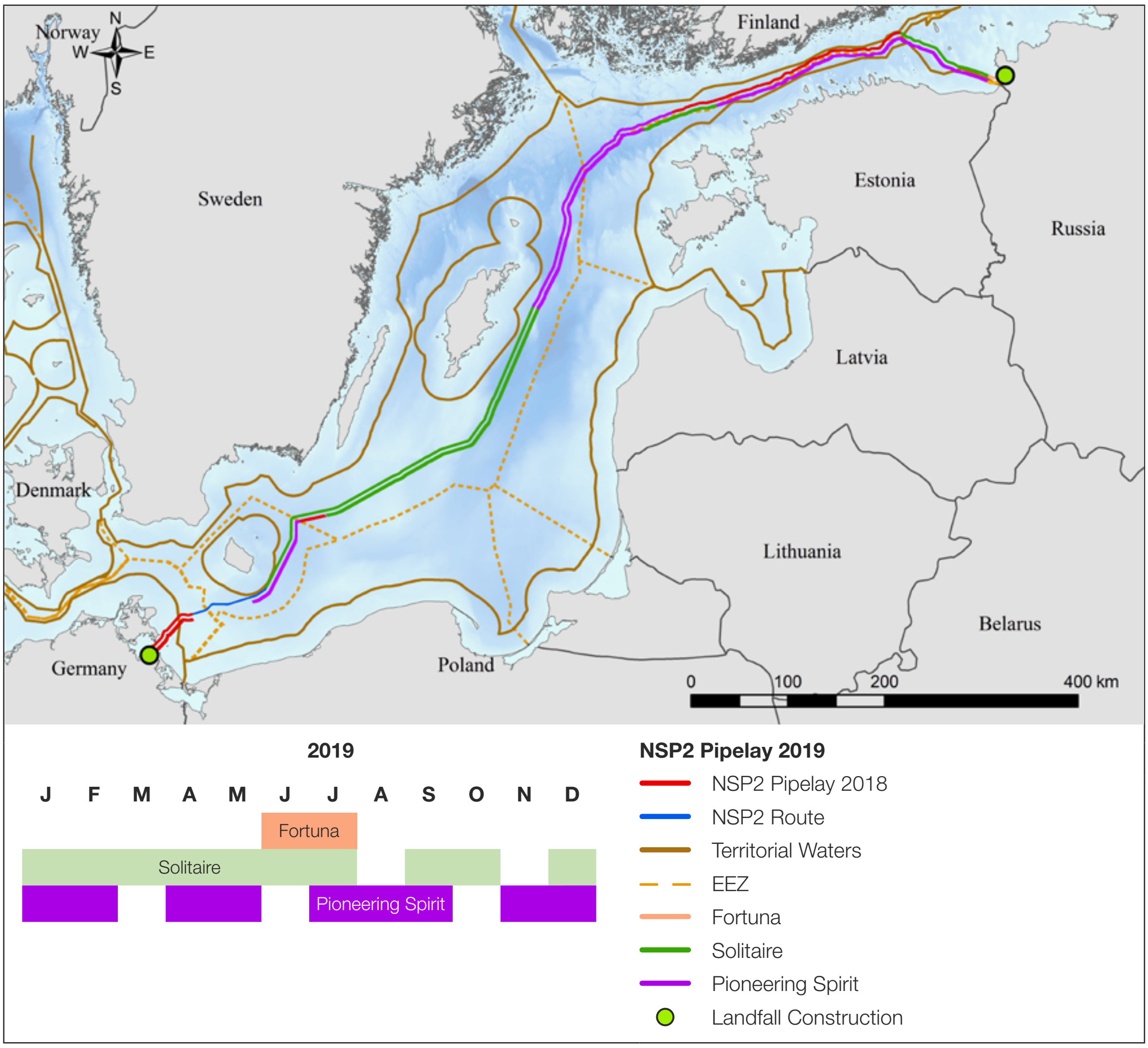


Figure 2. *Installation of Nord Stream 2 pipeline in 2019.*

2.1 Construction overview

Construction activities in 2019 mainly included pipelay in Russia, Finland Sweden and Denmark; no pipelay took place in Germany in 2019. Seabed intervention works such as post-lay trenching, rock placement, dredging and backfilling occurred at different locations along the route where stabilization of the pipelines was required. By the end of 2019, 1,147 km of Line A and 1,166 km of Line B were laid on the seabed comprising 94% of the total length of the pipeline. An overview of the offshore construction milestones is given in Figure 4. Details of the offshore construction activities in the five countries are outlined below in Sections 2.2–2.6.

On December 21st 2019 the President of the United States approved sanctions, which compelled the pipelay contractor, Allseas, to suspend pipelay operations by its two DP pipelay vessels, Pioneering Spirit and Solitaire. Up until this time, pipelay had been progressing along both Lines A and B on schedule and in accordance with the construction permit, with no unforeseen events or impacts.

Onshore construction progressed at the Russian and German landfalls. An overview of the onshore construction milestones is given in Figure 3. Details of the onshore construction activities in Russia and Germany are outlined below in Sections 2.2 and 2.6.

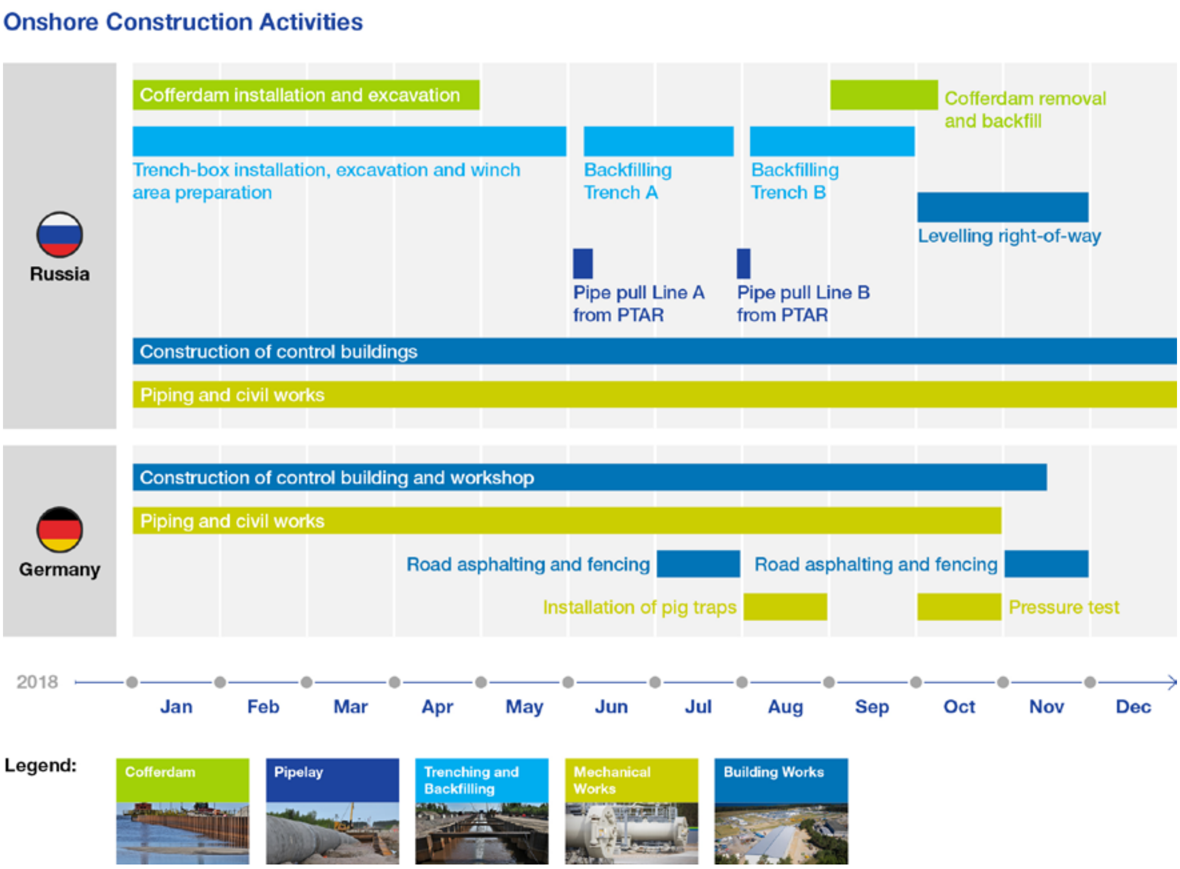


Figure 3. *Onshore construction milestones in 2019*

Offshore Construction Activities

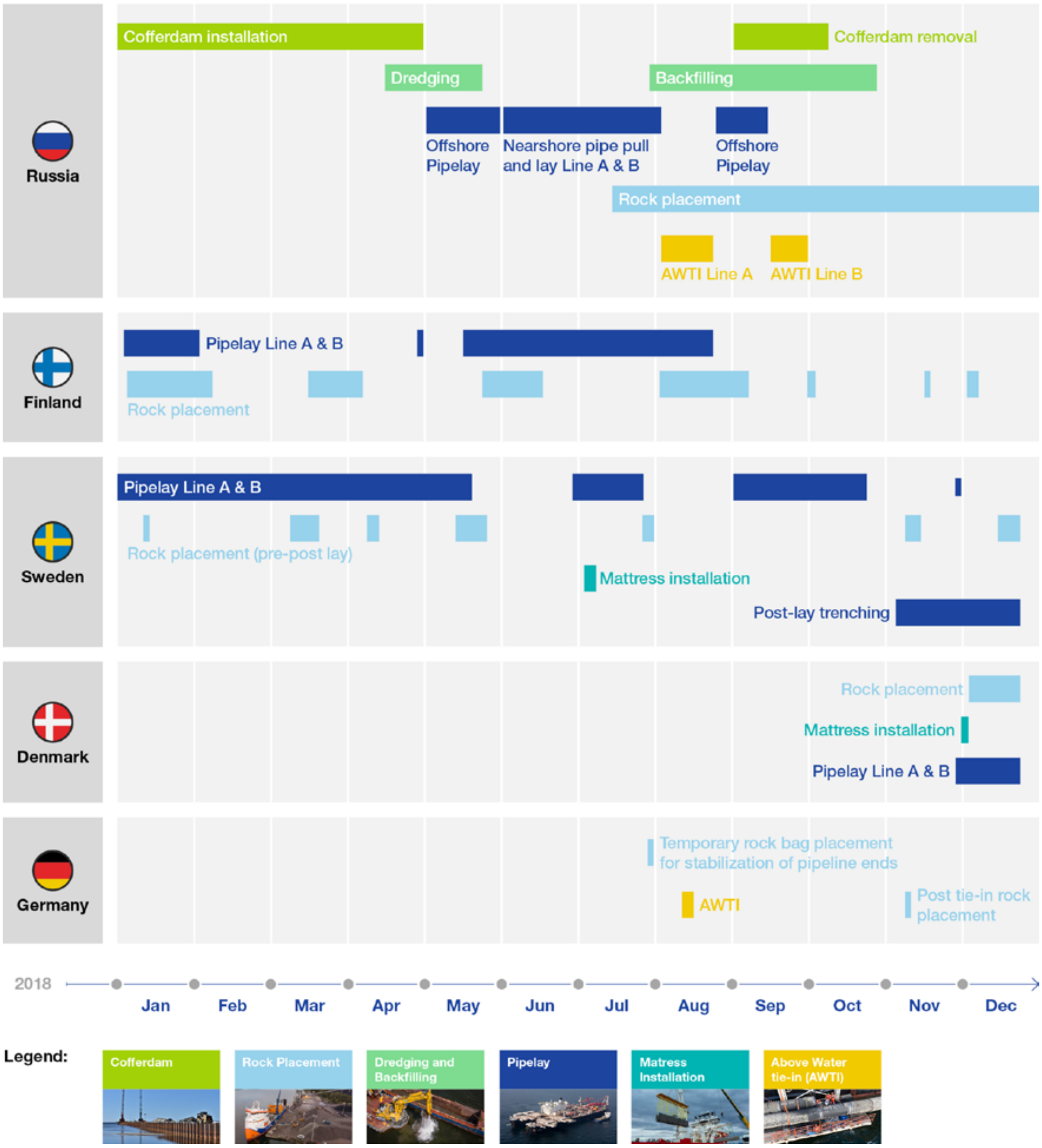


Figure 4. *Offshore construction milestones in 2019.*

2.2 Construction in Russia

Onshore construction

Onshore works were carried out throughout 2019 with significant progress. The linear part from the PTA to the beach was completed, with all pipes welded and pulled and all trenches backfilled, except areas where cathodic protection is being installed. A cofferdam was installed between January and April. The purpose of the cofferdam was to prevent collapse of the trenches and avoid additional impact on natural turbidity levels when pulling the pipelines though the shoreline and in the shallow waters. The pull of the pipelines from the nearshore section to the PTA and the dune was done throughout June–August.

The linear section of the pipeline onshore is approximately 3.9 km. The trench was backfilled in June–September and the cofferdam was removed in September–October. Technical reinstatement of the trenched sections was performed throughout October–November.

On the PTA itself all main piping was welded, structural steel installed and the hydrotesting of Line B successfully completed. Buildings were erected, and internal, electrical and automatization works are ongoing. On-site utilities were primarily installed.

Offshore construction

Nearshore construction in Russia was completed in 2019. Contractors installed the cofferdam, performed dredging and backfilling works, nearshore pipe pulling and pipelay. Installation of the cofferdam in the nearshore section was finished in April. Dredging works were carried out in April–May; dredged soil was placed in the temporary storage area for further backfilling. Pulling of the pipe and nearshore pipelay using a pipelay vessel Fortuna commenced in July. Once the pipelines were installed in the trench, backfilling of the trenches was carried out in August–October and the cofferdam was removed during September–October. Pipelay in the deep water section was carried out in May for the Line A using a pipelay vessel Solitaire and in August–September for the Line B using a pipelay vessel Pioneering Spirit. Rock placement for free-span corrections was performed between July and December. The two above-water tie ins (AWTIs) were installed in August and September 2019.

In total 228 km of pipelines were installed in 2019: 114 km each of Line A and Line B.

2.3 Construction in Finland

Construction activities in the Finnish EEZ in 2019 comprised pipelay and rock placement. Munitions clearance and installation of mattresses had already been completed in 2018. Pioneering Spirit continued the pipelay of Line A that had started in 2018: pipelay of Line A towards the Swedish border was completed in February 2019. Solitaire completed the pipelay of the remaining 3 km of Line A towards the Russian border at the end of April 2019. Pipelay of Line B started from the Swedish border on 18 May 2019. Both vessels Solitaire and Pioneering Spirit were used for the pipelay, which was completed on 21 August 2019. Rock placement took place throughout 2019, being more intensive in the first half of the year and slowing down towards autumn. Rock placement was completed in 2020.

In total 492 km of pipelines were installed in 2019: 118 km of Line A and 374 km of Line B.

2.4 Construction in Sweden

The remaining part of the pipelay scope in the Swedish EEZ was completed in 2019 with a total of 995 km of pipeline laid that year: 484 km of Line A and 511 km of Line B. Both the Pioneering Spirit and Solitaire vessels were laying pipe throughout the year. Pioneering Spirit moved from the Swedish EEZ into Finland whilst laying Line B at the end of May 2019. Solitaire laid down Line A 6 km short of the Danish border at the end of October. By the end of November 2019 both lines were completed in the Swedish EEZ.

Pre-lay rock placement and mattress installations were completed prior to pipelay in 2019. Post-lay trenching in four sections was completed in December 2019. Post-lay rock placement was performed throughout 2019.

2.5 Construction in Denmark

Construction in Denmark started in 2019 after receipt of the construction permit from the DEA. Construction works consisted of rock placement, mattress installation and pipelay. Pre-lay rock placement and mattress installation works were completed in 2019 between 28 November and 22 December. Pipelay vessel Pioneering Spirit started to lay Line B on 28 November 2019 and pipelay vessel Solitaire started to lay Line A on 30 November 2019. Pipelay in Denmark was suspended on 21 December 2019 by the pipelay contractor Allseas due to the risk of the sanctions being imposed by the US.

By the end of 2019 approximately 175 km of pipelines in Denmark were laid: 78 of Line A and 94 km of Line B. Line B was laid down approximately 50 km short of the German border and Line A approximately 70 km short of the German border.

2.6 Construction in Germany

Onshore construction

Pipeline construction and civil works in the vicinity of the onshore facilities in Germany continued throughout 2019. Furthermore, a control building and a workshop were erected. Preparation works for pre-commissioning started in October. Fencing off the facilities and road construction works were conducted during the second half of the year.

Offshore construction

Within the German Waters, pipelay was undertaken in 2018 with only 16.5 km remaining to be laid to the German-Danish border; no pipelay took place in 2019. The AWTI on Line B was carried out in August using Saipem's vessel C10. Following the successful tie in, rock placement was undertaken in November to stabilise the AWTI location.

3 Monitoring during onshore construction in Russia

The EIA and Espoo report concluded that possible damage to biotopes crossed by Nord Stream 2 within the Kurgalsky Nature Reserve could be the main potential impact of construction activities at the Russian Landfall. Therefore, as 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.

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. Monitoring of the Kurgalsky Nature Reserve in 2019 was largely a continuation of the monitoring started in 2018. Additionally, potential impacts from construction in the protected area were assessed by the Ramsar Advisory Mission (RAM) following their visit to the Kurgalsky Nature Reserve in November 2019.

Water discharges from the construction camp and construction sites could potentially have an impact, so the discharges 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, facility site and in the construction corridor (right-of-way through the Kurgalsky area), as well as at the nearest settlement.

The purpose of monitoring the Rosson river in 2019 was to monitor the potential effects on the river ecosystem of the water discharges from the water treatment plants. Monitoring of the Rosson river includes both the abiotic and the biotic environment.

3.1 Monitoring the Kurgalsky Nature Reserve

The Nord Stream 2 pipelines cross the Kurgalsky Nature Reserve in a 3.9 km long and 30–60 metres 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. An extensive monitoring programme was therefore established to monitor the territory of the reserve adjacent to the Project Area and to monitor the conditions of the RDBS in the years following the relocation. The objective of monitoring in the Kurgalsky Nature 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 both the abiotic and biotic environment, with particular focus on the particularities of a wetland ecosystem (e.g. from the monitoring of the water regime to the monitoring of rare and protected species). The monitoring locations established in the Kurgalsky Nature Reserve are shown in Figure 5.

Monitoring activities started before the start of construction (i.e. before tree cutting in the right-of-way), continued in 2019 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 the protection of Special Protected Natural Areas (SPNAs), the Decree on the Kurgalsky Reserve, as well as by the national EIA.

Furthermore, a visit by a Ramsar Advisory Mission (RAM) was organized in November 2019. The objectives of the RAM were to assess the impact of Nord Stream 2 construction on the ecological character of the Kurgalsky Nature Reserve, i.e. on its ecosystem components, processes, benefits and services.

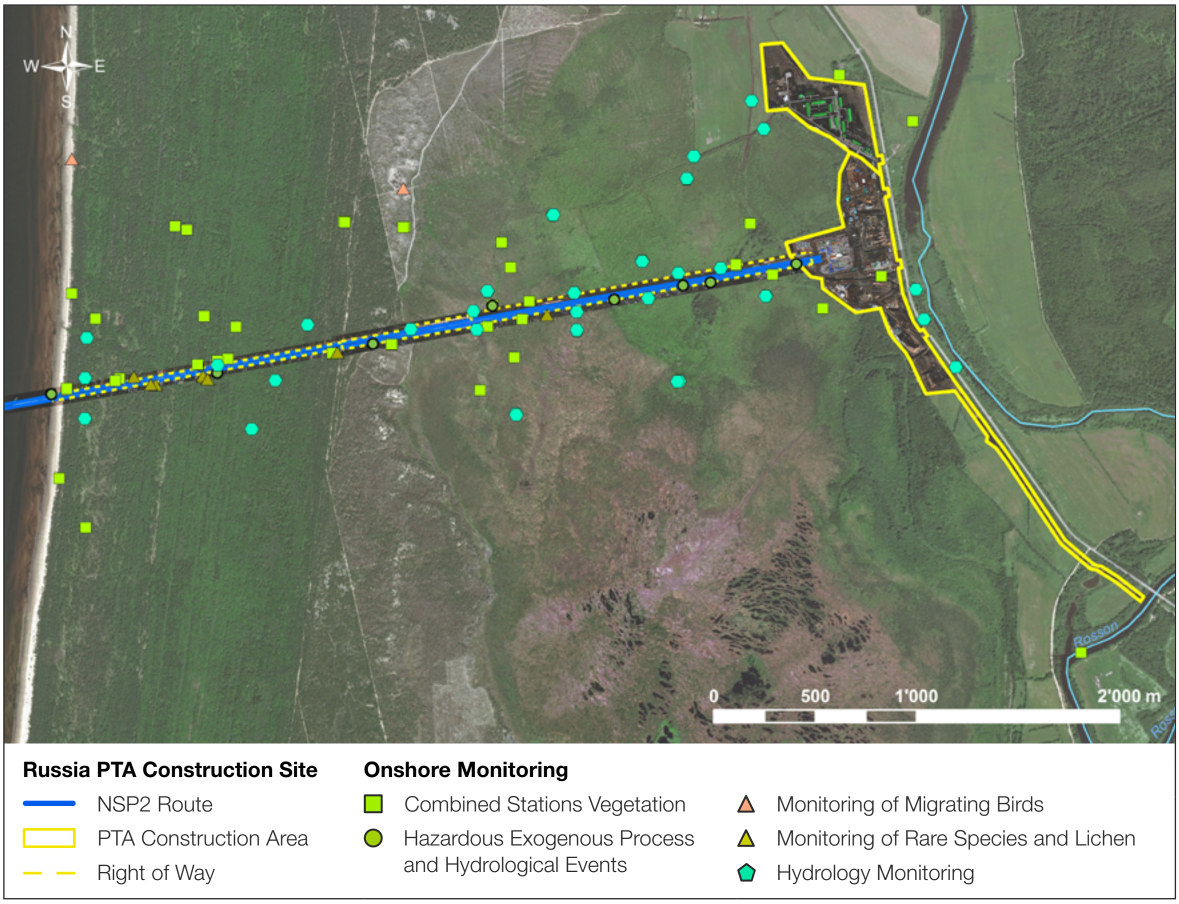


Figure 5. *Environmental monitoring at Kurgalsky Nature Reserve.*

Based on the monitoring results for 2019, 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). Hydrology monitoring showed that the recorded fluctuations in the water levels were generally in line with the natural dynamics (see Chapter 3.1.3). Monitoring of relocated RDBS plant species showed good survival of the relocated plants (3.1.4). Migratory birds showed some minor changes in their pattern of movement (see Chapter 3.1.5). A total of 36 protected species of vertebrates were recorded during the monitoring campaigns (see Chapters 3.1.6).

The Ramsar Advisory Mission's report confirmed the findings of Nord Stream 2 AG's environmental monitoring of the pipeline's offshore and onshore impacts i.e. that previously released results of monitoring showed that construction activities in 2018 and 2019 were in line with or less than the assessed impacts in the national environmental impact assessments (EIAs). The Ramsar report concluded that "impacts resulting from the cut and installation are local and largely confined to the construction corridor. They are assessed as not having adversely affected the overall ecological character of the Ramsar Site". The report further stated that "documentation produced by Nord Stream 2 AG represents a substantial body of work that greatly improves the understanding of the dynamics of the Ramsar Site and habitats found within the project site" /13/.

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 5).

METHODOLOGY

To monitor the potential impact of construction activities on different soil types, ten pairs of monitoring locations were established in 2018. For each soil type (and associated plant community), one plot was established in close proximity to the construction corridor ("control plot") and another one was established more than 180 metres from the construction area in an undisturbed area ("background plot"), for a total of 20 plots.

Description of the soil profiles, performed in 2018, 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, five soil samples were collected from the surface layer (0.0–0.2 metre) and were analysed by accredited laboratory centres for soil texture, pH and concentrations of heavy metals, oil products (total hydrocarbons) and benzo(a)pyrene.

This sampling programme started in 2018, before the main construction activities were carried out in the Kurgalsky Nature Reserve and will last until the end of the construction period, including remediation activities within the right-of-way.

Soil samples are collected once a year. However, four sampling plots, located within the water protection zone of the Gulf of Finland (500 metres from the shoreline) were monitored more frequently (on a quarterly basis, see Figure 6), in accordance with the Neva-Ladoga water basin authority requirements.

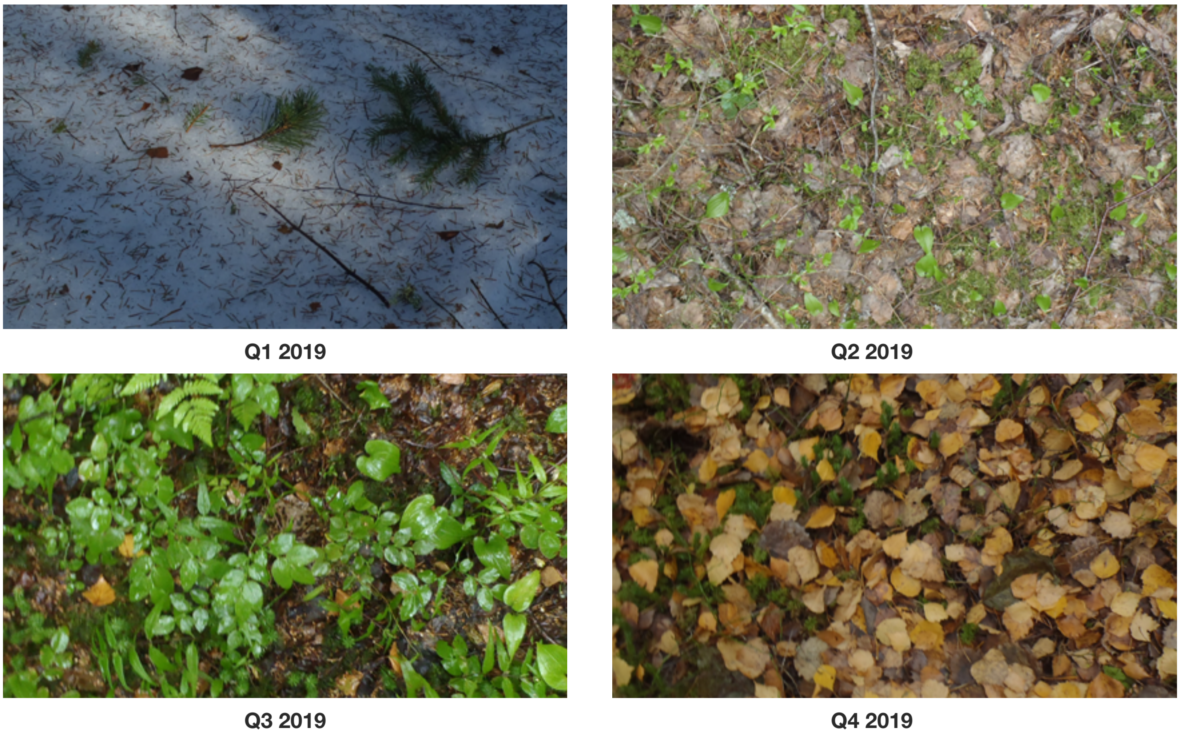


Figure 6. *Soil coverage at the baseline area R_SOIL_12.*

RESULTS

In August 2019, there were no significant differences between the control plots and the background plots. Compared with the general background values increased concentrations of oil products were recorded both in the control plots and the background plots of peaty soils. The content of oil products in peaty soils ranged from 850 to 2400 mg/kg. In two samples (R_SOIL_08 and R_SOIL_18), the oil content in the soil was 2 and 2.4 MPC respectively, so according to SanPiN 2.1.7.1287–03, these soils fall into the category of “moderately polluted”. However, no violations (e.g. signs of oil discharges) were visible on or near the sites, therefore these excesses are not expected to be associated with NSP2 construction activities.

The results were also comparable to the environmental baseline survey data and to the data collected in 2018.

No soil contamination with organic and non-organic pollutants was observed in 2019 within the Gulf of Finland water protection zone during all seasons.

CONCLUSIONS

According to the monitoring results, the 2019 construction activities had no impact on soil quality in the Kurgalsky Nature Reserve. 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 5).

METHODOLOGY

Monitoring of exogenous processes in 2019 took place during two survey campaigns: one at the end of April (after cofferdam installation and during preparation for pipe pulling) and one at the end of October (during technical remediation works in the right-of-way (ROW). Monitoring took place at the following eight 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

Two seasons of monitoring surveys showed that the dynamics of natural processes throughout 2019 were within seasonal changes. The trenches were almost completely closed during Q4, meaning that backfilling was almost completed. Flooding associated with this construction activity was the main process that was monitored: monitoring results showed that exogenous processes reverted to the natural dynamics after the main cause of impacts (i.e. open trenches) had been completed.

Following removal of the cofferdam the beach has returned to its original state.

Within some dune slacks (moist depressions between dunes) and drainage ditches there was an impact on the horizontal runoff, which resulted in ponding. In sections where the trenches had been backfilled but the upper peat had not been restored, extensive channels of standing water formed.

Partial flattening of artificial slopes was carried out in the dune area, and measures are being taken to prevent erosion of sandy slopes.

CONCLUSIONS

Considering that construction work caused considerable – albeit temporary – landscape changes at the sea shore, and considering that natural processes have their own seasonal dynamics, no activation of dangerous exogenous processes was detected throughout 2019. Project implementation was in compliance with the national EIA.

3.1.3 Hydrology

The condition of a body of water constitutes the base upon which the biotic and abiotic environments coexist and thrive in a wetland ecosystem. Therefore, particular attention has been given to monitoring the hydrological regime at the Kurgalsky Natura area, which was performed in accordancewith a special monitoring programme /14/ by the State Institute of Hydrology (SHI).

Part of the Kurgalsky Nature Reserve is a wetland: the Kader Swamp. The Kader Swamp is located in the western part of Leningrad Oblast in the Kurgalsky Peninsula. The gas pipeline crosses the wetland in the northern outskirts of the Kader wetland area.

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.

There can be different impacts on the hydrological regime of water bodies during both the construction and operation of the gas pipeline. Construction activities such as clearing and planning of a gas pipeline route, deforestation, laying of a temporary access road, construction of auxiliary production facilities, creation of culverts under the road, etc., were identified as potentially able to affect the hydrological regime. The impact of the pipeline construction on the aquatic environment may manifest itself in changes:

- in the natural conditions for the formation of watercourse runoff;
- in the relationship between surface and groundwater;
- in soil erosion and erosion conditions on catchments;
- in the characteristics of the channel cross-section of watercourses at construction sites.

Furthermore, the presence of the pipeline, in particular when positioned perpendicular to the grid of water runoff lines (see Figure 7 and Figure 8), causes changes in the flow characteristics of the micro-landscapes. These changes are caused by two impact factors:

- the gas pipeline located in the active layer of the swamp itself acts as a waterproof obstacle to the swamp water runoff;
- the gas pipeline and the temporary access road can cause a substantial compaction of the active layer and peat deposits. As a result, the hydraulic conductivity decreases. The average swamp water levels in the micro-landscapes increase and this causes the structure and composition of the vegetation cover to change. Ultimately, this leads to a change in the physical properties of the peat deposits and this in turn affects the flow characteristics of the micro-landscapes as thee vegetation has a new floristic composition.

METHODOLOGY

The construction of the Nord Stream 2 gas pipeline affects both surface and underground water bodies. The main surface water bodies in the construction route include: a section of the Kader swamp, old reclamation canals on it in the eastern part and small nameless streams in the coastal western territory. Underground water, which may be affected by construction, is represented by groundwater of the Quaternary sediments, occurring everywhere at depths from 0.5 to 4–5 metres from the ground level.

Monitoring consisted in measuring the water levels of surface and underground water bodies at the existing network of standpipes, groundwater wells and on surface watercourses located in the immediate vicinity of the gas pipeline route (see Figure 7). The typological characteristics of the swamp's micro-landscapes and the grid of marsh water runoff lines in the adjacent area were taken into account when selecting the location of standpipes to be monitored (see Figure 8). In addition, reconnaissance surveys of the construction site and the adjacent areas of the swamp were carried out to identify any visible changes in the hydrographic network, water cut, directions of the water flows and other phenomena associated with anthropogenic impact on the water level in the swamp.

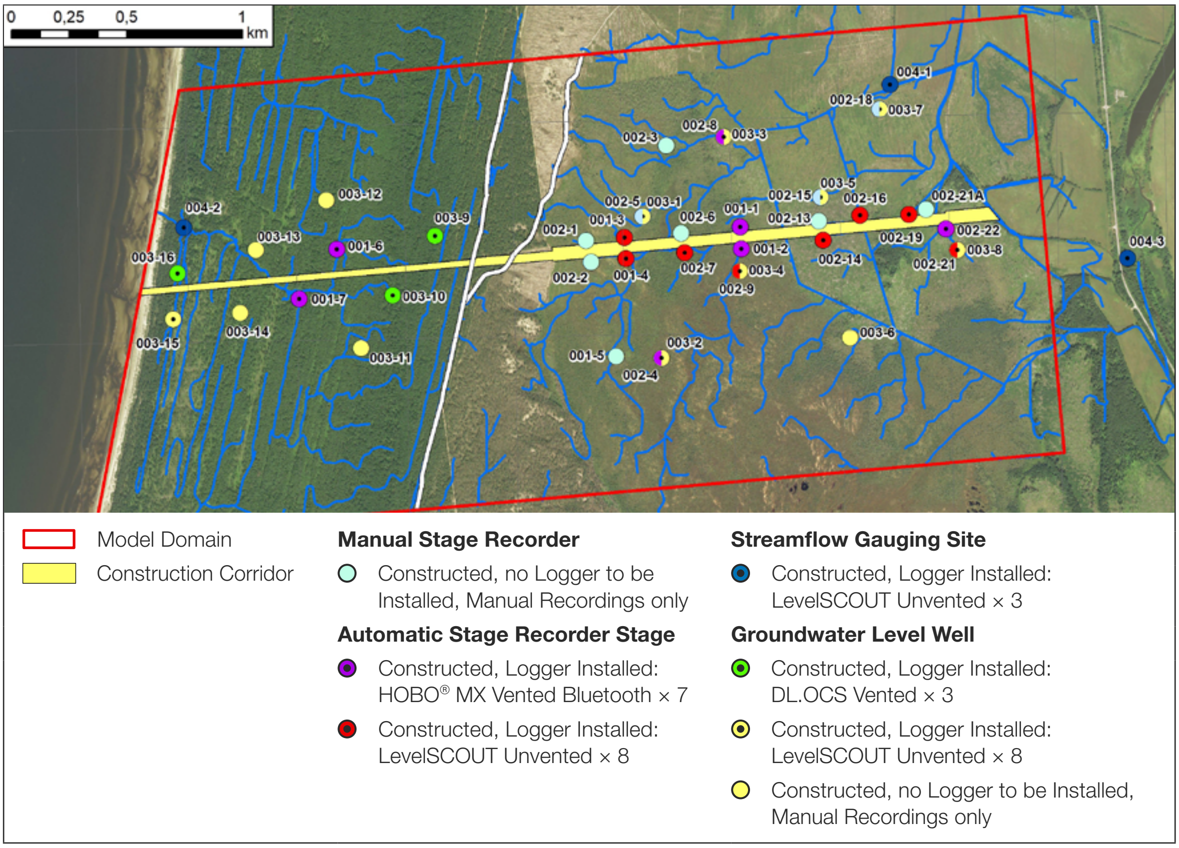


Figure 7. *Location of the monitoring sites with respect to water runoffs lines.*

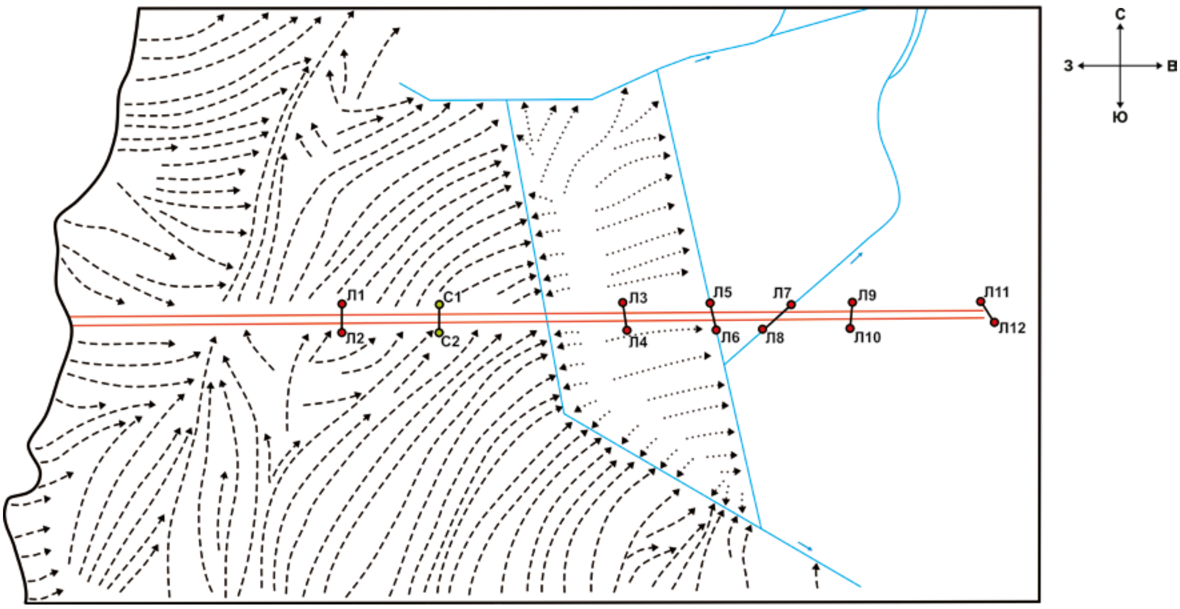


Figure 8. *Grid of swamp water runoff lines and location of control cross-sections for monitoring the swamp water level.*

According to the Federal State-funded educational institution of the State Hydrological Institute (RFSBI SHI), the boundary of this zone has been found to be 50 by 200/300 metres, the maximum width being 0.5 km. Therefore, the monitoring effort should cover the strip up to a width of 0.5 km on both sides of the route. Due to the value of the Kader Swamp as a specially protected natural site, the monitoring area at the end of 2019 was increased to 1 km in both directions. This allows a more objective comparison of the hydrological regime of water bodies in areas not affected by construction with the regime of water bodies located near the route.

RESULTS

According to the map of the grid of marsh water runoff lines (Figure 7) the water flows from the centre of the Kader swamp toward the north side of the site. Therefore the construction of the road and trenches together with the laying of pipes perpendicular to the water runoff lines created the conditions for flooding on the southern side of the route section (rising water level), and on its opposite side a drying zone (lowering water level). This was confirmed by observations of the swamp water level in the standpipes. The difference in the swamp water level increased by 5–10 cm in the standpipes at the site where the swamp water flow lines are directed crosswise to the route. Such a change is not critical, since it fits into the natural swamp water level fluctuations, amounting to 0.3–0.8 metres.

The direction of the swamp water flow lines in the western part of the construction territory and in the eastern half of the swamp is almost parallel to the route. In these areas, a change in the water regime practically did not occur. However, it should be noted that there is a significant slope along the route from west to east. Therefore, the construction of trenches with such a slope can lead to the overflow of marsh waters from the western part of the peat land to the east, the formation of an accumulation zone and flooding of the territory at this location. This stopped after the installation of waterproof jumpers in trench boxes[2] every 160 metres. If this innovative technology is used in the construction, the overflow of swamp waters itoward the east will be minimal.

The impact of the construction and operation of the gas transportation system on the swamp occurs against the background of larger-scale changes in this natural object associated with other factors, including drainage of the swamp by drainage channels, eutrophication by pollutants and a pyrogenic factor. The latter is related to fire. In 2006, the Kader Swamp experienced a grass-roots fire, which probably started in the forest belt adjacent to the swamp from the east. The swamp water flow line grid on the peat bog is currently affected by the drainage network. The drainage network is affected both by natural neglect and beaver dams. Therefore it is difficult to distinguish how much the route influences the water regime in this section of the adjacent swamp, as previous anthropogenic exposure caused more significant changes in its development.

During the construction process, monitoring on the coastal territory did not reveal significant changes in the water regime. Here the direction of the gas pipeline is parallel to the general slope of the flow into the Gulf of Finland. Some of the small streams crossed by the route created temporary accumulation zones up to 20–30 metres wide, but because of the high hydraulic conductivity of the underlying sandy deposits, they quickly dry out.

2 Or slope/trench breakers. These are wooden or peat (with a high degree of decomposition and low hydraulic conductivity) dam constructed diagonally across trench, leading to reduced water flows.

CONCLUSIONS

The construction activities in 2019 caused some fluctuations in the level of the water bodies, leading to the flooding of some parts and the drying out of other parts of the swamp area. These fluctuations were however within recorded natural fluctuations. Other potential changes caused by the construction activities are likely masked by the larger anthropogenic-driven changes that the wetland experiences. The use of innovative technologies (such as the waterproof jumpers in trench boxes) resulted in the impacts of construction activities on the bodies of water being limited.

3.1.4 Terrestrial flora

The construction corridor crosses a heterogeneous mix of plant communities made up of both 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 5).

In addition, in 2018, RDBS that were 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 construction activities. The monitoring work also included an assessment of the survival and general condition of the relocated RDBS.

METHODOLOGY

To monitor the potential impact of construction activities on different plant communities, nine pairs of monitoring plots were established in 2018. For each type of plant community, one plot was established in close proximity to the construction corridor (“control plot”) and another one was established more than 190 metres from the construction area in an undisturbed area (“background plot”), for a total of 18 plots.

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

Monitoring of the above 26 (18 + 8) plots included general geo-botanical surveys once or twice a year (see Figure 9). 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. This monitoring started in 2018 and was planned to continue until 2020.

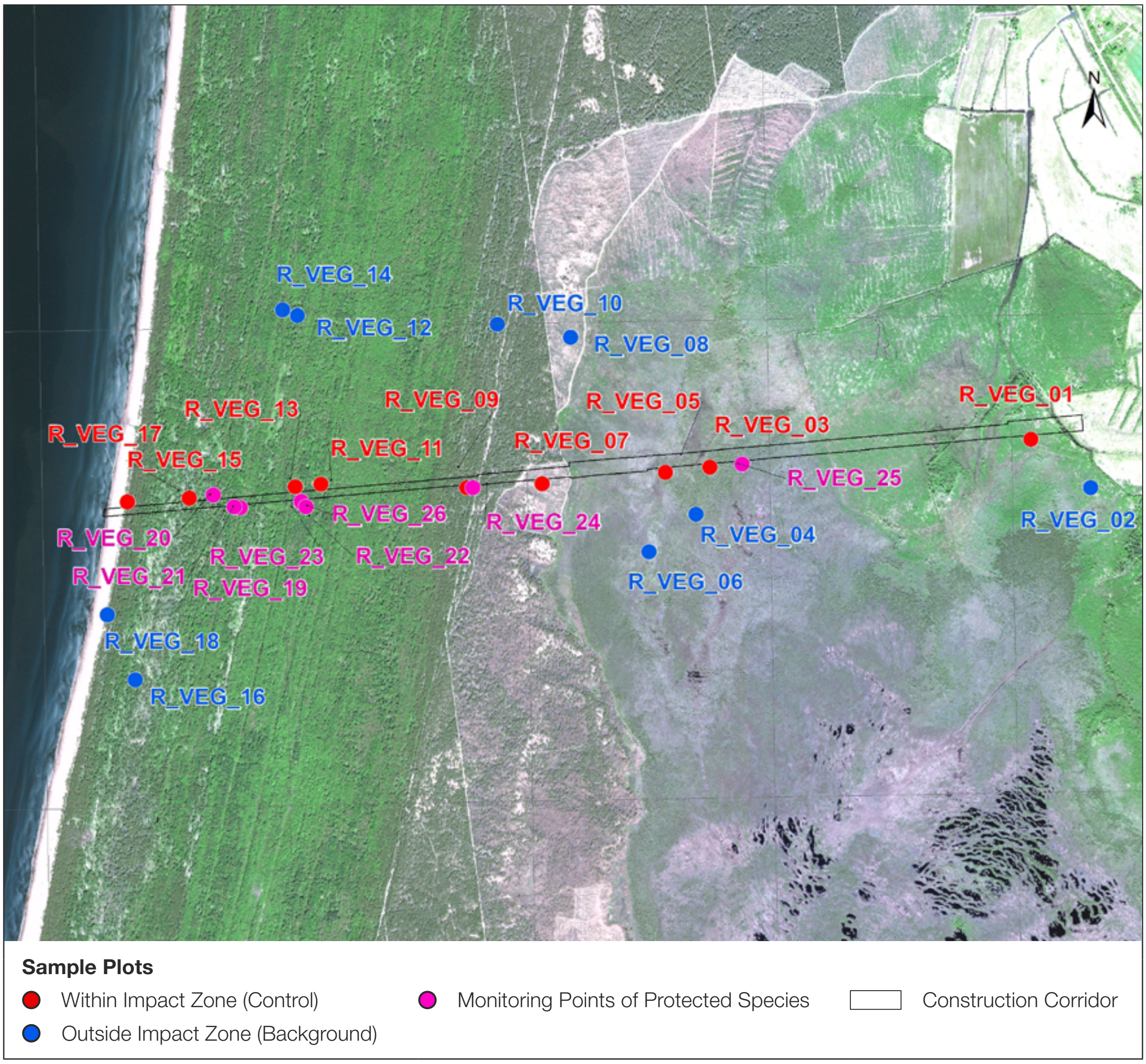


Figure 9. *Permanent monitoring plots.*

In addition, 27 plots were established for monitoring of relocated RDBS. Monitoring of relocated RDBS involved recording the plants' survival and general condition once or twice a year: in spring (May/June) and in summer (July).

Individual specimens from the following RDBS species were relocated in 2018: *Pulsatilla pratensis*, *Pulsatilla patens*, *Epipactis atrorubens*, *Drosera intermedia*, *Hottonia palustris*, *Neottia nidus-avis* and *Aulacomnium androgynum*. Monitoring started in 2018 and is planned to continue until 2020.

RESULTS

No impact from construction has been detected on the forest stand, the undergrowth or epiphytic lichens at any sampling plots. Shrub layer and ground cover were generally found to be in a good state, with the exception of a few control plots located in swampy area and in boggy forest (stations R_VEG_03, R_VEG_05 and R_VEG_13). The RDBS *Aulacomnium androgynum*, *Lobaria pulmonaria* (protected lichen), *Epipactis atrorubens* and *Drosera intermedia* monitored in the proximity of the ROW were also found to be in a good state (see Figure 10).

Figure 10. *Condition of three RDBS monitored in the proximity of the ROW. From the left: Aulacomnium androgynum in R_VEG_20, Lobaria pulmonaria in R_VEG_11 and Epipactis atrorubens in R_VEG_17*

Some changes in the vegetation cover were observed, such as the presence of fallen trees, mainly on the southern side of the construction corridor. Increased exposure to light also caused the death of some forest species in the 5 metre strip on the northern side of the construction corridor and also caused changes in the grass layer of the black alder fen in one site. The presence of ungulates and other animals also caused disturbance to the ground vegetation cover of sites located along the southern border of the construction corridor. In particular, the high concentration of animals along the fence caused visible damage to individuals specimens of *Pulsatilla pratensis*, *Pulsatilla patens* and *Hottonia palustris* (see Figure 11).

Figure 11. *Plants damaged by animals. From the left, Pulsatilla pratensis in R_VEG_09, Pulsatilla patens in R_VEG_24 and Hottonia palustris at R_VEG_19*

The temporary changes in the water regimes due to the construction activities (see Chapter 3.1.3) together with seasonal variability caused desiccation of the sphagnum cover at two sites (stations R_VEG_03 and R_VEG_05) and caused a decrease in the number of *Drosera intermedia* specimens at one site (R_VEG_05) (see Figure 12).

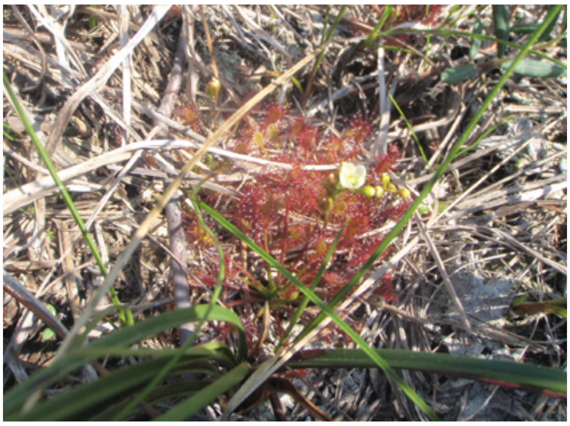



Figure 12. *Drosera intermedia. On the left, plot R_VEG_05 displaying strong drying hollows and sphagnum cover; on the right, plot R_VEG_25 displaying a healthy cover.*

In addition, it should be noted that *Neottia nidus-avis* has been excluded from the Red Book of the Leningrad Region by order of the Committee on Natural Resources of the Leningrad Region (No. 14 of September 12, 2018). This species has mostly an underground growth, with unpredictable appearance of aboveground flower stalks. In 2019, no aerial parts of *Neottia nidus-avis* were recorded at any of the monitoring sites. Continuing observation will allow information about this type of chlorophyll-free orchids to be added and their condition to be compared with that of the replanted specimens.

CONCLUSIONS

According to the monitoring results, the impacts on vegetation in the Kurgalsky Nature Reserve that occurred due to the construction activities in 2019 were acceptable and in line with the EIA documentation.

The monitoring of protected species which were affected through the change to local hydrology as a result of the open trench, such as *Drosera intermedia*, as well as monitoring of locations affected by wild animals will be extended into 2020.

The project has been implemented in compliance with the national EIA, national requirements for protection of SPNAs, the Decree on the Kurgalsky Reserve and the RDBS relocation permit requirements.

3.1.5 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:

- Local avifauna;
- Migratory avifauna;
- Three breeding indicator species[3], one for each biotope crossed by the project area (wetlands, forest and beach);
- Monitoring of protected species of birds.

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 13. Monitoring started in 2018 and is planned to continue until 2020.

- 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;
- 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;
- 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);
- Visual observations of protected species of birds were recorded during all above-mentioned monitoring activities.

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/ active acoustic monitoring	Camera traps	Number of observations and findings
Common crane	> 18 surveys > 104 km in total	71 h in total	11 camera traps in feeding biotopes served on monthly basis during breeding and nesting period (May–August)	> Voice signals registered in 50 locations > Visual observations recorded in 8 locations (13 individuals) > 20 camera traps pictures (36 birds in total). It is estimated that 6–9 couples are nesting and breeding in the project area

3 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.

Species	Route surveys	Passive/ active acoustic monitoring	Camera traps	Number of observations and findings
Black woodpecker	> 9 surveys > 62.5 km in total	33 h/24 h	–	> 80 observations (visual and acoustic, incl. 22 answers to voice signals) > 16 new potential nesting locations (findings), incl. inhabited hollow with at least 2 chickens on the ROW northern border
Ringed plover	> 10 surveys > 60 km in total	–	–	> 31 nesting locations (one resultative laying close to construction area). > 26 observations. > It is estimated that 2 bird couples live in the project area

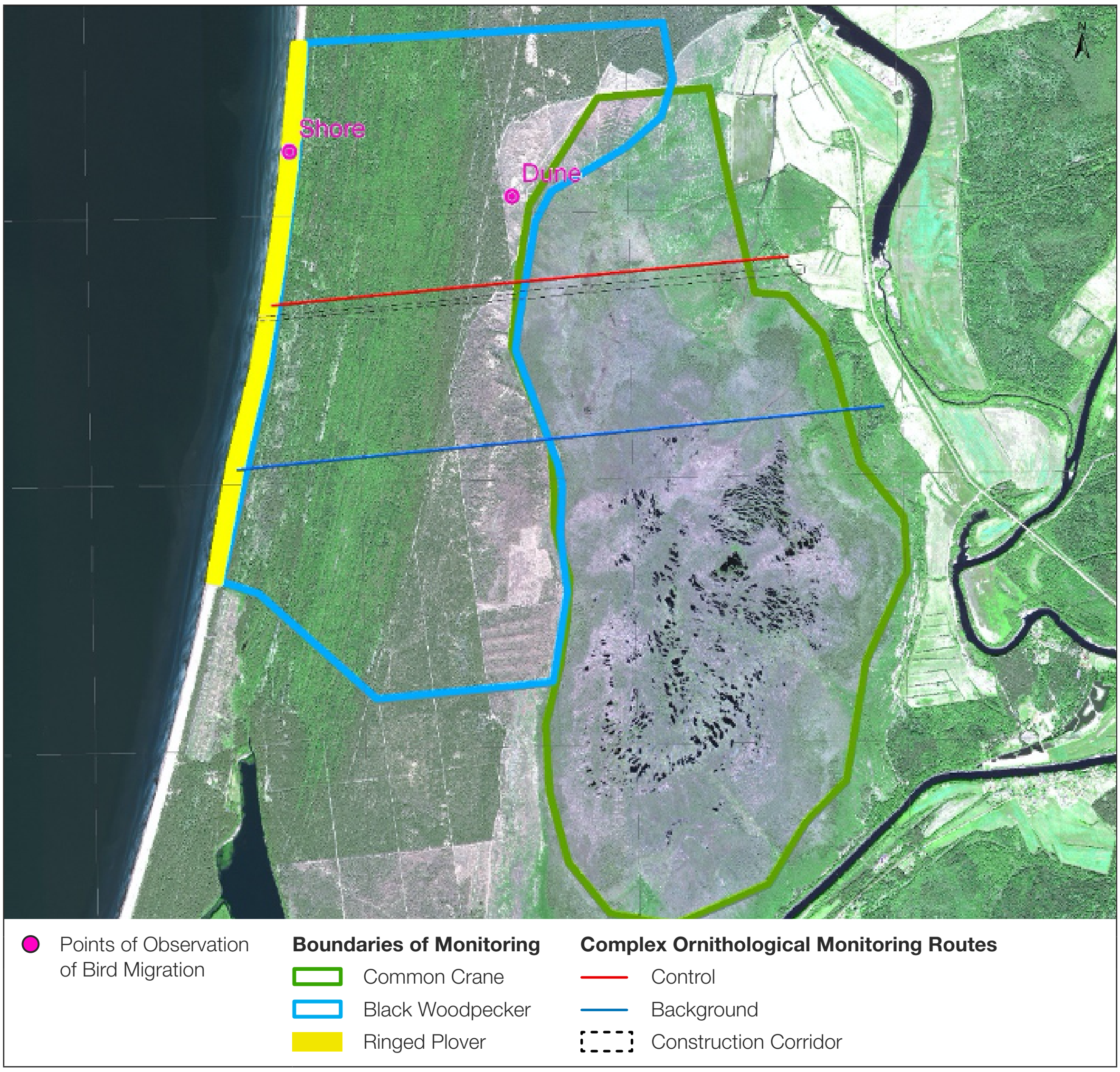


Figure 13. *Overview of bird monitoring locations at the Russian landfall.*

RESULTS

Monitoring of local avifauna showed that changes in species composition and population sizes on the different transects throughout the monitoring period 2018–2019 were comparable (see Figure 14). 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.

There were no signs of impact on the composition, number and displacement of birds in the period from September to November 2019 (end of construction activities, see Chapter 2.2) within the project area. In general, it could be assessed as a positive trend, which is expressed in the restoration of the structure of the local grouping of birds that characterized the territory before the impact.

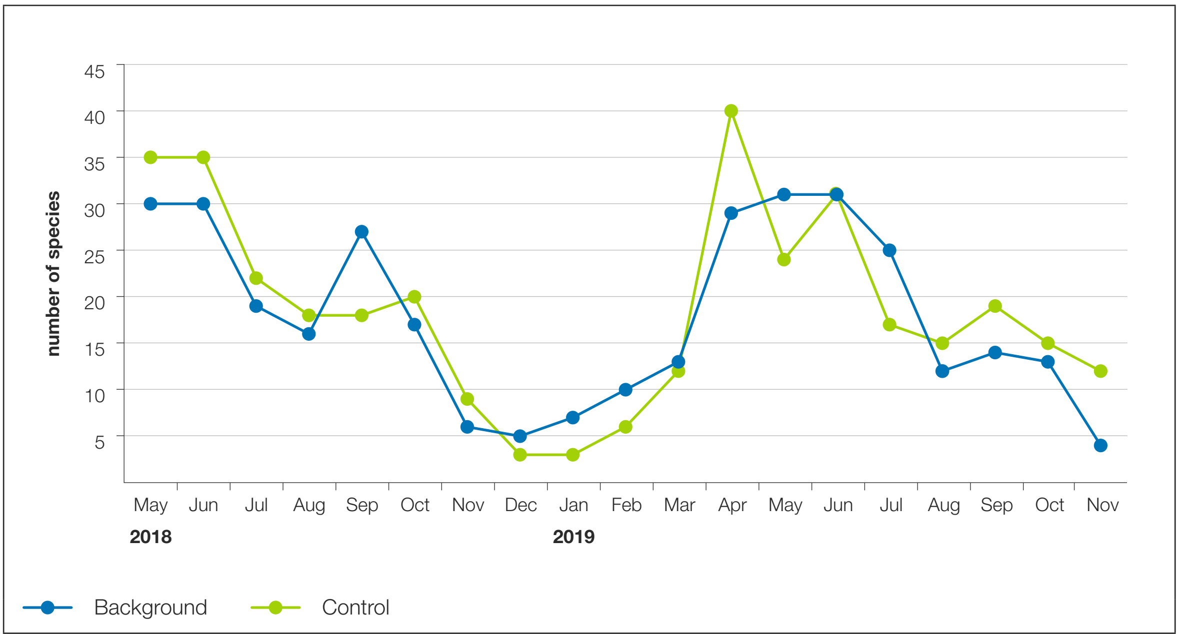


Figure 14. *Retrospective dynamics of species diversity (2018–2019). Control transect is located in close proximity to the construction corridor; background transect is located approximately 1 km south of the construction corridor.*

Monitoring of migratory avifauna showed changes in migration patterns of geese and some sea ducks probably related to construction activities. The data obtained indicate a consistent decrease in the number of migrating geese during both 2019 seasons. No clear conclusion about the nature of the recorded phenomenon could be made.

No changes in the flight patterns of other birds were detected. A total of 26,194 individuals were recorded during the observation period, including 15,852 during the spring period and 10,342 during the autumn migration.

According to the surveys conducted in April–June 2019, there were no signs that construction had any impact on the placement of nesting territories of cranes, the number of local groups or the state of local groups within the monitoring zone. The estimated population size of the common crane in the Kader Swamp area was assessed as 7–9 couples (the same as during previous season 2018). At least three couples have successfully bred in 2019 (see Figure 15). Cranes of the local group stayed within the nesting area until mid-August and later flew away to places for autumn clusters and wintering.

Figure 15. *A pair of common cranes with a brood.*

A comparison with the data on black woodpecker encounters in 2018 indicates that most of the identified habitat for this species was successfully preserved. During the 2019 monitoring season (April–August) 16 new sites of potential breeding hollows were found in living pines. At least two of them were considered to be inhabited (see Figure 16).

Figure 16. *Two black woodpecker chicks, in a hollow in an aspen growing on the northern border of construction corridor.*

The number of ringed plover and its localization within the project area in general corresponds to the results in 2018. Registered birds do not show signs of anxiety associated with the presence of construction infrastructure and equipment within the habitats. On the contrary, positive effects for the population of local birds were observed during the 2019 monitoring season (May–June). Due to the fencing of the construction corridor, the southern sector of the shoreline has been isolated and protected from any recreational activity. Two pairs of ringed plover successfully bred in the area close to the ROW (see Figure 17). In 2018 no such findings had been detected in the project area as a result of the great stress to biotopes affected by local recreation in early summer before tree cutting in the ROW and before the fence was installed.

Figure 17. *A nest of a ringed plover close to the cofferdam area (about 200 m to the south).*

In total, 34 species of birds specie of category 3 (NT) and higher in the Red Book of the Russian Federation, Red Book of the Leningrad Region, Red List IUSN and Red List HELCOM were recorded during the period from November 28, 2018, to November 28, 2019 (Table 4). Of the 34 registered bird species, 20 (58.8%) species are representatives of the wetland avifauna, 24 species breed within the Kurgalsky Peninsula, four species possibly breed, six more species were found exclusively during migration.

Table 4. *List of protected rare bird species found during the 2019 monitoring.*

Species	Status in the territory*	Type of monitoring works		
		Observation of migration	Observations on the routes	Incidental observations
		Aves Galliformes		
The Horned grebe *Podiceps auritus*	nest. migr.			×
Willow grouse *Lagopus lagopus*	nest. settl.	×	×	×
		Anseriformes		
Whooper swan *Cygnus cygnus*	nest? migr.	×	×	×
Taiga bean goose *Anser fabalis*	migr.	×		×
Greylag goose *Anser anser*	nest. migr.	×		
The Gadwall *Anas strepera*	nest. migr.			×

Species	Status in the territory*	Type of monitoring works		
		Observation of migration	Observations on the routes	Incidental observations
Long-tailed duck *Clangula hyemalis*	migr.	×		×
Tufted duck *Aythya fuligula*	nest. migr.			×
Charadriiformes				
The European golden plover *Pluvialis apricaria*		×		
The Common Redshank *Tringa totanus*	nest?, migr.		×	
The Ruff *Philomachus pugnax*	migr.	×		
The Great snipe *Gallinago media*	nest?, migr.			×
The Black-tailed godwit *Limosa limosa*	nest?, migr.		×	
Eurasian curlew *Numenius arquata*	nest. migr.	×	×	
The Whimbrel *Numenius phaeopus*	nest?, migr.			×
The Eurasian oystercatcher *Haematopus ostralegus*	nest?, migr.	×		×
Common ringed plover *Charadrius hiaticula*	nest. migr.	×		×
Common sandpiper *Actitis hypoleucos*	nest. migr.	×		×
Northern lapwing *Vanullus vanellus*	nest. migr.	×	×	×
The Lesser black-backed gull *Larus fuscus*	nest. migr.	×		
The Little tern *Sternula albifrons*	nest. migr.			×
Falconiformes				
The White-tailed eagle *Haliaeetus albicilla*	nest. settl.	×	×	×
Osprey *Pandion haliaetus*	nest. migr.	×		×
The Peregrine falcon *Falco peregrinus*	nest?, migr.	×		
Columbiformes				
The Stock dove *Columba oenas*	nest. migr.	×		
Piciformes				
The Grey-headed woodpecker *Picus canus*	migr.	×		
The Three-toed woodpecker *Picoides tridactylus*	nest.	×	×	×

Species	Status in the territory*	Type of monitoring works		
		Observation of migration	Observations on the routes	Incidental observations
European green woodpecker *Picus viridis*	**migr.**	×		
		Passeriformes		
Spotted nutcracker *Nucifraga caryocatactes*			×	
Northern wheatear *Oenanthe oenanthe*	**nest. migr.**			×
Great grey shrike *Lanius exubitor*	**nest. settl.**			×
Woodlark *Lululla arborea*	**nest. migr.**	×	×	×
The Coal tit *Periparus ater*	**nest.**		×	
The Rustic bunting *Emberiza rustica*	**nest. migr.**		×	

* Abbreviations: nest;–nesting; nest?–possibly nesting; migr.–migratory; settl.–settled

A pair of white tailed eagles (*Haliaeetus albicilla*) nested at their previous nest site ca. 56 metres from the southern ROW border. The nesting and laying of the eggs was observed from February 2019 to the end of April, when the eagles left the nest. In this period, the installation of the cofferdam started in January and continued through to mid-April. Consequently, the conclusion is that construction activities did not disturb initial phase of nesting. Ornithologists could not find a clear connection between project activities and abandonment of the nest.

Based on monitoring results 2019, no suppression of breeding, change of nesting sites or other signs of the impact on these species were observed during construction activities.

CONCLUSIONS

Minor not critical impacts on the migration of geese and sea ducks were observed in 2019. Those effects were assessed in the national EIA as temporary and an acceptable impact. Project implementation was in compliance with national requirements for SPNA protection and the Decree on the Kurgalsky Reserve.

3.1.6 Terrestrial fauna

Monitoring of terrestrial fauna included monitoring of rare and protected species of terrestrial fauna and monitoring of other wild life. Rare and protected species of terrestrial fauna are defined as 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 bird species is presented in Chapter 3.1.5 and monitoring of protected plants included in the Red Data Book Species List is discussed in Chapter 3.1.4.

METHODOLOGY

Visual observations of protected species of terrestrial fauna and observations of their tracks and signs were recorded during all bird monitoring activities (see Chapter 3.1.5). In addition several camera traps were installed in sensitive areas and on potential animal migration routes (see Figure 18).

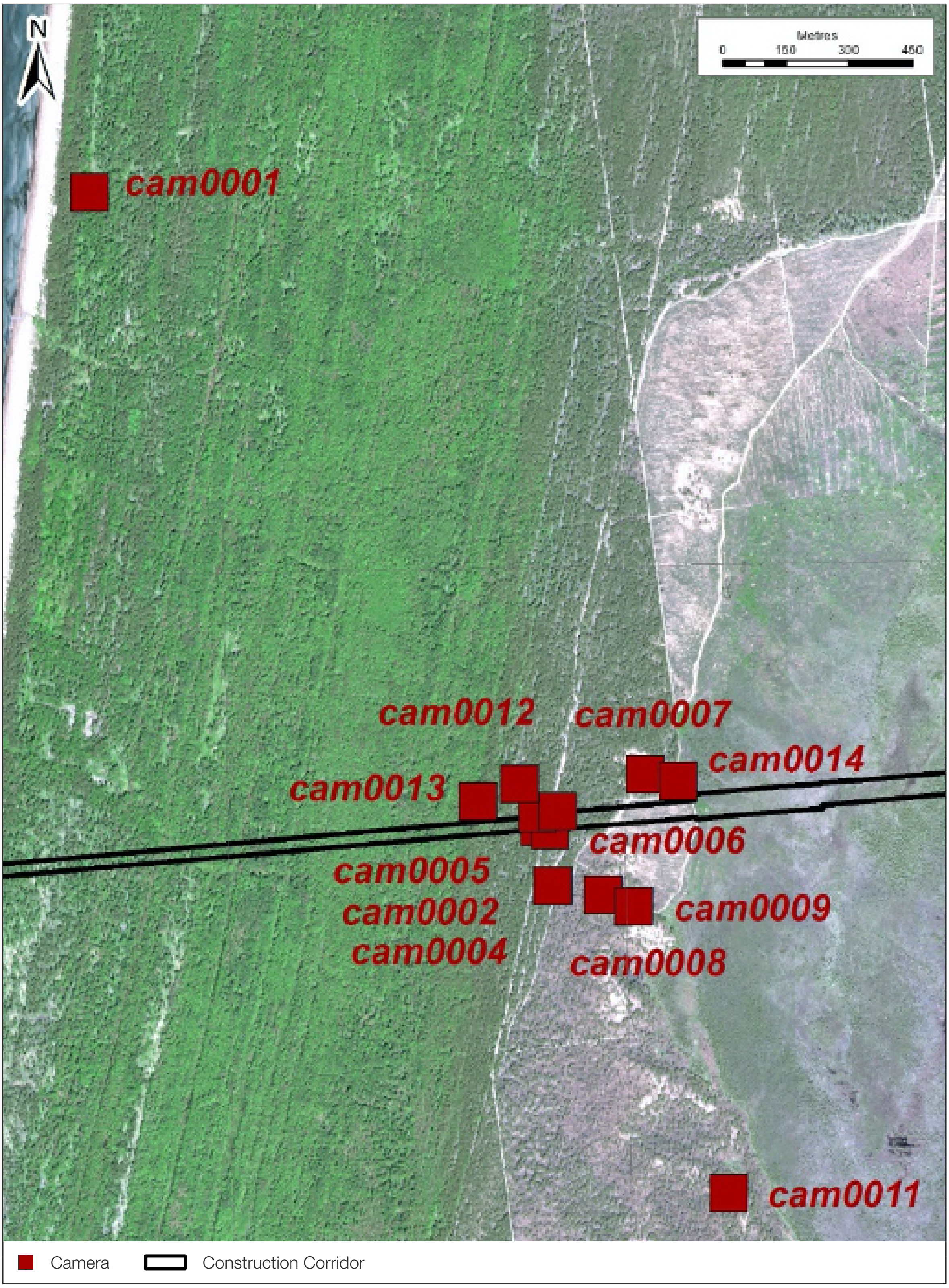


Figure 18. *Camera traps locations (monitoring of vertebrates' migration)*

RESULTS

Both common in the project area protected species grey seal and grass snake were observed in 2018 and again in 2019. In 2019:

- the corpse of a killed grey seal *(Halichoerus grypus*) drawn in a gill net was found on the beach in early summer;
- grass snakes (*Natrix natrix*) were observed several times along the northern ROW border in spring, and in the cofferdam area in summer.

The migration routes of ungulates (such as moose and roe deer) were affected by the fencing of the ROW. Those animals (unlike wild boar and predators) avoided using the wild life crossing corridor close to the relict dune, which was opened in beginning of 2019. This led to a high concentration of ungulates in the fenced forest section, and some local populations of rare and protected plants near the fence were affected by animals (see Chapter 3.1.4). Wider wild life corridors were open later to facilitate animal crossings in different biotopes. The opening of the additional wild life corridors took place as soon as it was deemed safe, namely after backfilling of trenches. Based on the late autumn data, the opening of these wider wild life corridors helped to normalise the ungulates' migration routes. The restoration of local plant populations will however be visible only in the 2020 monitoring season.

CONCLUSIONS

Based on the monitoring results, the construction activities had no impact on Red Data Book Species. Other wild life, such as ungulates, were affected to some extent by the construction activities, but the impacts were deemed to be temporary. Project implementation was in compliance with the national EIA, national requirements for SPNA protection and the Decree on the Kurgalsky Reserve.

3.2 Monitoring of construction camp and work areas

Monitoring at the construction camp and work sites (including the ROW) 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 close to the nearest settlement to ensure that there is no adverse impact on 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 19.

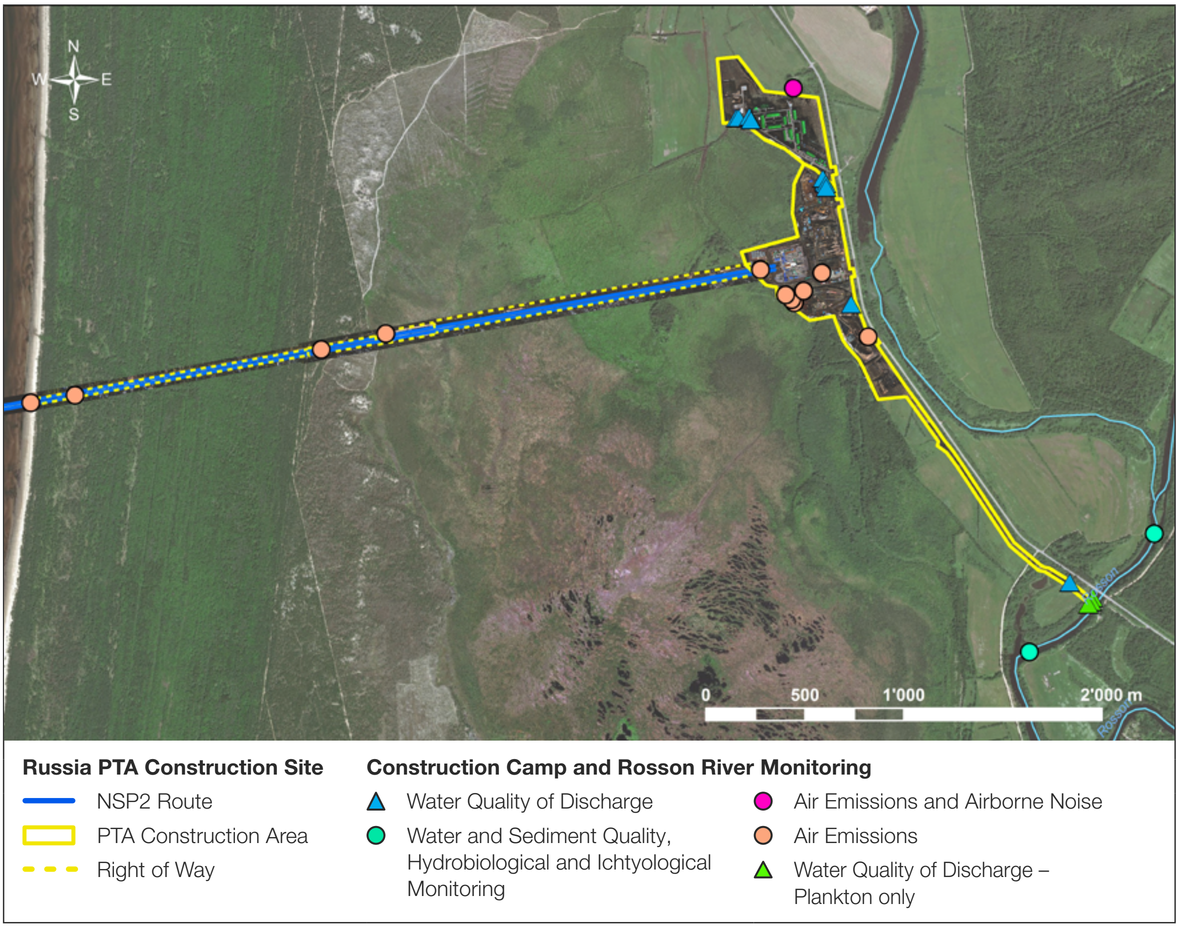


Figure 19. *Environmental monitoring at the construction camp and work areas and in the Rosson river.*

In general, the construction activities occurring at the construction camp and work sites in 2019 were in line with the estimates given in the national EIA. The quality of discharged water was temporarily not in compliance with sanitary norms. However, problems were identified with the effectiveness of sewage treatment and were successfully solved in the first half of the year (Chapter 3.2.1). In discussion with authorities it was agreed that additional actions would be undertaken in 2020 to normalise the quality of discharged water. Those actions are related to the discharge pipeline. Monitoring of air emissions (Chapter 3.2.2) and airborne noise (Chapter 3.2.3), measured both in the construction camp and close 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 at the Landfall Russia worksite. These comprise:

- A sewage treatment plant (STP) located at the workers camp;
- A storm water treatment plant (SWTP) treating runoff from parking areas, and
- A drainage water treatment plant (DWTP) treating wastewater from the dewatering of excavations at the Pig Trap Area.

Treated water from these facilities is transported by pipeline and discharged at an outfall on the Rosson River.

The discharge permit, the water licence and the discharge limit documentation regulate water discharges from the work sites and served as the basis for development of the monitoring programme for water discharges.

The volume and quality of water discharges are monitored at the three water treatment plants. In an adaptive management sense, this information enables remedial actions to be implemented when the quality of treated effluent is out of compliance with license conditions

Where treated water quality is 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 a number of locations distributed as follows (see Figure 20):

- one upstream of each treatment plant;
- one downstream of each treatment plant, except for the sewage treatment plant which had two monitoring stations (additional location was added in October, after treatment plant extension);
- one at the outfall into the Rosson river;
- two additional sampling locations shown in Figure 19 are related to baseline monitoring of the Rosson river and will be discussed in Chapter 3.3.

The monitoring programme specifies quarterly sampling of water discharges (since October 2019 increased to monthly). In addition, the treated effluents were sampled on a weekly and later bi-weekly basis to support the operation of the various treatment plants. Additional sampling locations were monitored from time to time, including the holding tank, pumping station well and pressure reducing wells.

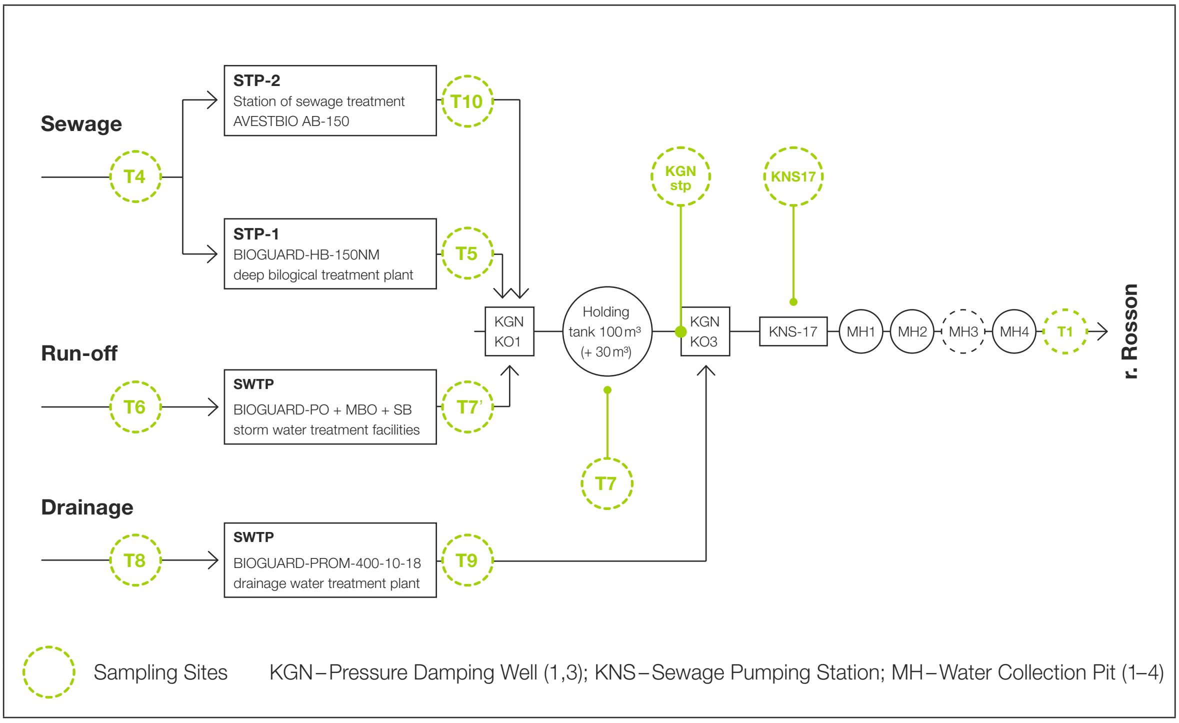


Figure 20. *Distribution of treatment plants and its monitoring. STP – Sewage Treatment Plant; SWTP – Storm Water Treatment Plant; DWTP – Drainage Water Treatment Plant.*

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.

RESULTS AND CORRECTIVE ACTION

Sewage Treatment Plant (STP)

The quality of treated sewage in the first two months 2019 remained poor for sanitary parameters (thermotolerant coliform and later, total coliform bacteria count). In February 2019 the number of bacteria increased dramatically (up to 2018 levels). BOD, COD, phosphates and ammonium nitrogen were also above thresholds. Consequently, treated effluent discharge was stopped from the beginning of March, and on the advice of experts the company initiated modification of the treatment facilities.

After maintenance and improvement of the plant, the quality of treated effluent was in compliance with licence conditions except during a short commissioning period, when minor issues with the denitrification cycle were identified.

Due to increasing loads on the treatment system associated with increasing numbers of workers, significant amounts of sewage were tankered to external licensed facilities in parallel with the discharge of treated effluent at the outfall on the Rosson River. The capacity of the sewage treatment plant was subsequently increased. The extended facilities started operating in November 2019. After a short commissioning period, the quality of treated effluent remained in compliance with licence requirements.

Storm Water Treatment Plant (SWTP)

Treated run-off from hardstand area in the camp complied with licence and permit requirements for most of the year for the main monitored parameters (TPP and TSS) in accordance with the obligatory monitoring programme.

Due to high chloride levels associated with brine disposal into the storm-water treatment facility, treated effluent was tankered away for offsite treatment for much of 2019.

Drainage Water Treatment Plant (DWTP)

Discharge from the DWTP was stopped at various times due to maintenance of the plant. The quality of treated effluent remained stable over much of the year and was in compliance with licence requirements for all parameters, except for minor deviations in iron, manganese, ammonium nitrogen and BOD. Those results are not related to poor performance of the plant but were influenced by the characteristics of the incoming drainage water. The effectiveness of the treatment is assessed as 97–99% for these parameters. This situation is typical for the Leningrad region and did not require any remedial action.

Quality and quantity of water at the outfall on the Rosson River

Combined water discharge into the river (from all treatment plants) was stopped between October 30th and November 24th due to maintenance of the treatment plants (commissioning of extended sewage treatment plant and repair of drainage water treatment plant).

The total volume of water discharged in 2019 was about three times less than permitted in accordance with documentation limits (57,500 m^3 instead of 184,300 m^3). A comparable volume was tankered to external licensed treatment facilities during the year.

Although the STP and DWTP plants were working in an effective manner up to the end of the year, the quality of the water at the outfall was found to be of poor quality. Based on the sequential elimination of different factors it was concluded that the main issue was not related to the performance of the treatment plants and was possibly due to a problem with the functioning of the discharge pipeline system.

The monitoring programme and discharge permit were updated at the end of the 2019 with additional requirements. Nord Stream 2 was advised by the authorities to undertake a pressure test of the discharge pipeline before June 2020 and rectify faults no later than September 2020.

CONCLUSIONS

Monitoring results were submitted to the water basin authority and later to Committee of Natural Resources of Leningrad Region and the Fishery Authority on a quarterly basis in accordance with discharge permit conditions /15/.

The total volume of water discharged was in compliance with the discharge permit and water licence conditions. Where water quality results were out of compliance with licence conditions, water was tankered away for offsite treatment. Problems associated with the operation of the discharge pipeline infrastructure will be investigated and rectified in 2020. All wastewater will be taken away for offsite treatment until the problem has been identified and rectified.

3.2.2 Air emission and quality

Monitoring of air quality was carried out at the construction camp and at the village of Khanike, near the construction camp (see Figure 19). The purpose of the monitoring is both to verify compliance with the national EIA, the SEER report and permits, and to ensure that the construction activities do not have a negative impact on the local community.

METHODOLOGY

The air emission sources that are monitored are the diesel generators at the construction camp and the main generators used for particular construction activities, such as: welding, pulling (winch generators), construction workshops and generators of checkpoints located along the ROW. Monitoring includes comparison of the actual location of the sources with the planned location as per the EIA documentation and the sampling and analysis of the gas mixtures.

With respect to particular operations like welding and pulling, two sampling campaigns were arranged:

- 22nd–27th May – 13 sources mostly related with the TWA, PTA, cofferdam area and checkpoints located along the ROW;
- 26th July–1th August – ten sources, including six camp generators, two winch generators and two welding generators.

Each individual sample was taken over a period of 2–2.5 hours. The samples were analysed by an accredited laboratory (see Table 5).

Construction camp generators were identified as the main source of air emissions potentially affecting Khanike village, as in 2018.

Air immissions were monitored between 28th May and 2th June at a sampling station located close to the village less than 100 metres from the construction camp. Sampling was carried out every six 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 more than planned in the EIA documentation (23 actual operational sources vs 14 planned). However, thanks to optimisation of the construction processes and also due to a conservative assessment in the EIA phase, the total emission volumes at the construction camp and Khanike village were well below the planned volumes stated in the EIA for the whole construction period.

Table 5. *Actual volume of emissions in 2018 and 2019 compared with EIA's estimates.*

No.	Pollutant	Air emission Volume (t)		
		Measured emission in 2018	Measured emission in 2019	EIA, whole construction period
1.	Nitrogen oxide	0.896468	4.123626	12.684546
2.	Nitrogen dioxide	5.518161	25.376025	78.057830
3.	Kerosene	0.098237	0.382216	20.626482
4.	Sulphur dioxide (sulphurous anhydride)	0.507809	2.653518	20.834053

No.	Pollutant	Air emission Volume (t)		
		Measured emission in 2018	Measured emission in 2019	EIA, whole construction period
5.	Formaldehyde	0.002511	0.028732	0.235214
6.	Black carbon (soot)	0.029282	0.251669	12.778055
7.	Carbon monoxide	0.685934	4.395957	79.957796
8.	Benzo(a)pyrene (3,4-Benzpyrene)	0.0000003	0.0000012	0.000039

The results were reported in quarterly and annual reports /16/, /17/.

CONCLUSIONS

Air emissions were in compliance with the national EIA. Although the number of sources was 1.6 times higher than listed in the air emission documentation, the total emissions volumes were well below the estimated values. The total air immissions have no negative impact on the local community.

3.2.3 Airborne noise

Airborne noise was monitored close to Khanike village (see Figure 19). The purpose of this monitoring 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, five 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”, which provided a positive expert opinion regarding the noise levels originating from the construction activities /16/, /17/.

At the same time, night levels of airborne noise generated by camp diesel generators (working in 24/7 mode) were close to the permissible level (45 dBA) in 2019 – see trend on the Figure 21.

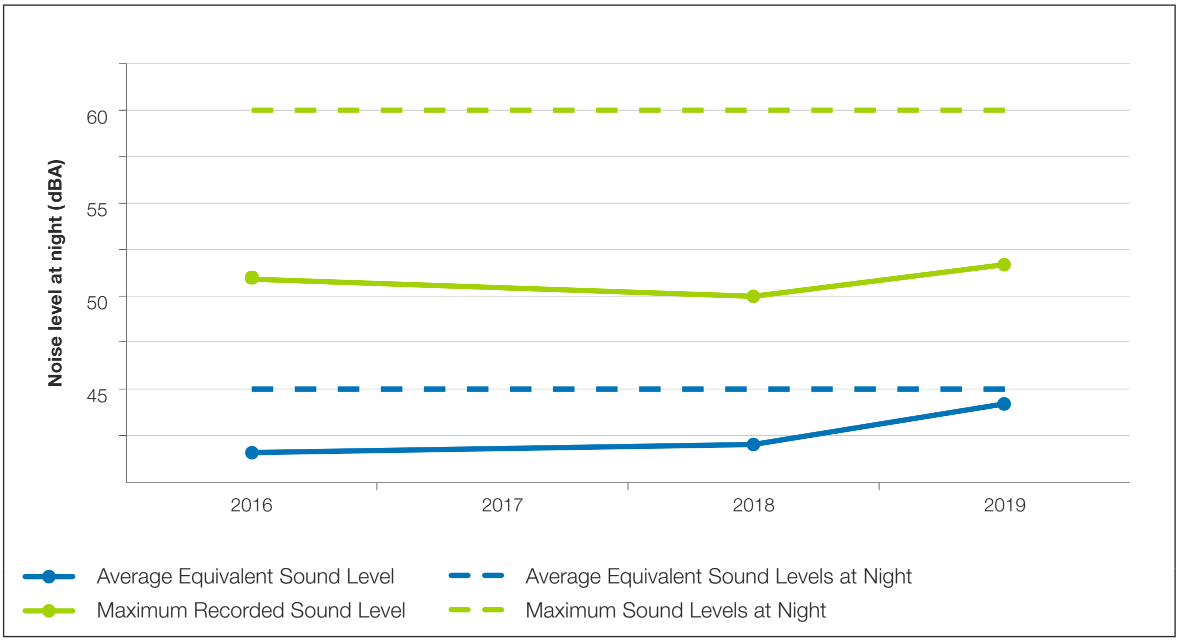


Figure 21. *Airborne noise monitoring results of noise from camp diesel generators.*

The sanitary authority recommended that the generator area be protected with screens. These were installed as soon as possible (see Figure 22).

Figure 22. *Screens installed around the generators to limit air noise immissions.*

CONCLUSIONS

Noise immissions in 2019 were in compliance with the national EIA and with the regulatory requirements for noise levels in residential areas. The noise immissions had 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. Monitoring of the river environment covers water and sediment quality as well as the biological environment, such as benthos and plankton communities and fish fauna. The two monitoring locations are situated 500 metres up – and down-stream of the discharge point (see Figure 19). 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 monitoring of the Rosson river is designed to ensure that the water discharges from the water treatment plants at the Russian landfall do not impact the ecological status of the river.

Monitoring results for 2019 did not show any changes in the river environment related to Nord Stream 2 discharges. Monitoring of water quality began prior to the start of discharge in summer 2018. No significant changes of contamination level were registered during 2019 in spite of water being discharged which was not in compliance with water licence requirements (see Chapter 3.2.1). No epidemiologically significant non-compliance or toxicological manifestations was detected as in 2018 (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 and pre-construction monitoring in 2018 (see Chapter 3.3.1). Monitoring of the river's biotic environment was in line with earlier baseline surveys and pre-discharge monitoring results for 2018 (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 assess potential impacts of water discharges from the Nord Stream 2 construction sites into the river (see Figure 19). In addition, the monitoring work also took into consideration the natural seasonal dynamics of river bodies. Monitoring took place on a quarterly basis. Starting in November 2019, the frequency of water quality sampling was increased to monthly, as defined by the updated water licence requirements.

METHODOLOGY

Monitoring of water and sediment quality was carried out at two sampling locations, during five sampling campaigns (February, May, August (2 samples), November), in order to account for seasonal variability. Additional water quality sampling took place in December due to the extension of the monitoring programme.

Water samples were taken from the top 0.3–0.5 metres 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 0.20 metre soil layer. The soil samples were analysed by accredited laboratories including chemical analysis tests.

RESULTS

The water quality of the Rosson river during the reporting period (2019) as well as prior to the treated wastewater discharges (2018) mostly corresponded to the category "moderately polluted". This applies to both water up – and down-stream of the discharge point, see Figure 23 and Table 6 /17/.

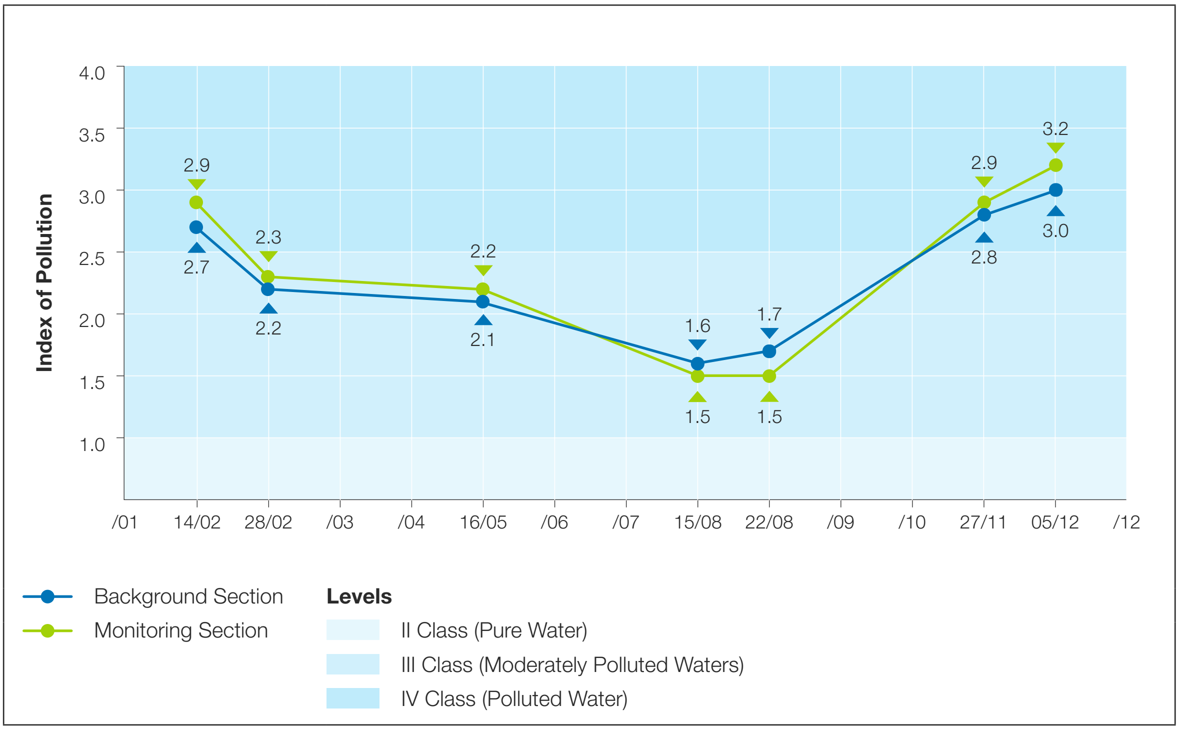


Figure 23. *Monitoring of Rosson river results in 2019. Results are presented as index of pollution /18/.*

The river water was found to have a high content of components that is typical for wetlands (iron, manganese, ammonium ions, phenols and humic substances). The monitoring results indicate that the state of the water body has not been affected in terms of the monitored parameters for the construction period. The water quality was generally in compliance with the recommended values, with the exception of some pollutants (i.e. phenols, ammonium nitrogen, manganese, BOD5, total iron, aluminum and oil products) for which low and medium concentrations were recorded.

The main contaminants of the river water according to monitoring results were iron and manganese, which are common natural soil metals. These contaminants are characterised by natural increases during ice periods: their seasonal dynamics were captured well by the pollution index (see Figure 23).

Pollution of river water by coliform bacteria (total and thermotolerant bacteria count) up – and downstream from the discharge outlet in 2019 was observed throughout the monitoring period, indicating the likelihood of faecal contamination. In 2018, before the start of discharges from the treatment plants, the water quality was also found to exceed temporarily the recommended values for total coliform bacteria and thermotolerant coliform bacteria.

Helminths (ascaris, whipworm, toxocar, fasciol), oncosphere taeniidae and viable cysts of pathogenic intestinal protozoa were not detected, therefore meeting the sanitary standards. Coliphages in February–May were not detected in the samples. In August, November and December they were found in all samples but within the required sanitary standard concentration (less than 10 CFU/100 ml) /19/.

According to the biotesting results, the water at the control location (down-stream) did not show a toxic reaction to the two test objects applied and were therefore categorised in the lowest categories of hazardous waste. In the background location (up-stream) in 2 samples (May and August), signs of the toxic effect of water on the test object *Daphnia magna* were revealed. The samples did not have an acute toxicity effect since the analysis did not observe the death of 50% of hydrobionts. However, they cannot be assigned to class V (i.e.: "almost not dangerous") according to the Sanitary rules for determining the hazard class of toxic waste production and consumption /20/, since according to the biotesting, an excess of daphnia mortality over the standard of 10% was found. Further, biotesting on the second object (*in vitro* bull sperm) showed however no toxic effects. The results of the biotest suggest that the toxicity of these samples was between V and IV ("polluted") classes according to the classification of the Ministry of Natural Resources of Russia.

Soil sampling in 2019 was based on quarterly profiling and showed no changes in bottom topography related to water discharges. Metal concentrations measured in all bottom sediment samples were comparable to the median concentrations of these metals during pre-construction monitoring 2018 (before the start of the discharge of treated wastewater). Measured concentrations of oil products were also comparable with the average background level in 2018 and in four samples of 10 they were even less than the detection limit. Bottom sediments were classified as: 0 ("clean" sediments) or I ("low contamination" sediments) as per the Regional Standards /21/. Categorization to class I was only because of the presence of oil products (see Table 6).

Table 6. *Rosson river sediment quality results, according to the Regional Standards categorization.*

Location	Monitoring subject	Period/class				
		February	May	August	August	November
Background (500 m upstream)	water	**Class IV** "polluted"	**Class III** "moderately polluted"	**Class III** "moderately polluted"	**Class III** "moderately polluted"	**Class IV** "polluted"
	sediment	**Class I** "low contamination"	**Class 0** "clean"	**Class 0** "clean"	**Class I** "low contamination"	**Class 0** "clean"
Control (500 m downstream	water	**Class IV** "polluted"	**Class III** "moderately polluted"	**Class III** "moderately polluted"	**Class III** "moderately polluted"	**Class IV** "polluted"
	sediment	**Class I** "low contamination"	**Class 0** "clean"	**Class 0** "clean"	**Class 0** "clean"	**Class I** "low contamination"

CONCLUSIONS

The discharge of wastewater did not have a significant impact on the chemical pollution levels of river water and sediments /17/. The river water was slightly affected by discharge in terms of bacteriological pollution, but no epidemiological or toxicological effects were determined in that regard. The conditions of water and sediment of the Rosson river were not significantly impacted by the waste water discharge.

3.3.2 Hydrobiological environment

Monitoring of the hydrobiological environment of the Rosson river was set up to assess potential impacts of water discharges from the Nord Stream 2 construction sites into the river (see Figure 19). The monitoring investigated the conditions of phytoplankton, zooplankton, zoobenthos and macrophyte communities.

METHODOLOGY

Sampling was performed in August–September to compare 2019 data with 2018 pre-construction monitoring results and the baseline survey with respect to seasonal trends.

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 metre 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 four sites (see Figure 19). 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 characteristics of the phyto – and zoo-plankton community in the area under consideration corresponded to the seasonal characteristics of the plankton of the Leningrad Region rivers. Taking into account the biomass of phytoplankton, the Rosson river in 2019 can be described as a water body of mesotrophic conditions with oligotrophic features.

Although the structure of phytoplankton communities' was similar in both the up – and down-stream locations, the biomass and number at the control location were 2 and 3 times lower (see Figure 24). For zooplankton, deviations between up – and down-stream locations were even more visible: the number of species, abundance and biomass of zooplankton, both general and for individual groups, at the control down-stream location were 2–3 times lower than at the background up-stream one (see Figure 25).

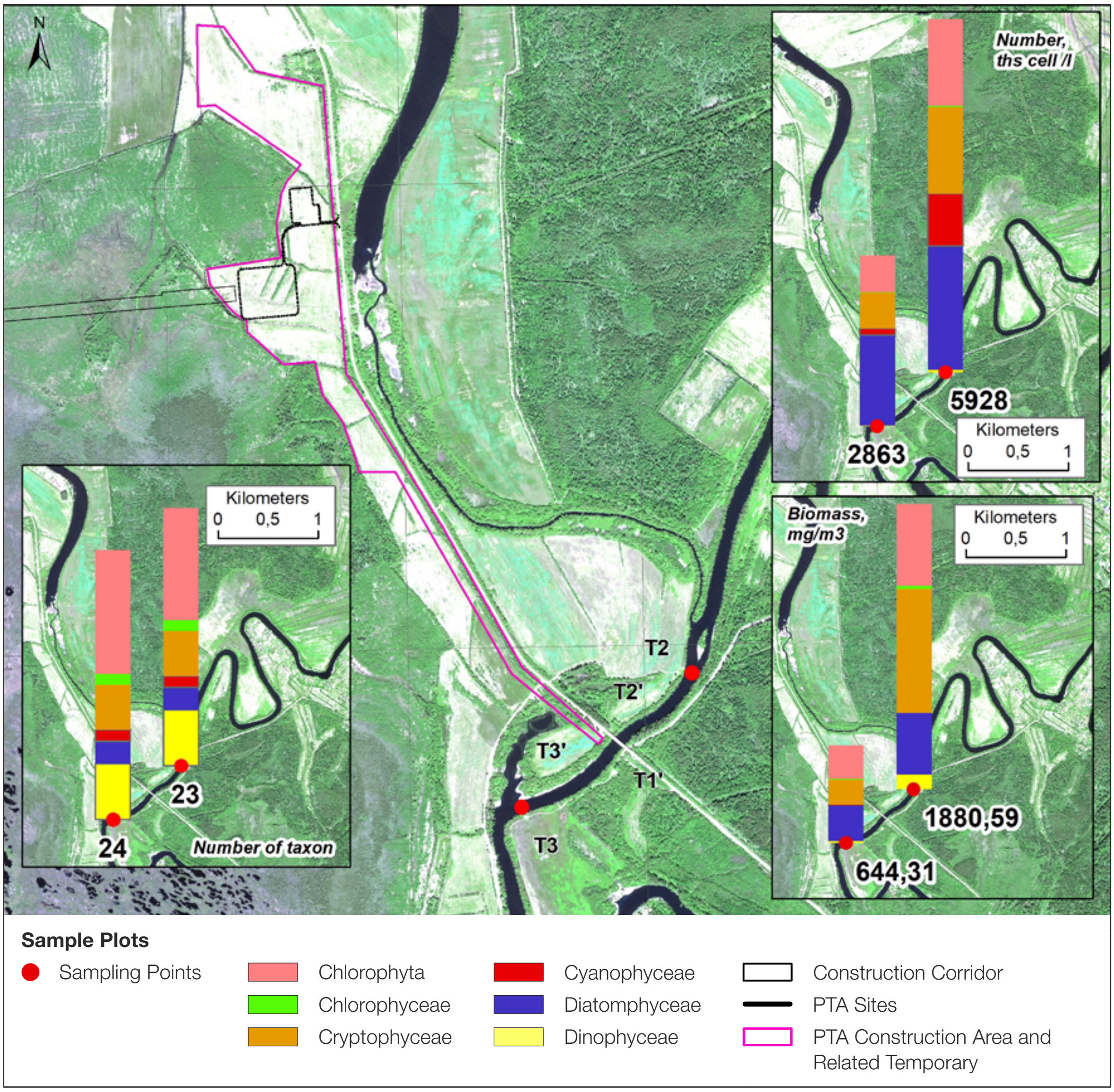


Figure 24. *Phytoplankton monitoring results – August 2019.*

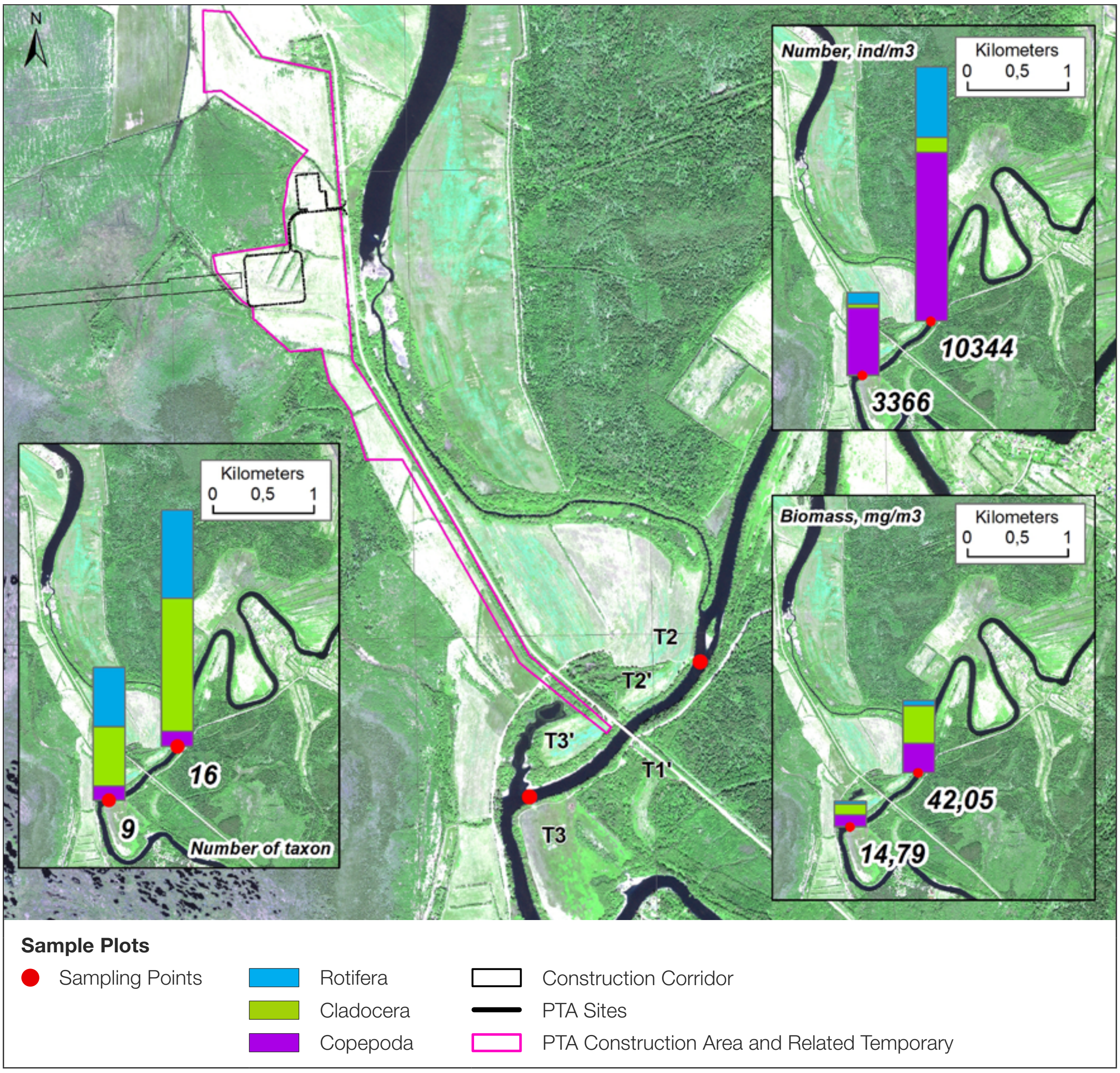


Figure 25. *Zooplankton monitoring results – August 2019.*

Additional plankton sampling was undertaken to confirm that the deviations found in the abundance and structure of the plankton communities was not related to the discharge of treated wastewater into the river. Samples were taken in 5 locations:

- two standard locations 500 metres up – and down-stream from the outlet;
- one in front of the outlet;
- two additional locations 100 metres up-and down-stream from the outlet.

Results for all locations in September were slightly different in terms of phytoplankton structure. The number and biomass of microalgae at individual points varied by 2–3 times. Quantitative characteristics in the area of the treated wastewater discharge were close to average values (see Figure 26), which led to the conclusion that the previously detected situation had been caused by the natural variability of phytoplankton communities, probably related not only to the seasonal dynamic, but also to the bifurcation of the Rosson river.

The abundance of green algae of the genus *Chlamydomonas*, which are an indicator of organic pollution, in September decreased by two orders of magnitude. In general, compared with the August studies, the total phytoplankton abundance decreased by six times on average, and biomass – by 15 times. The decrease in the phytoplankton abundance can be associated with its consumption by zooplankton, the mass development of which was noted in September. Studies in 2019 did not reveal a significant increase in the productivity of the phytoplankton of the Rosson river compared to 2017. The variation of structural and quantitative parameters of the phytoplankton community is within the natural range.

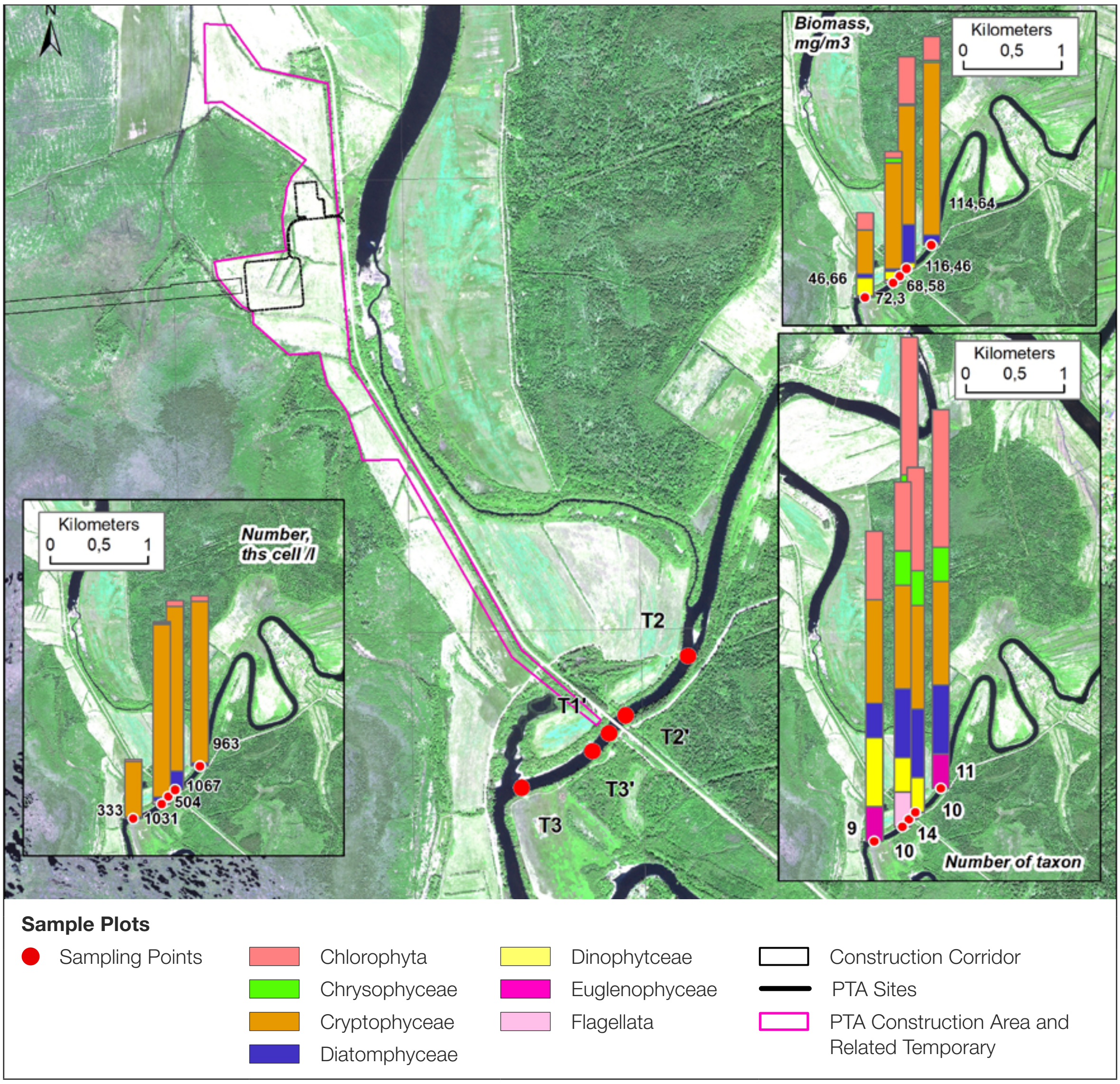


Figure 26. *Phytoplankton additional study – September 2019.*

The additional locations investigated in the Rosson river slightly differed in composition, structure and quantitative characteristics of zooplankton. Quantitative characteristics in the area of the treated wastewater discharge were close to average values, which leads to the conclusion that the zooplankton community is naturally variable in the area studied. The zooplankton abundance also in August 2019 fit into the range of abundance fluctuations shown in 2017. An increase in the abundance of zooplankton in September was in line with the autumn peak of development.

The characteristics of macrozoobenthos of the surveyed water area in August 2019 corresponded to the seasonal characteristics of the benthic communities of the rivers of the Leningrad Region. Taxonomic composition in 2019 corresponds to that observed in August 2017. The increase in benthos biomass in 2019 is due to the abundant growth of bivalve mollusca *Dreissena polymorpha*. The differences in the quantitative characteristics of zoobenthos at the stations were associated with variation of the abundance of *D. polymorpha*, which accounted for most of the benthos abundance and biomass. The abundance of the other groups of benthic invertebrates did not differ significantly at the stations. Differences in the composition and abundance of zoobenthos can be explained by the variability of bottom sediments.

The composition of the macrophyte communities was typical for the water area and coastline of the Rosson river. The differences in the species composition, projective cover, and macrophyte phytomass between 2018 and 2019 are probably due to the survey in 2018 being conducted later in the year than the 2019 survey, and therefore it reflects the seasonal variability of the described communities.

CONCLUSIONS

Hydrobiological monitoring results in 2019 are in general comparable with baseline survey data. No changes in benthic and macrophytes communities were observed. The recorded variation in the structural and quantitative parameters of the phyto – and zoo-plankton community had a natural origin and was not related to the wastewater discharges into the river.

3.3.3 Fish

The purpose of monitoring was to confirm that the project discharges of wastewater have not affected fish communities in the Rosson river. The monitoring of fish communities took place in the spring of 2019, as agreed in the EIA documentation. It should be noted that pre-construction monitoring in 2018 took place in autumn and that the data about the abundance of ichthyofauna are not comparable because of the seasonal dynamic of the populations. Monitoring is provided by an authorised regional fishery institute, and in 2020 will be carried out for both seasons (spring and autumn).

METHODOLOGY

Ichthyological surveys at the two sampling locations took place at the end of May 2019. Fish samples were collected with combined gill nets (from 12 to 60 mm) during 12-hour sampling campaigns. Species composition, abundance and biomass of the catches were calculated.

RESULTS

The species composition of the fish caught in 2019 was typical for the Rosson river during the summer-autumn period and in general corresponded to the spring-summer composition of the fish population of the Luga and Narva rivers. Of the species found in 2018, two species were not confirmed in 2019 – pikeperch (or zander) *Sander lucioperca* and common bleak *Alburnus alburnus*. However, these species were considered a rare occurrence in 2018. The dominant species complex in May 2019, compared with September 2018, remained unchanged: the catch was dominated by white bream *Blicca bjoerkna* and ruffe *Gymnocephalus cernus*.

The total number of fish caught in the spring-summer period of 2019 was almost three times less than in the autumn of 2018; fish biomass decreased 1.4 times. Seasonal dynamics of fish distribution are the most likely cause of the differences identified in the number and biomass of fish caught in 2018 and 2019. The presence or absence of an impact can only be assessed after the final observation cycle in the autumn 2020, which will provide data comparable to 2018.

CONCLUSIONS

The fish communities that were monitored in 2019 displayed the expected seasonal variability that was identified with the data collected in 2018. The potential impact of water discharges on fish communities in the Rosson river will be evaluated after the ichthyological survey planned for the autumn of 2020.

4 Monitoring during onshore construction in Germany

Since the landfall Germany and the PTA are entirely located inside a designated industrial park (see Figure 27), monitoring requirements for onshore construction in Germany are characterised as low complexity compared with the requirements for the landfall Russia.

Figure 27. *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 28).

Continuous environmental construction supervision in 2019 ensured that the implementation and maintenance of various mitigation measures:

> Control of the spatial extension of site preparation works (habitat protection measure);
> Maintenance of biotope and reptile/amphibian protection fences (species protection measure);
> Implementation of light mitigation measures (species protection);
> Monitoring of airborne noise (human protection).

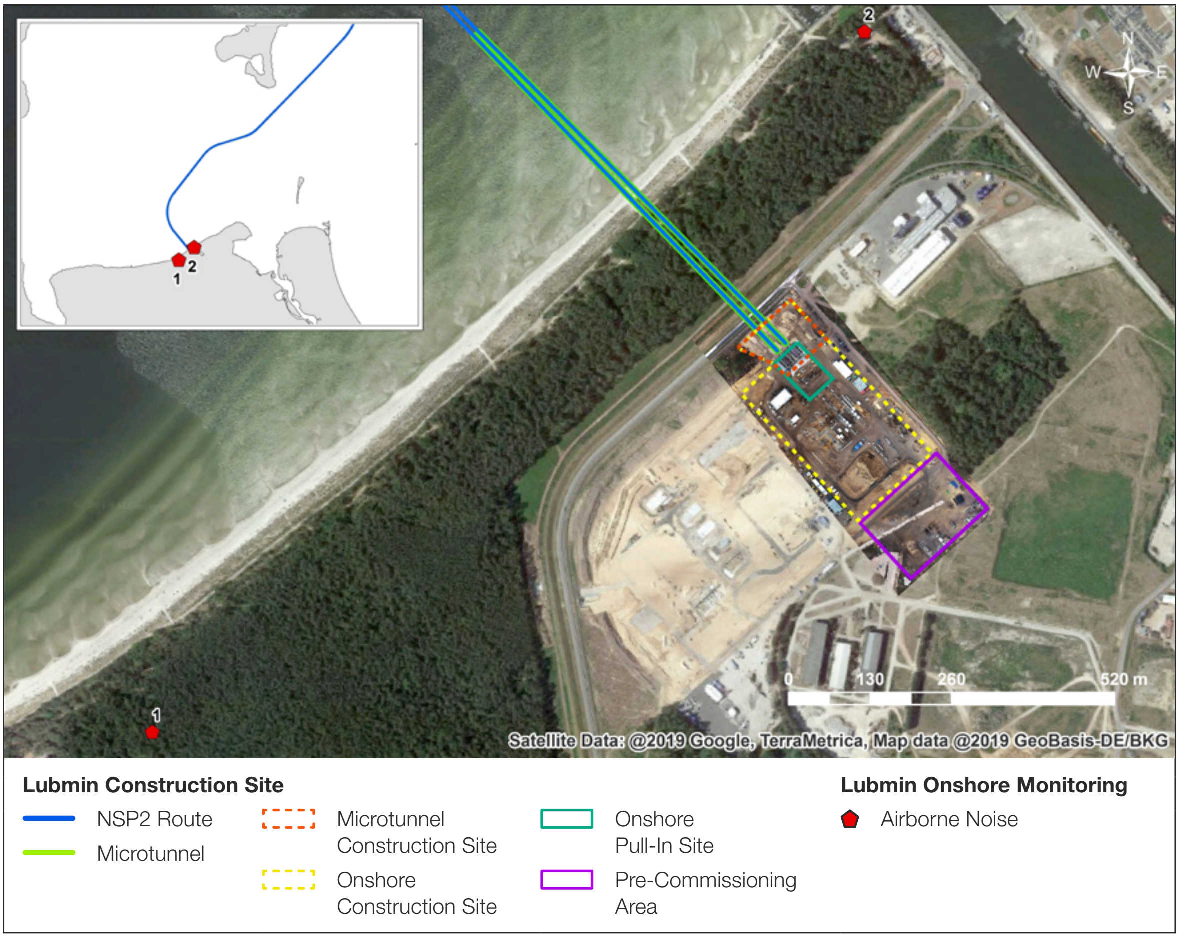


Figure 28. *Environmental monitoring associated with onshore construction in Germany.*

The results of monitoring of construction activities at the German landfall in 2019 showed that airborne noise levels (see Chapter 4.1.1) were in compliance with the permit provisions.

4.1 Monitoring of abiotic environment

4.1.1 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 off-shore 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 in 2018 and continued in 2019 according to German design criteria for construction noise measurements. Permanent sound pressure level recordings were taken throughout the year at two sites: Lubmin village, Lubmin marina (both sites are close to the Pig Trap Area and offshore route/tunnel pit, see Figure 27).

RESULTS AND CONCLUSIONS

No acoustic impact from construction noise could be detected at any of the two monitoring sites throughout the course of 2019 /22/.

5 Monitoring during offshore construction

Monitoring during the offshore construction activities was carried out extensively during 2019. Offshore construction activities in 2019 took place in Russia, Finland, Sweden and Denmark, while all offshore construction activities in Germany were completed in 2018. Monitoring of the construction activities described below was defined by the monitoring programmes of each country. Furthermore, below are presented also the additional monitoring activities implemented through specialist studies that are outside the scope of the national monitoring programmes. This chapter presents the monitoring results related to pipelay, dredging and its associated activities (for Russia only), post-lay trenching (for Sweden only) and rock placement.

5.1 Pipelay

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

Environmental monitoring during pipelay in 2019 was planned in Russia and Sweden (see Table 7). No monitoring was required during pipelay in Finland.

Table 7. *Overview of monitored parameters during pipelay*

	Marine water quality	Underwater noise	Birds	Marine mammals	Cultural heritage	Ship traffic	Munitions object
2019	R	S	R	R	D*, S, F*, R*	D, S, F**, R**	D*

R–Russia; F–Finland; S–Sweden; D–Denmark
Notes:
* Cultural heritage and Munitions objects chance find procedure in place – no monitoring required.
** Ship traffic monitoring was not included in the monitoring programme. Ship traffic safety is ensured by compliance with relevant permit requirements.

Pipe sections installed in 2019 and the monitoring stations are shown in Figure 29.

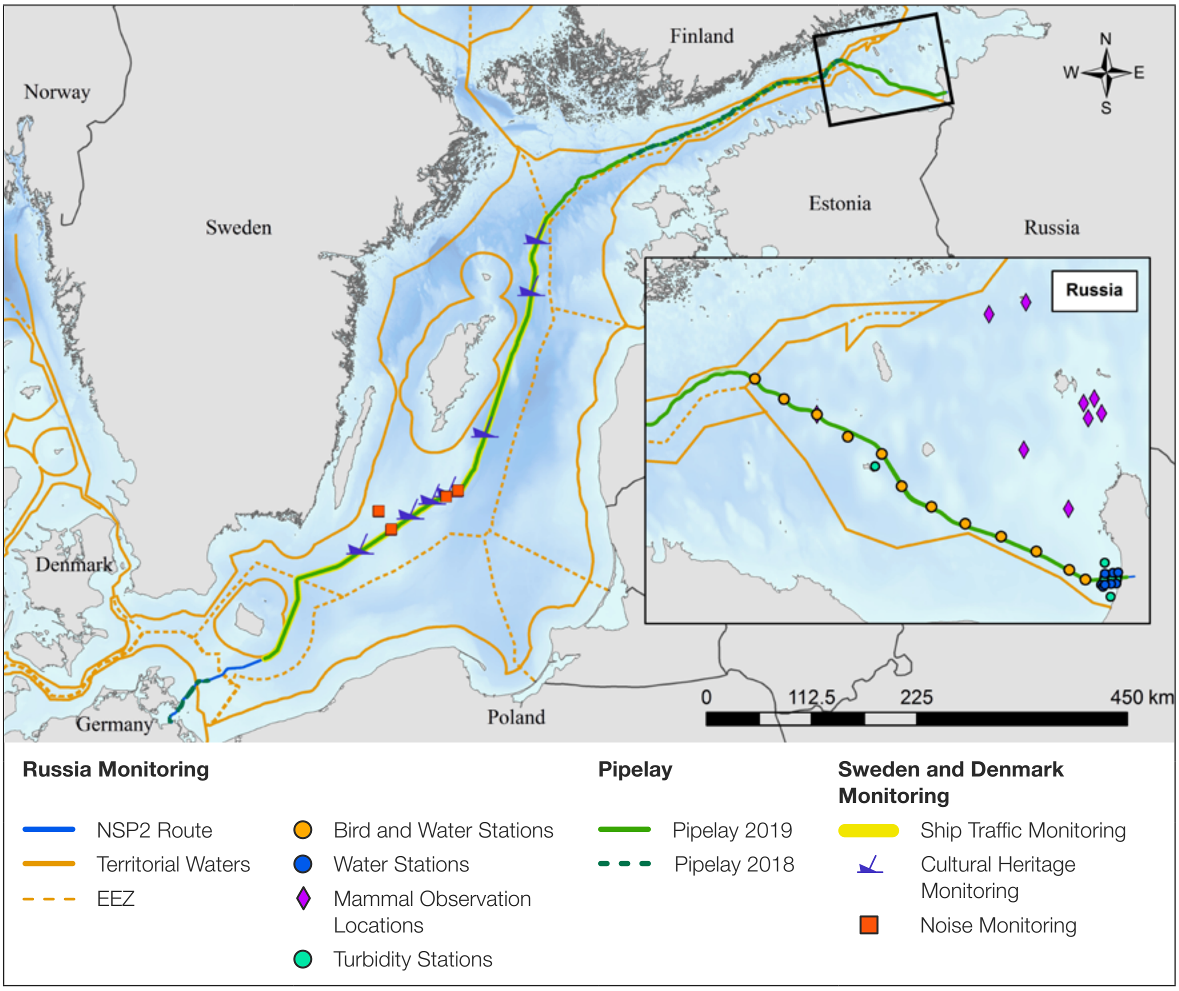


Figure 29. *Environmental monitoring associated with pipelay.*

In 2019, the abiotic and biotic environment was monitored during pipelay along the route of the Nord Stream 2 pipeline in Russia, Finland, Sweden and Denmark. No impacts on sea water quality were identified. Water quality within the survey area was found to meet the sanitary norms with a few exceptions, which could not be attributed to the construction activities (see Chapter 5.1.1).

Monitoring of underwater noise showed that noise from the pipelaying vessel and support ships was comparable in level and frequency to noise radiated from commercial cargo ships in the area, and no impact on marine mammals was observed (see Chapter 5.1.2). Seasonal monitoring of marine mammals and birds showed that construction activities did not have an impact on these species (see Chapter 5.1.3 and 5.1.4). Ship traffic in the area was not affected by pipelaying activities, as demonstrated by Ship traffic monitoring (see Chapter 5.1.6). No incidents were recorded and communications to the authorities were in line with the relevant permit provisions. Construction activities have not caused any impact on the identified cultural heritage objects (see Chapter 5.1.6) and there were no chance findings of munitions along the route (see Chapter 5.1.7).

5.1.1 Marine water quality

Water quality was monitored during pipelay in Russia. The purpose of monitoring was to confirm, in line with the EIA assessment, that pipelay in the offshore section does not have any impact on water quality.

METHODOLOGY

In accordance with water licence requirements, monitoring of marine water quality along the pipeline route (between KP 4.5 – KP 114) was done 4 times during 2019 at 12 location agreed in EIA:

- In April after ice melting, prior to construction
- In May during Solitaire laying line A
- In August during Pioneering Spirit laying line B
- In September after the end of pipe laying in the Russian sector

Sampling was provided at 12 locations along the pipeline route (about 8 km in-between) – see Figure 29.

Monitoring included profiling at each location and sampling from surface, thermocline (intermediate) and bottom layer.

Monitoring results were reported to the Water basin authority on quarterly basis /23/ and were also discussed in the 2019 annual report /24/.

RESULTS

The water quality within the survey area was found to meet the standards established for commercial fishery water bodies with regard to the majority of hydrochemical indicators. During the period of monitoring, surface water temperature demonstrated strongly manifested seasonal variability with a minimum in April and a maximum in August, while in the bottom layer seasonal variability was less pronounced and more noticeable at the shallower stations. Seawater in the area of monitoring was characterized by content of suspended matter. No exceedances of suspended solids MPC for commercial fishery water bodies were detected throughout the whole offshore section of the Gulf of Finland.

The highest pH values (up to 8.86) were measured at the surface in May and were associated with a spring phytoplankton bloom.

The content of dissolved oxygen was within the norm established for commercial fishery water bodies in the surface layer, while bottom layers at offshore stations were found to be oxygen-deficient, which is associated with a characteristic feature of the Baltic Sea – the problem of aeration of deep waters due to vertical stratification. Oxygen deficiency (dissolved oxygen as low as 1.2 mg/l) was also detected during the baseline hydrochemical survey performed in 2016.

Seasonal variability in BOD was traced during monitoring. The highest BOD5 and BODfull values associated with the peak of photosynthetic activity were observed, as in the near-shore water area, mainly in April (spring bloom of phytoplankton) and in August (second phytoplankton bloom), and exceeded relevant MPCs (up to 1.5 MPC) in most of the area of monitoring. In September, with the reduction of photosynthetic activity, BOD5 and BODfull values decreased to below relevant MPCs established for commercial fishery water bodies.

The concentrations of nutrients (nitrite, nitrate and ammonium nitrogen and phosphate) were within relevant MPCs in all analysed samples throughout the whole monitoring period within the offshore section of the Gulf of Finland. Organic forms of nitrogen and phosphorus prevailed in the surface layer, while the proportion of their mineral forms tended to increase toward the bottom (mainly phosphates and nitrates).

Analysis of monitoring data concerning water contamination of the offshore section of the Gulf of Finland indicates that the quality of water in the survey area is satisfactory with regard to the majority of the indicators monitored. MPC exceedances were detected only during the baseline survey and only at individual stations: iron (1.2–5.5 MPC), copper (1.0–4.2 MPC) and zinc (1.7 MPC). Subsequent surveys (May, August–September) did not reveal any MPC exceedances for these metals. Therefore, it can be concluded that these exceedances were not related to the construction activities and were caused only by natural factors.

The content of most contaminants, such as benz(a)pyrene, heavy metals (cadmium, cobalt, lead, chromium and mercury), in all samples was either at the trace level, below the detection limit, or far below the established MPCs for commercial fishery water bodies. At some stations, low concentrations of iron, zinc, nickel and arsenic were detected, which were below the established commercial fishery MPCs.

Exceedances of commercial fishery MPCs were detected only in the content of manganese in the bottom layer at offshore stations (up to 9.6 MPC). In August, exceedance was registered in one sample of 36 (bottom horizon, 34 m depth, less than 2 MPC). In September 4 samples demonstrated comparable exceedance in the bottom layer at the depths 59–71 metres, with the maximum registered at maximal depth. According to the baseline environmental survey (September 2016) and the existing literature, very high manganese concentrations (up to 5 MPCs) were also previously observed in the bottom layer of the offshore sections, suggesting that the recoded values fall within natural background variation.

Oil products MPC exceedance (1.04 MPC, location close to the Finnish EEZ border, 0.052 mg/dm^3 vs. 0.05 permitted) was detected in August 2019 in the surface layer at station RUS_MON_IPM_15, but that was only a one-time occurrence. The exceedance was likely not related to the construction activities, but could rather be the result of vessel traffic in the survey area, transfer of pollutants with sea currents, or natural fluctuation in the concentrations of natural hydrocarbons in summer.

CONCLUSIONS

No impact on the quality of seawater was identified during pipelay in the Russian deep-water section.

5.1.2 Underwater noise

Monitoring of underwater noise was conducted during pipelay in Sweden to further verify the conclusions in the Environmental Study and expert opinions presented during the public referral regarding potential impacts from NSP2 construction activities on harbour porpoises in the Natura 2000 area during pipelay.

METHODOLOGY

Acoustic recording was done at four stations in the Baltic Sea (A, B, C and D) to monitor the background noise, noise from passing vessels, pipeline construction activities and presence of harbour porpoises.

Each of the stations contained a rig with additional backups: stations A, B and C contained in total three rigs (A1–A3, B1–B3, C1–C3) with data loggers, while at station D – that was only used in autumn 2019 – five rigs were installed (D1–1, D1–2, D2, D3–1 and D3–2) to capture both pipelay and rock placement with two hydrophones recording simultaneously during each activity. The four monitor stations are shown in the map below. For rock placement, only station D was used on the 10th November 2019.

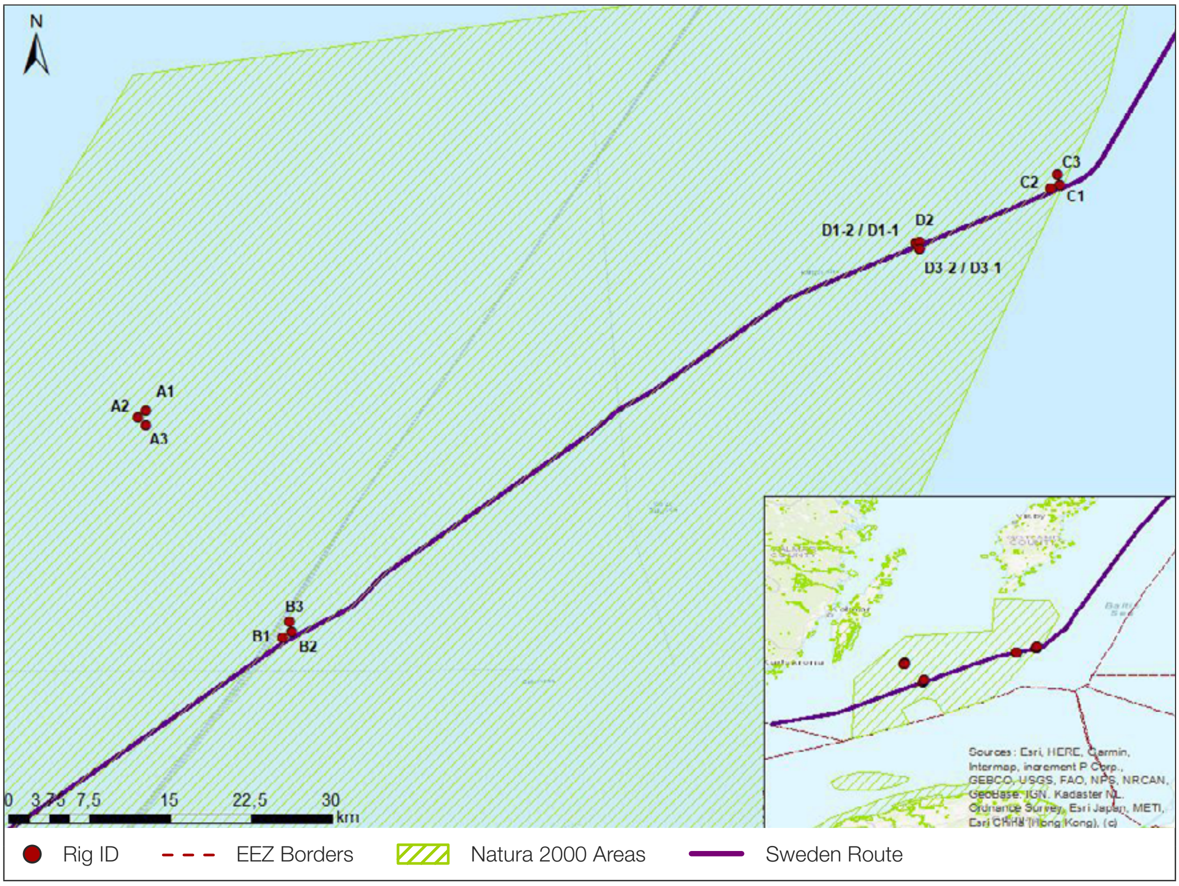


Figure 30. *Underwater noise monitoring locations in Sweden.*

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

RESULTS

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

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

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

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

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

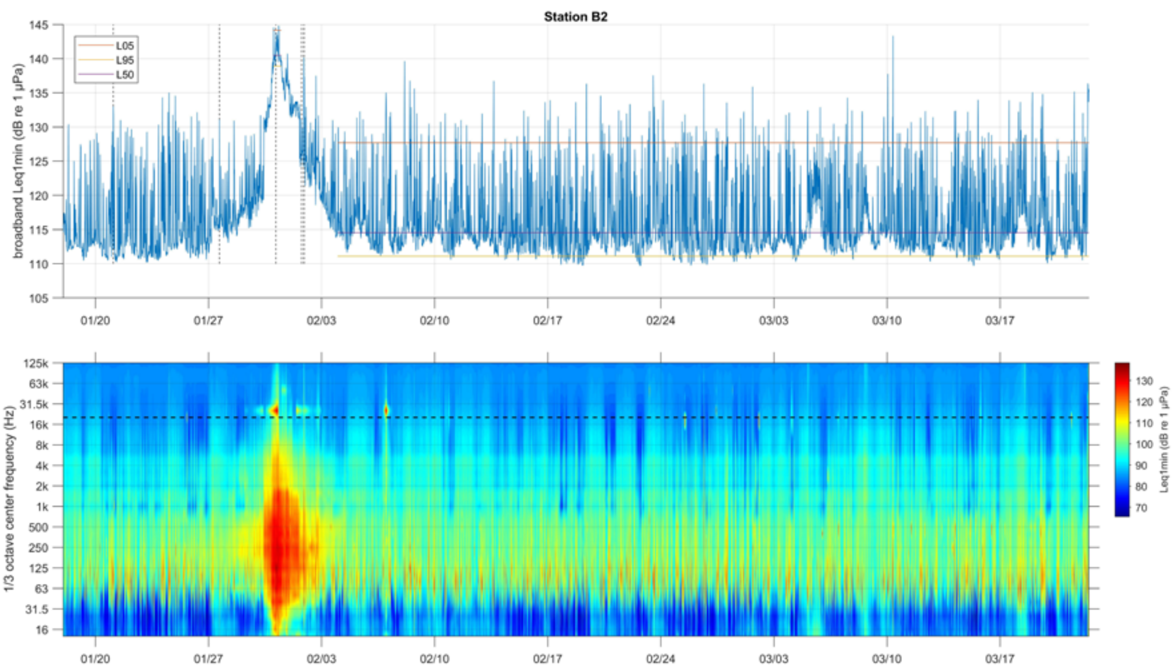


Figure 31. *Solitaire passing station B end January.*

CONCLUSIONS

Underwater noise from the pipelaying vessel and support ships was as expected, comparable in level and frequency to noise radiated from commercial cargo ships in the area. Since the pipelaying operation during Nord Stream 2 was faster than during construction of Nord Stream, the time spent inside the Natura 2000 area was shorter than what had been assumed in the impact assessment.

All in all the observations support the assumptions on which the original assessment on the potential impact on harbour porpoises was made, indicating that the noise generated by the pipelay vessel and supply vessels does not harm the porpoises, since they do not spend prolonged periods close to the construction activities. With respect to harbour porpoise impact, the expert review of the results from the noise measurements came to the conclusion that the integrity of the Natura 2000 site was not compromised by the construction of the pipeline. Neither permanent nor temporary hearing shifts were likely to occur in marine mammals as an effect of pipelay works, and the potential disturbance effects were local and temporary. A stationary acoustic monitoring of harbour porpoise presence carried out simultaneously in the vicinity of the underwater noise monitoring area furthermore revealed that the presence of harbour porpoises was recorded on numerous occasions before and after passage of the pipelaying vessel.

5.1.3 Birds

The observation of marine birds, as an associated activity[4], was performed during each offshore field monitoring campaign and it is not associated with a specific construction activity. Therefore, this chapter describes how all Russian offshore construction activities, such as pipelay and rock placement, may have an impact on marine birds. The monitoring was carried out to determine if any behavioural changes in the local and migratory fauna were caused by any 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

The results discussed below were collected as visual observations from the vessels during 13 monitoring campaigns that took place in April–June and September–November. The duration of observations amounted to a total of 372.5 man-hours.

RESULTS

59 bird species belonging to 10 orders were observed during the 2019 surveys.

Most abundant in terms of species diversity were Anseriformes (25 species) and Charadriiformes (15 species), and these species were the leaders in terms of the number of sightings. Pelecaniformes were represented by only one species – the great cormorant (*Phalacrocorax carbo*), however, these birds were sighted practically in all cycles of observations. Representatives of the two species belonging to Gaviiformes were also regularly met during the monitoring. Podicipediformes were also represented by two species, but were only seen during the autumn migration.

24 out of total 59 observed bird species are on various Red Lists, including five species on the Red Data Book of the Russian Federation (black-throated loon, tundra swan, white-tailed eagle and tufted duck), 13 species on the Red Data Book of the Leningrad Region, twelve species on the Red List of the International Union for Conservation of Nature (IUCN), and 13 species on the HELCOM Red List (see Table 8).

4 Monitoring of birds and seals was not the main purpose for which the monitoring was developed. These species were monitored alongside the monitoring of other receptors.

Table 8. *List of the protected 24 bird species and their conservation status*

Species name	Family/order	Red List Category RF	Red List Category Leningrad region	IUCN Red List Category	Red List Category (HELCOM)
Somateria mollissima **Common eider**	**Anatidae Anseriformes**		3	VU	VUb, ENw
Gavia stellate **Red-throated loon**	**Gaviidae Gaviiformes**		4		CRw
Gavia arctica **Black-throated loon**	**Gaviidae Gaviiformes**	2	3		CRw
Alca torda **Razorbill**	**Alcidae Charadriiformes**			NT	
Anser anser **Greylag Goose**	**Anatidae Anseriformes**		3		
Uria aalge **Common murre**	**Alcidae Charadriiformes**		3	NT	
Larus fuscus **Lesser black-backed gull**	**Laridae Charadriiformes**		2		VU
Podiceps auratus **Slavonian grebe**	**Podicipididae Podicipediformes**		3	NT	VUb, NTw
Mergus merganser **Common merganser**	**Anatidae Anseriformes**		4		
Mergus serrator **Red-breasted merganser**	**Anatidae Anseriformes**				VUw
Cygnus bewickii **Tundra swan**	**Anatidae Anseriformes**	5	5		
Cygnus cygnus **Whooper swan**	**Anatidae Anseriformes**		3		
Mergellus albellus **Smew**	**Anatidae Anseriformes**		4		
Rissa tridactyla **Black-legged kittiwake**	**Laridae Charadriiformes**			VU	VUw, ENb
Clangula hyemalis **Long-tailed duck**	**Anatidae Anseriformes**			VU	ENw
Aythya farina **Common pochard**	**Anatidae Anseriformes**			VU	
Haliaeetus albicilla **White-tailed eagle**	**Accipitridae Accipitriformes**	3	3		
Melanitta nigra **Common scoter**	**Anatidae Anseriformes**				ENw
Melanitta fusca **Velvet scoter**	**Anatidae Anseriformes**			VU	VUb,ENw
Hydrocoloeus **Little gull**	**Laridae Charadriiformes**			NT	NTw
Larus argentatus **European herring gull**	**Laridae Charadriiformes**			NT	
Aythya marila **Greater scaup**	**Anatidae Anseriformes**			VU	VU
Aythya fuligula **Tufted duck**	**Anatidae Anseriformes**	2	3		NT

Species name	Family/order	Red List Category RF	Red List Category Leningrad region	IUCN Red List Category	Red List Category (HELCOM)
Vanellus vanellus **Northern lapwing**	**Charadriidae** **Charadriiformes**			VU	NT

The observation periods from early April to late May 2019 coincided with the time of active migration of many aquatic birds. It is known that running through the Kurgalsky Peninsula and its neighbouring areas is one of the primary migration routes of geese and other semiaquatic birds, among which there are also species included on the Red Data Books of the Russian Federation and the Leningrad Region and the HELCOM Red List /25/.

Beginning from early April, flocks of great cormorants and migrating anseriformes (mostly long-tailed ducks, *Clangula hyemalis*) were sighted near the Narva Bay coast. The earlier start of mass migration of some marine duck species was probably due to the relatively warm spring and early ice drift in the Gulf of Finland. Flocks of migrating common scoters (*Melanitta nigra*) and velvet scoters (*Melanitta fusca*) appeared in the second third of April. Most abundant species sighted in the open water areas farther from the shore were mew gulls (*Larus canus*) and European herring gulls (*Larus argentatus*), while common black-headed gulls (*Larus ridibundus*) were spotted mostly near the shore. Sighted during the shore-based observation were flocks of herons over the Gulf of Finland (*Árdea cinérea*) and in the Rosson River delta (*Ardea alba*).

In late May, as in the previous surveys, large flocks of migrating Anseriformes were observed in Narva Bay and near the Maly Tyuters Island. Anseriformes commonly stop to rest in these areas during migration.

The monitoring period in the second half of September and early October coincided with active migration to wintering grounds of most birds in northwestern Russia. The observed anseriformes demonstrated migration activity, moving in flocks in the southern and south-western directions or resting on the water in large groups. Most abundant were long-tailed ducks, while velvet scoters and wigeons (*Mareca penelope*) were sighted in smaller numbers. Migration flocks of barnacle geese (*Branta leucopsis*), pink-footed geese (*Anser fabalis*) and common scoters appeared toward the end of September. The prevalence of mew gulls and European herring gulls among thelaridae is characteristic of open sea areas relatively remote from the shore. European herring gulls and mew gulls can be called "background species."

CONCLUSIONS

On the whole, the avifauna occurrence picture is generally consistent with the available literature data. No signs of impact of construction operations on species composition or distribution of bird occurrence were detected.

5.1.4 Marine mammals

The observation of marine mammals, as an associated activity, was performed during each offshore field monitoring campaign and it is not associated with a specific construction activity. Therefore this chapter describes how all Russian offshore construction activities, such as pipelay and rock placement, may have an impact on marine mammals. The monitoring was carried out to determine if any behavioural changes in the local fauna were caused by any construction activity.

METHODOLOGY

Visual observations from vessels during 13 monitoring campaigns that took place in April–June and September–November are discussed below. The duration of vessel observations in total amounted to 372.5 man-hours.

RESULTS

A total of 88 seals were observed in April, May and September, with most observations taking place in April–May and only four individuals being recorded in September observed during vessel transit (no seals were observed during the June, October and November monitoring campaigns). No seals were observed during pipelay along the pipeline route. The only two observations of grey seals (three individuals in total) directly on the pipeline route (between KP 90 and KP 100) were during the pre-construction monitoring campaign in April.

Table 9. *Marine mammals' observations results – 2019.*

Specie	Observations events	Total number of Individuals	Incl. observed on well-known rockery (observations/individuals)
Grey seal	16	85	5/53
Baltic ringed seal	1	1	–
Not confirmed species	2	2	–

An overall increase in the population of grey seals in the Russian sector of the Gulf of Finland has been observed in the 21st century /26/, /27/.

A previously unknown small rockery of grey seals (11 individuals) was detected on stones near Sommers Island. Repeated sightings of grey seals (6–30 individuals) in the area of the Ostrovnaya Bank of the Kurgalsky Reef indicate that the bank is a regular resting point for these animals during spring and summer. Earlier, a rockery of grey seals was discovered on the Seskar Island /28/. The finding of grey seal rockeries is of a certain scientific interest, since there are relatively few documented locations of grey seal rockeries /29/.

Sporadic grey seal sightings were recorded in the open sea, including in an area close to the Maly Tyuters Island, where a fairly large grey seal population can be found /28/.

Also, individual sightings of seals of unidentified species were recorded closer to Neva Bay (see Figure 32). According to the literature, both species – the Baltic ringed seal and the grey seal – may occur in that area /27/, /29/.

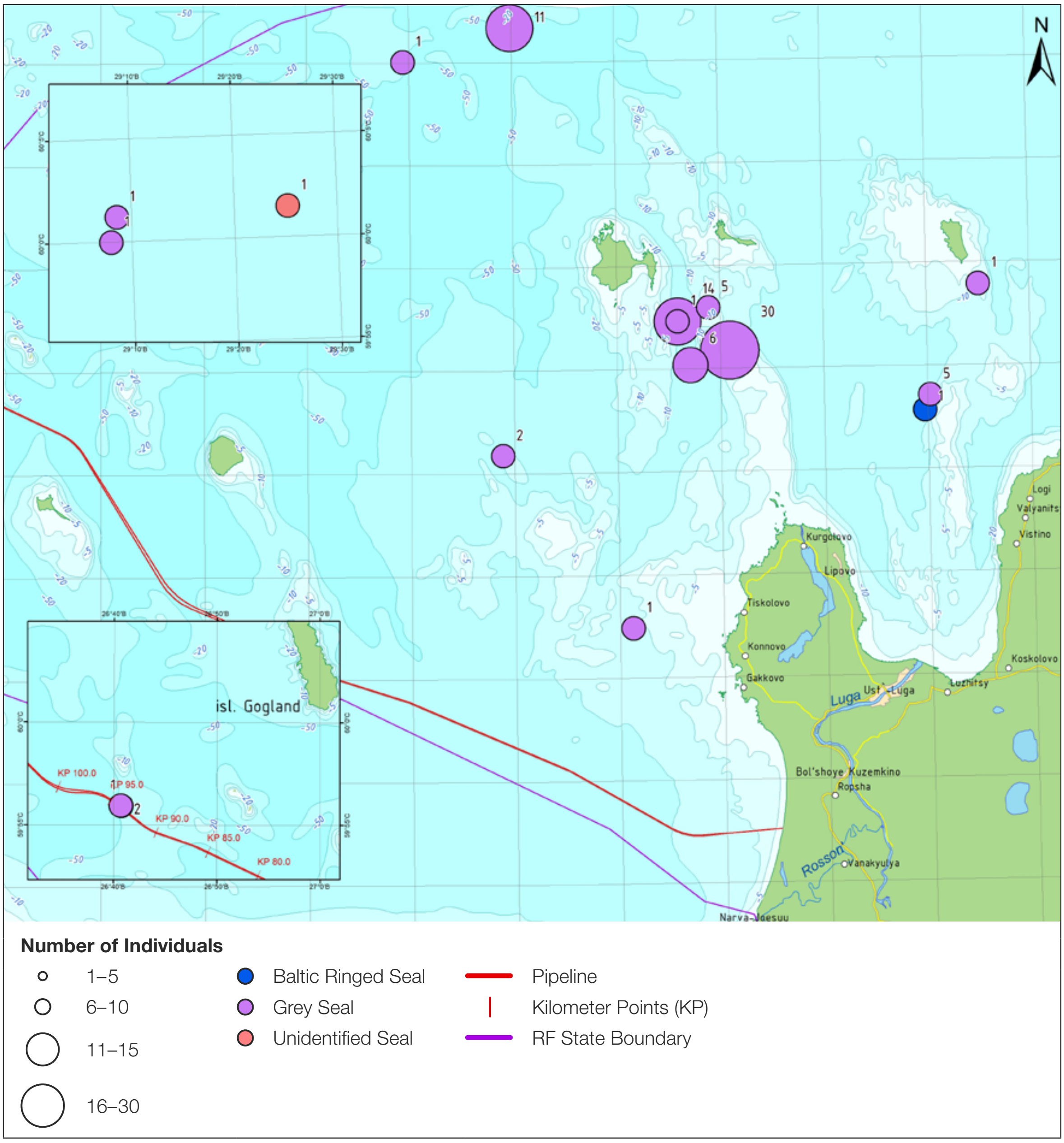


Figure 32. *Vessel-based monitoring of mammals in April–June.*

Additional monitoring of marine mammals not included in the monitoring programme: telemetry study of the Baltic ringed seals

A telemetry study of the Baltic ringed seals started in 2017 and continued in 2018 and 2019. The study allows collection of continuous information on the seals' behaviour and movement patterns. Between June and September 2019, seven ringed seals (five males and two females) were tagged in Russian waters of the Gulf of Finland.

The 2019 data confirmed the main core distribution areas around the Kurgalskii reef and Islands Moshnyi and Malyi with another ringed seal hotspot around Malyi Tyters. The tracks suggested that the Malyi Tyters area is more in use in the summer period as a resting area next to foraging grounds, Kurgalskii is used around the year in ice-free periods. In late autumn/early winter seal movements extended to Vyborg Bay and to the Finnish south coast in search of breeding ice. Data collected in late autumn showed some extraordinary movements, such as the non-stop round trip of a male seal to Vormsi, in

the West Estonian Archipelago (see Figure 33). This kind of behaviour deviates notably from the "routines" of diurnal and seasonal cycles demonstrated by the majority of marked seals. The trip is indicating that the ringed seals in the Gulf of Finland are having contact (but very rare and short) with the other southern populations of ringed seals in the Baltic Sea. As the seal returned to the Eastern Gulf of Finland soon after arrival, the finding does not suggest yet that there is exchange of individuals within the populations. Nevertheless, this is new information for the Baltic ringed seal research and should be taken into account.

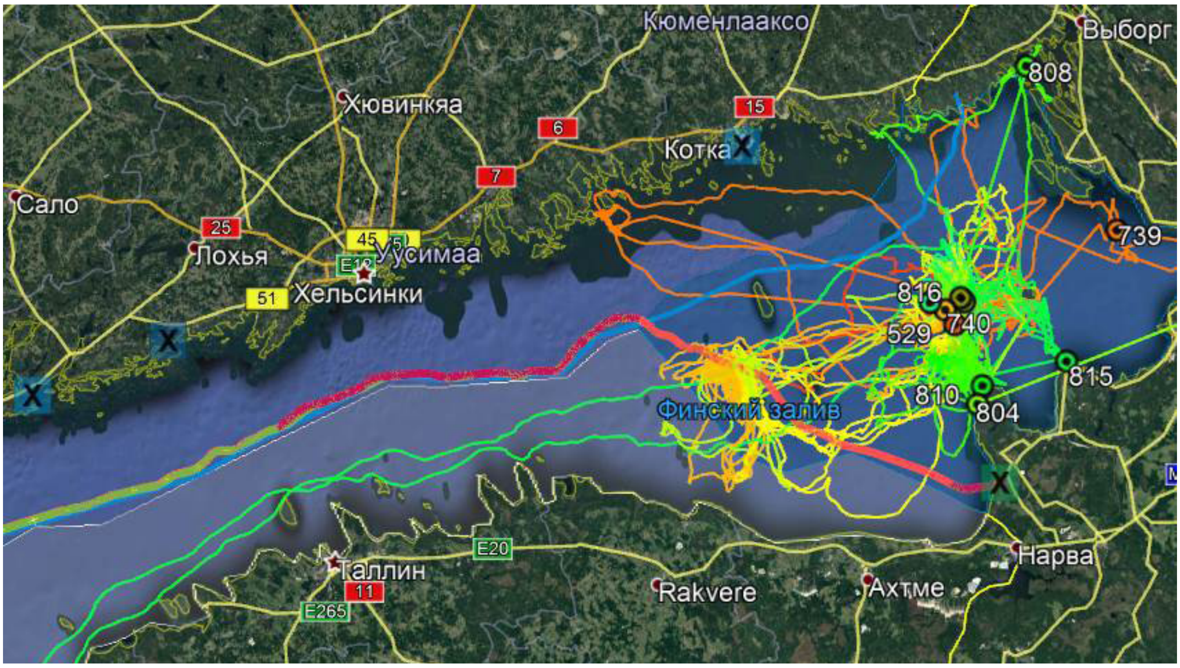


Figure 33. *Seals movements in 2019.*

CONCLUSIONS

The project did not affect marine mammals. Interesting notes from the scientific perspective were the finding of a previously unknown rockery of grey seals at the Sommers island rockery and the round trip of a tracked Baltic ringed seal to Estonia.

5.1.5 Cultural heritage

According to the countries' monitoring programmes, the survey of known cultural heritage objects was required prior to and after the construction activities in Sweden and Finland. In Denmark, the monitoring programme focuses on the identification and management of chance finds during construction and operation of the NSP2 pipelines. In addition, a cultural heritage chance find procedure was in place in all countries where pipelay took place, namely Russia, Finland, Sweden and, as already mentioned, Denmark. During pipelay, no unknown cultural heritage objects were found.

In Finland, monitoring of cultural heritage prior to the construction activities took place in 2018 and is therefore not covered in this report; a cultural heritage post-construction survey is planned for after completion of construction, in 2020 or 2021. Monitoring of Cultural Heritage in Denmark and in Sweden is discussed below.

Denmark:
The purpose of the cultural heritage monitoring programme in the Danish EEZ is to verify that construction of NSP2 has not damaged cultural heritage objects (CHO) near the pipeline or made them inaccessible for archaeological investigations. The results of baseline surveys undertaken in the pipelay and intervention works corridor in 2018–2019 have been analysed by the relevant Danish authorities. The Danish Agency for Culture and Palaces has concluded that none of the identified objects require dedicated monitoring before, during or after construction. On this basis, the monitoring programme focuses solely on the identification and management of chance finds during construction and operation of the NSP2 pipelines.

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

Initial detailed seabed surveys were performed before and after pipelay. The scope of the surveys consisted of a geophysical survey, visual inspection and an expert evaluation of the findings by The Swedish Maritime and Transport Museums (SMTM).

This assessment resulted in seven potential CHO objects suggested to be closely monitored. Six objects were located within 250 metres from either of the pipelines, but none closer than 50 metres, which was the protection zone established to minimize the risk of impacts on these sites. In addition, one object (S-R30-0997) was located approximately 700 metres from the pipeline corridor but was also included in the monitoring programme as this site is of special interest for the Swedish cultural heritage authorities.

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

METHODOLOGY

Denmark:
If new findings are identified as chance finds, they will be reported to the relevant Danish authorities to define monitoring requirements. The need for further inspections, establishment of exclusion zones and the need for monitoring, including geophysical investigations and visual inspections, will be agreed in consultation with the Danish Agency for Culture and Palaces. Therefore, the potential extent of the monitoring area along the NSP2 route depends on the locations of any confirmed CHO that require monitoring (following identification as chance finds).

Sweden:
The methodology follows the same approach used during NSP. The pre-lay ROV-filming and multibeam-imaging of the wrecks was performed between 4 and 8 January 2019 by the survey company MMT with the vessel Stril Explorer. The post-lay inspections of the five wrecks were performed in August and October 2019. High resolution bathymetry/multibeam-images as well as still pictures of each of the five wrecks, with “events” (photo stations) has been used for comparison of the wrecks’ status before and after construction.

The impacts of the construction activities on the CHO sites was detected by comparing the baseline survey and the post-lay survey results. This assessment was done by marine-archaeological experts (SMTM).

RESULTS

Denmark:
No CHO chance finds were identified during construction in Danish waters in 2019.

Sweden:
The results showed that two out of the seven objects proposed to be monitored were rock outcrops and therefore excluded from the following monitoring activities. The five analysed shipwrecks from post-pipelay are considered by SMTM to be undisturbed by the construction of the pipeline. Minor changes on shipwreck S-R30-0997 possibly depends on trawling, fishing, waves and/or currents. SMTM has estimated that three wrecks (S-R17-4285, S-R28-5046 and S-R30-0997) foundered before 1850 and are therefore considered to be ancient monuments according to the definitions in the Swedish Heritage Conservation Act (1988:950).

Table 10. *Cultural heritage objects monitored in Sweden.*

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

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

The shipwreck S-R30-0997 is considered to be undisturbed by the construction of the pipeline, but minor changes are visible. A comparison of the multibeam-images from the pre-lay inspection and the post-lay inspection shows no signs of changes on the wreck and the surrounding seabed. The ROV-inspection shows that three of the eight object "events"[5] on the wreck have moved slightly (please see pictures below). The minor changes are possibly the result of trawling or fishing and very unlikely due to the pipeline construction. Because it lies on just 38 metres deep it is probably affected both by waves, currents and fishing/trawling, as parts of fishing nets where visible on the wreck (Fredholm 2019a).

5 Each analysed object position is defined as an "event".

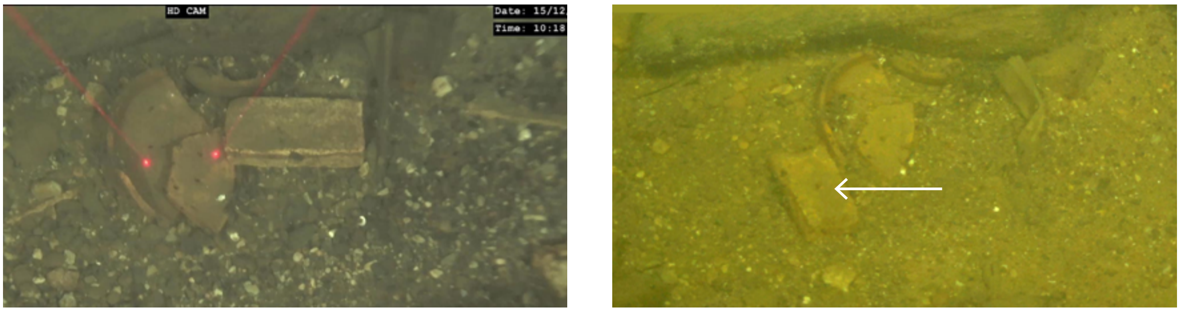


Figure 34. *Event A, where a brick has moved around 20cm. Pre-construction (left) and post lay (right). Photo: MMT and Allseas.*

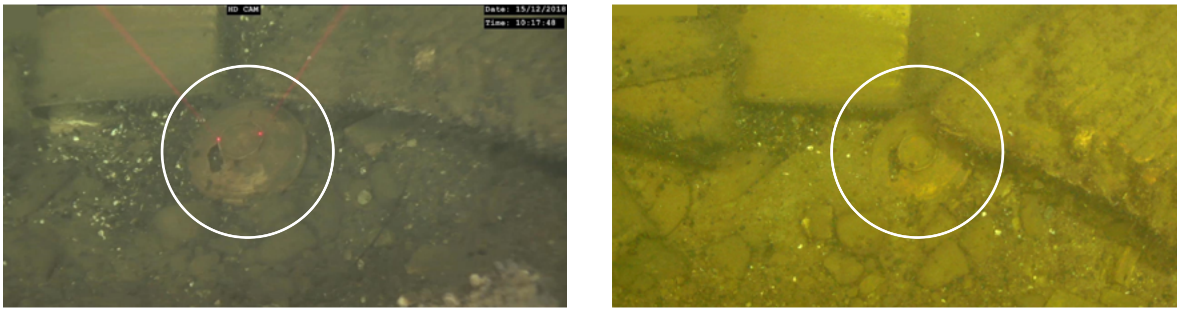


Figure 35. *Event B, possible lid pot, where a wooden object might have moved a few cm. Pre-construction (left). Photo: MMT and Allseas.*

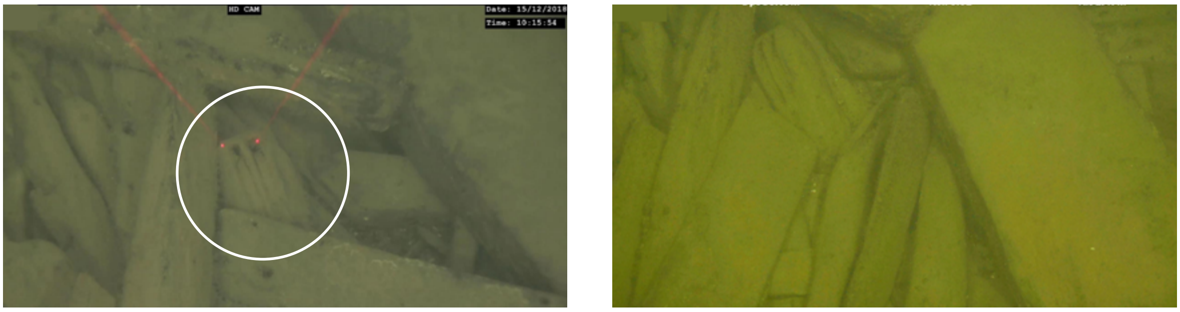


Figure 36. *Event H; a block, where a plank has moved. Pre-construction (left) and post lay (right).*

CONCLUSIONS

In Denmark, no cultural heritage object was found during the construction activities and in Sweden, the pre- and post-construction monitoring results of cultural heritage showed that construction activities have not caused any impact on the five identified objects. A very minor disturbance to one of the five monitored wrecks was assessed by the authority experts to be due to natural factors, such as currents, or due to fishing activities and not due to any construction activity.

5.1.6 Ship traffic

Ship traffic was monitored during pipelay in Sweden and Denmark. In general, the monitoring of ship traffic in Denmark and in Sweden followed the same approach and methodology. In Finland and in Russia, monitoring of ship traffic is not included in the monitoring programme: NSP2 however ensured that it was compliant with requirements related to ship traffic, such as safety zones, which were defined in accordance with the local authorities. Such compliance is described in the Annual report in Finland and in the notices to mariners and reporting to the Russian authorities.

The overall purpose of the control of maritime traffic is to minimize the risk of collisions or other accidents involving commercial shipping traffic and/or vessels carrying out construction activities for the project. Before and during construction, the locations of the construction vessels are announced by the national shipping authorities in Notices to Mariners to increase awareness of project-generated vessel traffic. To ensure notification of smaller vessels, fishing organizations and maritime organizations are informed prior to the commencement of construction works and updated during the performance of the construction works.

During construction works, a daily report (and weekly reports in Finland) on all construction activities is transmitted from the vessels to the relevant local authorities. These reports include the name, call sign, current position and plan of the vessel for the next 24 hours. Any unexpected vessels entering a 'closest point of approach' radius during the construction work are contacted by the responsible shipping authority and monitored closely and, if necessary, the construction support vessels can be used to alert them.

The overall purpose of the monitoring of maritime traffic is to document safe navigation for commercial ships passing the construction works by analysing the ship traffic data and possible incidents. This monitoring also enables verification of the risk assessment performed in the EIA.

In Denmark and in Sweden, during pipelay activity in 2019 the ship traffic around the pipelay locations and Karlshamn harbour was monitored. The methodology and results of the monitoring in Sweden and in Denmark are described below.

METHODOLOGY

Monitoring activities in Denmark and in Sweden focused on demonstrating that information has been provided to the authorities as agreed (Activity 1), that the construction vessels such as the pipelaying vessels operated as intended (Activity 2) and that safe passage for third-party vessels was possible (Activity 3). Analysis is performed by an independent environmental consultant.

In order to meet monitoring objective 1, correspondence between Nord Stream 2 AG and the authorities is analysed in order to document whether information is provided to the authorities as agreed.

In order to meet monitoring objective 2, the proper and safe operation of construction vessel traffic is monitored using Automatic Identification System (AIS) data. The AIS data are gathered and analysed to illustrate observed ship tracks from the construction vessels. The observed ship tracks can then be compared to the intended operation of the construction vessels as described in the plans for the construction activities and the restrictions set by the safety zones, in order to demonstrate the degree to which the observed operation matches the plans. The results are presented in maps showing the operation of the construction vessels. Videos presenting vessel movements in space and over time can be produced to illustrate any incidents of special interest that may have occurred. The results of the monitoring enable Nord Stream 2 AG to either confirm or adjust the operation of the construction contractor.

In order to meet monitoring objective 3, AIS data are used to document that commercial ship traffic has safe and free navigation when passing the slow-moving construction vessels. The AIS data for commercial ships are analysed to generate observed ship tracks from commercial vessels which show whether the commercial ships are able to recognise the construction vessels and their safety zone in due time to safely plan their journeys around the slow-moving pipelay vessel, also within the Traffic Separation Scheme (TSS) Adlergrund and when the deep water shipping lane was crossed south of Gotland. Videos presenting vessel movements in space and over time can be produced to illustrate any incidents of special interest that may have occurred. The results of the monitoring enable Nord Stream 2 AG to either confirm or adjust the safety measures adopted to enable safe and free passage of commercial ships passing the construction activities.

Monitoring targeted the pipelay vessels Pioneering Spirit and Solitaire, the ship traffic around them and the ship traffic at the Karlshamn harbour. The safety zone for the pipelaying vessels was 1 nautical mile.

RESULTS

Activity 1

Denmark:
Communication between Nord Stream 2 AG and the maritime authorities was found to have taken place as required. Namely, Nord Stream 2 AG issued daily notifications about the progression of the work over the previous 24 hours, the planned work for the next 24 hours, and the expected work over the following 24 to 48 hours. Nord Stream 2 AG also issued daily progress reports on each vessel's progress, fuel consumption, and onboard work activities. The Danish Maritime Authority was able to track the progress of construction and to inform approaching vessels via Notices to Mariners about the project, its activities and status.

Sweden:
Swedish authorities were informed more than one month prior the start of pipelay, in line with the agreed procedure. Throughout 2019, NSP2 sent construction notification updates on a monthly basis.

Since pipelaying through the Natura 2000 area and DW Shipping lane was considered to be the most critical work, the verification of NSP2 notifications to the authorities focused on the two Solitaire pipelaying campaigns during twelve days in January (line B) and 13 days between September and October (line A). Daily notifications were sent from the vessel during these periods which included positions, updates on the last 24 hours of operation, plans for the next 24 and 48 hours, support vessels, pipes and cables crossings. The information provided in these notifications corresponds with the scope of work for Solitaire and expected days in the DWSL provided in the monthly reports for these periods. 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 that the communications from Nord Stream 2 and the respective vessels was satisfactory.

Activity 2

Denmark:
For monitoring objective 2 (behaviour of the work vessel fleet), a comparison of the work vessels' activity logs with their observed routes, as recorded by AIS data, showed coherence between the two.

Sweden:
Analysis of AIS data confirmed that the pipe supply vessels respected the predefined channel and followed the main commercial shipping lanes while transiting between harbour and pipelay vessels. On few occasions the pipe supply vessels crossed over the most southern part of the predefined channel, but they did not enter into the areas Norra Midsjöbanken or Hoburgs bank.

The analysis of historical AIS data proved that construction vessels (supply vessels and supporting vessels) were moving at a significant distance from the banks and that official shipping lanes generally were used for transportation to and from the construction locations.

Overall, there was a good match between the notification information and the actual work performed.

Activity 3

Denmark:
The results of monitoring objective 3 showed that in general, the intensity of third-party ship traffic was low, and the safety exclusion zones around the pipelay vessels were respected. The few observed violations of the safety exclusion zones were minor and occurred in situations where no other vessels were nearby and no apparent evasive actions were taken. Nord Stream 2 AG did not receive any incident reports from the pipelay contractor on any observed incident, indicating that the situations were not experienced as threats to maritime traffic or health and safety. As such, it can be concluded the construction works in Danish waters allowed free passage to third-party vessels.

Sweden:
On a few occasions the safety zone of the pipelaying vessels was intruded by third party vessels. However, it was never any dangerous situation. No report from the pipelaying vessel or from the guard vessel in the DWSL was given in 2019, which indicates that the third party vessels could safely pass the pipelaying vessels.

CONCLUSIONS

Dedicated monitoring in Sweden and in Denmark showed good coherence between notification information and actual work performed. The analysis of historical AIS data has proved that construction vessels were moving at significant distances from the sensitive shallow banks and that official shipping lanes generally were used for transportation to and from the construction locations. The construction vessels followed the communication and reporting procedures that had been agreed with the shipping authorities. There were no accidents or incidents involving maritime traffic, including fishing vessels. Impact on maritime traffic is thus confirmed as being minor, localised and of a short-term nature, in line with the Swedish ES and the Danish EIA /03/, /05/. Also other countries' compliance with navigations rules resulted in no accidents affecting ship traffic.

The monitoring program is considered concluded in Sweden.

5.1.7 Munitions objects

Part of the route in the Danish waters goes through the area where works on the seabed are discouraged due to the risk of encountering chemical munitions. The purpose of the monitoring programme for munitions in Danish waters is to document that identified munitions objects are not disturbed during the construction or operation of NSP2.

The NSP2 routing was adapted to safely accommodate all munitions found during the baseline munitions surveys along the NSP2 pipelay corridor and intervention works footprint. All munitions finds were discussed with the Danish authorities and it was concluded that no dedicated monitoring is required for any of the finds. Therefore, the focus of the monitoring programme is on objects identified as chance finds during construction and operation.

METHODOLOGY

Visual and sonar munitions surveys are planned to be carried out by ROV for both Line A and Line B before pipelay (pre-lay survey), after pipelay (as-laid survey), and during operation. Any major anomalies such as munitions findings observed during the surveys will be reported immediately. Dedicated monitoring of any munitions found along the route has to be discussed and agreed upon with the Danish authorities/Royal Danish Navy, as necessary.

Figure 37 shows an illustration of an ROV inspecting a munitions object, and an example of a monitored munition object found during baseline surveys.

Figure 37. *Left: Deployment of an ROV for inspection of a munition objects. Right: Example of munition object, showing a chemical mustard gas bomb with heavily corroded casing (re-routed around during the design phase).*

RESULTS AND CONCLUSIONS

In Denmark, most of the munitions close to the pipeline route were determined to be remains of KC-250 chemical weapons and had been classified by the relevant Danish experts as non-explosive. For some munitions safety exclusion zones were established. In some cases, local re-routing or lay avoid procedures were implemented in order to avoid munitions and respect the established exclusion zones. A smaller exclusion zone was established for one munitions object (R-DKSD7S-0408), in agreement with the Danish authorities, as a rock berm is planned to be constructed on the pipeline at this location.

No munitions chance finds were encountered during construction in 2019. No munitions objects were disturbed during construction activities in 2019, and all exclusion zones were respected.

5.2 Dredging, dredge soil disposal, back filling, cofferdam removal and nearshore pipe-pull in Russia

Monitoring in the nearshore section started in 2018 and covered pre-construction survey and first short stages of dredging and placement of the dredge spoil. In 2019, the monitoring started in mid-April after ice melting and covered: dredging and associated disposal of dredge spoil (both at the temporary storage site and at the permanent storage site), preparation for nearshore pulling, pulling itself, backfilling of the trenches and cofferdam removal. In November, when all above mentioned construction activities were completed, post-construction surveys took place.

Samplings of water were provided on a monthly basis, bottom sediments were sampled at the beginning and end of 2019, and hydrobiological and ichthyological survey took place in summer (July) and in autumn (October–November). In addition, according to permit conditions, some particular monitoring of specific subjects was carried out, such as monitoring the nearest spawning area, monitoring of salmon migration, monitoring of Luga bay permanent storage of dredge spoil. All observations of birds and seals were performed as associated activities (i.e.: monitoring of birds and seals was not the main purpose for which the monitoring was developed. These species were monitored alongside the monitoring of other receptors) and results are discussed together with other specialized observations (Chapters 5.4.3, 5.4.4).

Table 11. *Overview of monitored parameters during dredging and associated activities*

	Marine sediment quality	Marine water quality	Benthos	Plankton	Fish	Birds	Marine mammals	Cultural heritage chance finds
2019	R	R	R	R	R	R	R	R

R – Russia

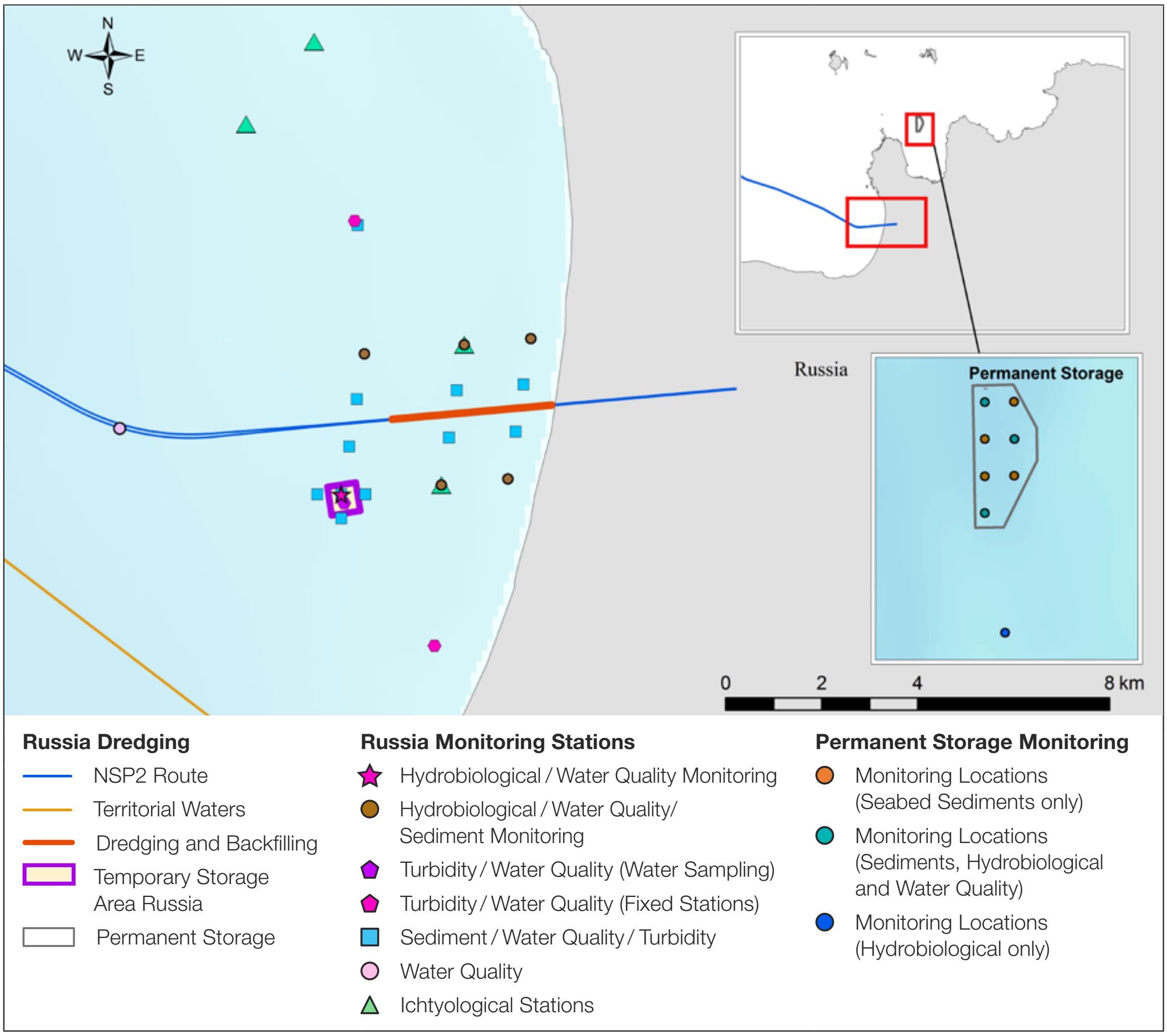


Figure 38. *Nearshore monitoring associated with dredging.*

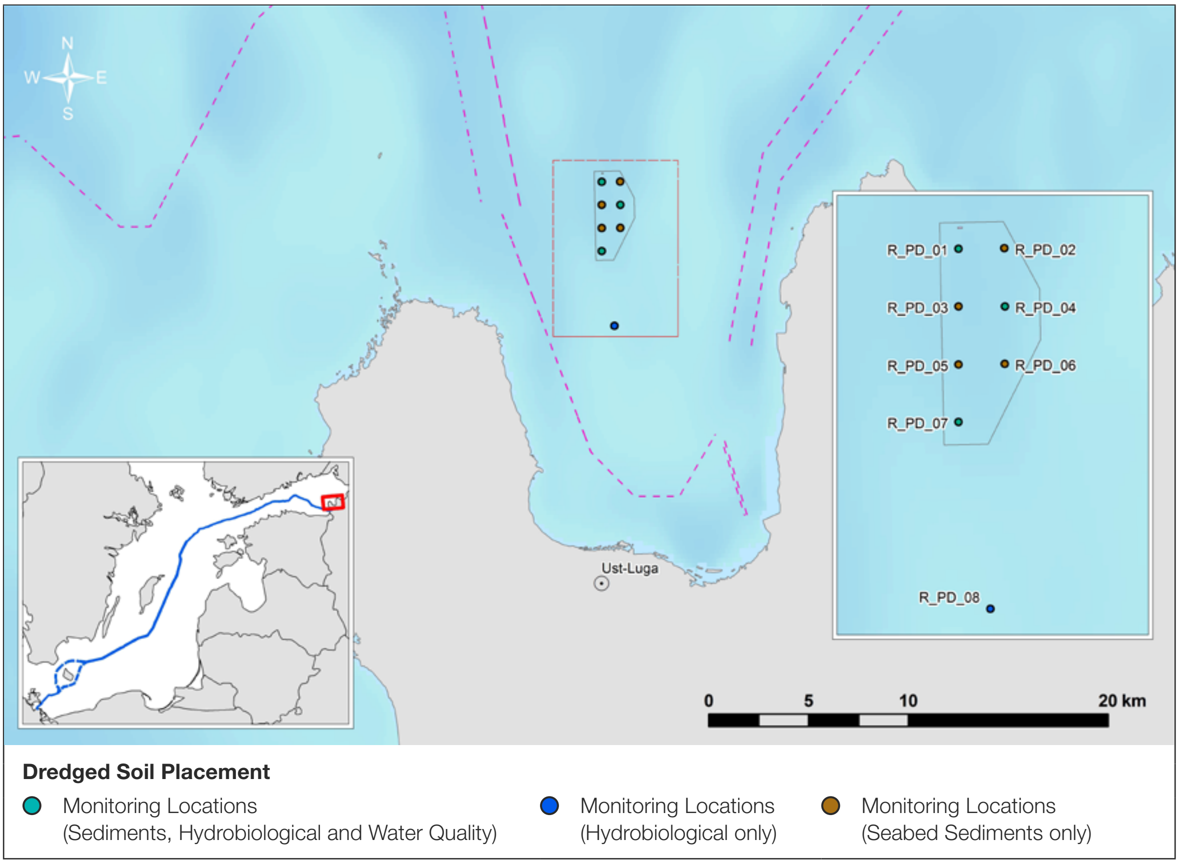


Figure 39. *Map for Luga Bay (Valshtein bank) permanent storage of dredge spoil monitoring.*

No impacts on water and sediment quality were detected during 2019 (Chapters 5.2.1 and 5.2.2). Turbidity increase comparable to seasonal changes was registered during cofferdam removal at the boundary of the spawning area (Chapter 5.2.2). These were assessed as permissible in accordance with the national EIA. Benthic communities were affected by the dredge spoil placement and backfilling: study is prolonged to 2020 to monitor reinstatement processes (5.2.3). Impact of temporary spoil storage was confirmed by phytoplankton complex survey in summer. In the EIA, these impacts were assessed as local and temporary, which was confirmed during the autumn post-construction survey. Zooplankton communities did not show any reaction to the construction activities, and result were comparable to the 2016 baseline survey (Chapter 5.2.4). No impact on spawning and salmon migration, as well as ichthyocenosis in general, was confirmed by the monitoring results (Chapter 5.2.5). Bird migration was slightly affected by the concentration of equipment and fleet in the nearshore area: migration routes of geese and sea ducks slightly changed (see Chapter 5.2.6 and more in the on-shore section, Chapter 3.1.5). No seal observations in the project area during near-shore works were registered by either the construction or monitoring contractors (see Chapter 5.2.7). No chance finding of cultural heritage objects was encountered during dredging and associated activities in Russia (5.2.8).

5.2.1 Marine sediment quality

Monitoring of seabed sediments associated with construction was developed 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, the spoil disposal both at the temporary and at the permanent storage area, and backfilling activities. Those sampling was performed in accordance to EIA requirements and special request by the water basin authority.

In addition, monitoring of dredged soil as well as of the areas where the soil was permanently placed in the Ust-Luga bay was done in accordance with dumping permit.

METHODOLOGY

Sampling in the project area took place twice:

> During cofferdam installation, before dredging (mid-April);
> After end of construction activities (beginning November).

In total 16 locations were sampled (see Figure 38):

> One baseline location close to the nearest spawning area (outside of area of potential impact);
> 6 locations along pipeline route, at 500 metres from the pipeline;
> 6 locations along pipeline route, at 1,500 metres from the pipeline;
> 4 locations in the area where the dredge spoil was temporarily placed (including 1 at 1,500 metres).

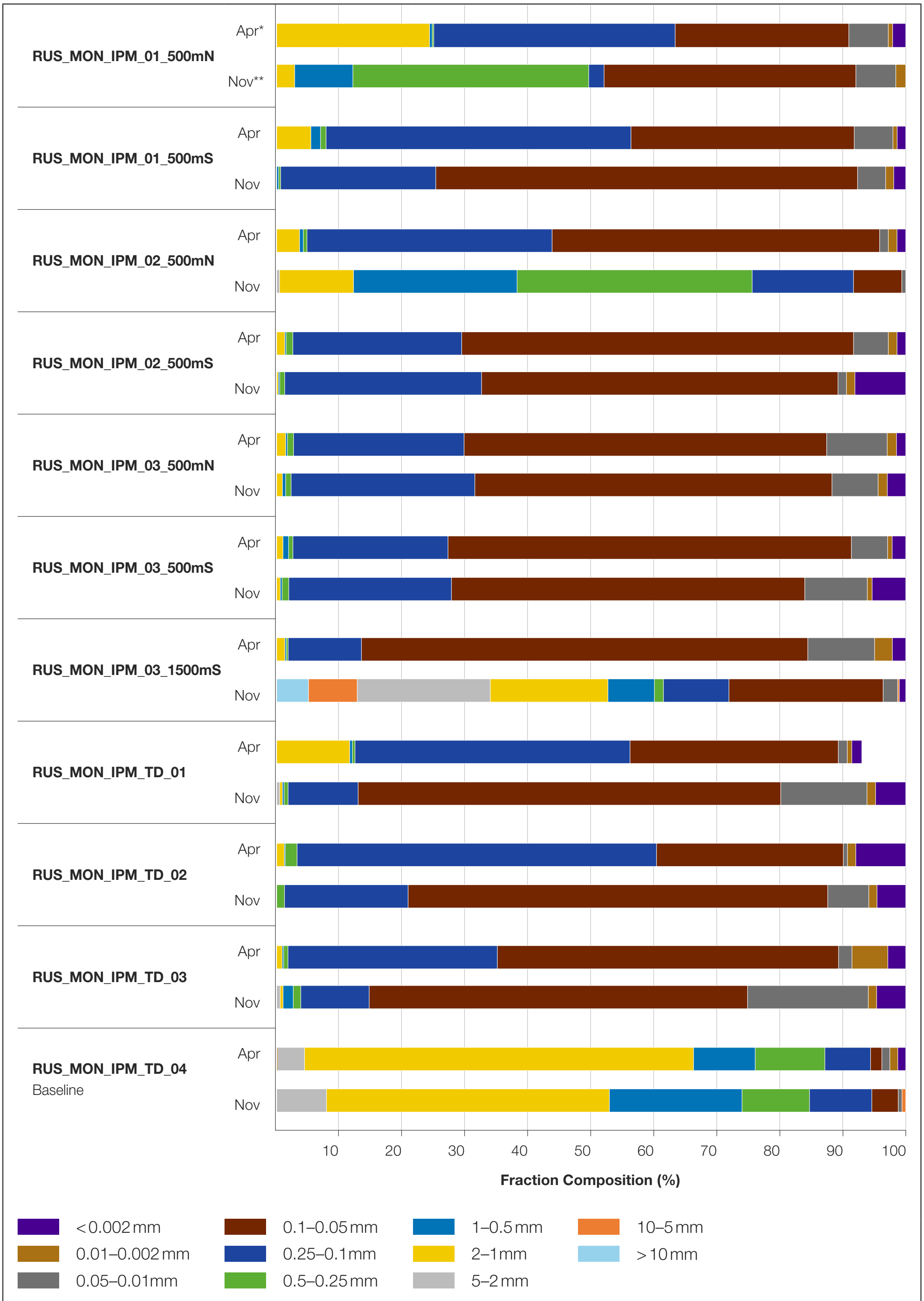
Comparison between the monitoring results from earlier baseline studies/literature and the data collected in 2019 was used to calculate the total pollution index. The total pollution index (Zc) compares pollution levels over time and determines whether pollutants are accumulating in the soil (higher 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.

Seabed sediment monitoring at the permanent dredge spoil placement area was carried out at 7 locations (see Figure 39). Sediment samples were collected prior to, during and after the dredge spoil placement. In addition, eight soil samples were also collected from the dredging site to confirm compliance with dumping permit requirements. The soil samples were analysed by laboratories accredited for chemical and analytical testing.

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

RESULTS

The seabed sediments composition slightly changed after intervention works in backfilling along the pipeline route, but remained stable in the baseline location (see Figure 40).



* Before intervention work, survey in April 2019 (the lowest is baseline)
** After intervention work, Survey in November 2019 (the lowest is baseline)

Figure 40. *Seabed sediment composition before and after intervention works.*

According to the results of seabed sediment studies in the project area, before and after intervention works, fairly low concentrations of pollutants were detected. The 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 (Table 12).

Table 12. *Indexes of total pollution. In bold are marked values higher then permissible (between 16 and 32 is classified as moderately polluted/dangerous).*

Monitoring station	Total pollution index Zc, depending on the selected baseline values			
	VSEGEI (Russian Geological Research Institute), 2010	Environmental baseline survey 2015	Environmental baseline survey 2016	Baseline monitoring location (April 2019)*
Monitoring during cofferdam installation before intervention works				
RUS_MON_IPM_01_500mN	1.0	3.2	10.6	1.8
RUS_MON_IPM_01_500mS	1.0	4.7	15.3	3.1
RUS_MON_IPM_02_500mN	1.0	8.2	**27.3**	8.2
RUS_MON_IPM_02_500mS	1.0	5.0	**16.1**	3.7
RUS_MON_IPM_03_500mN	1.0	8.3	**25.3**	6.3
RUS_MON_IPM_03_500mS	1.5	8.3	**26.8**	10.2
RUS_MON_IPM_03_1500mS	1.0	5.2	**18.0**	4.3
RUS_MON_IPM_TD_01	1.2	6.4	10.0	3.8
RUS_MON_IPM_TD_02	1.0	1.7	**19.0**	3.3
RUS_MON_IPM_TD_03	1.0	7.0	**22.2**	5.5
RUS_MON_IPM_01_1500mN	1.0	4.4	10.1	1.6
RUS_MON_IPM_01_1500mS	1.0	5.7	14.2	2.0
RUS_MON_IPM_02_1500mN	1.0	4.7	12.3	1.6
RUS_MON_IPM_02_1500mS	1.0	6.1	15.6	2.6
RUS_MON_IPM_03_1500mN	1.0	4.8	12.0	1.7
Final monitoring survey in project area				
RUS_MON_IPM_01_500mN	1.0	1.0	1.3	1.2
RUS_MON_IPM_01_500mS	1.0	1.0	2.3	1.3
RUS_MON_IPM_02_500mN	1.0	1.0	1.0	1.0
RUS_MON_IPM_02_500mS	1.0	1.3	6.3	2.2
RUS_MON_IPM_03_500mN	1.0	1.0	4.2	2.0
RUS_MON_IPM_03_500mS	1.0	2.8	11.3	3.7
RUS_MON_IPM_03_1500mS	1.0	4.1	13.5	3.6
RUS_MON_IPM_TD_01	1.0	3.0	11.4	3.5
RUS_MON_IPM_TD_02	1.0	1.8	7.6	2.2
RUS_MON_IPM_TD_03	1.0	3.5	13.3	4.0
RUS_MON_IPM_01_1500mN	1.0	1.2	2.09	1.36
RUS_MON_IPM_01_1500mS	1.0	1.2	2.45	1.23

Monitoring station	Total pollution index Zc, depending on the selected baseline values			
	VSEGEI (Russian Geological Research Institute), 2010	Environmental baseline survey 2015	Environmental baseline survey 2016	Baseline monitoring location (April 2019)*
RUS_MON_IPM_02_1500mN	1.0	3.7	9.74	2.38
RUS_MON_IPM_02_1500mS	1.0	1.4	3.21	1.37
RUS_MON_IPM_03_1500mN	1.0	1.0	1.33	1.00

* Note: For baseline location itself Zc November to April calculated as 2.3

In accordance with the regional standard, the sediments in the project area were classified as 0-class of pollution ("clean") at the beginning of the year and after the end of construction /21/.

The same results were received for the area where the dredged soil was permanently placed in Luga Bay (Valshtein bank): Pollution index Zc during and after placement of the dredge spoil was very low compared with the pre-placement survey (1.0–2.9). According to the regional standard, class of bottom sediments remained "clean" during and after the end of soil placement operations /21/.

Comparison of analysis results for bottom sediments of the area where the soil would be placed and the dredged soil itself (Table 13) demonstrates that the concentrations of pollutants measured were characterized by low values at both locations. Concentrations of pollutants in all the studied samples (both of bottom sediments of the storage site and sediments meant for dumping) are, practically, in the same range of values for each indicator listed in the governmental decree No. 2753-p.

No excessive content of pollutants such as lead, cadmium, mercury, radioactive isotopes, oil products was observed in sediments excavated during the dredging operations compared with bottom sediments of the area where the dredged soil was placed. The content of organochlorine pesticides, polychlorinated biphenyls and terphenyls, organotin compounds was below the detection limit in all the samples (Table 13). Observed variations of pollutant concentrations in bottom sediments, extracted prior to and after the soil placement overlap with the margin of error of measurements of the corresponding indicators (i.e.: standard error of the detection method).

Table 13. *Assessment of placed soil according to Decree No. 2753-p.*

Value of measured indicator	Pb, mg/kg	Cd, mg/kg	Hg, mg/kg	Oil products, mg/kg	Organochlorine pesticides, mg/kg	Polychlorinated biphenyls, mg/kg	Polychlorinated terphenyls, mg/kg	Organotin compounds, mg/kg	Cs-137, Bq/kg	Sr-90, Bq/kg
Monitoring prior to start of placement of dredge spoil										
Minimum	1.65	<0.01	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	<19	5
Maximum	11.26	0.064	0.036	<5	<0.0001	<0.0001	<0.005	<0.01	<24	36
Average	5.79	<0.01	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	21	18.3

Value of measured indicator	Pb, mg/kg	Cd, mg/kg	Hg, mg/kg	Oil products, mg/kg	Organochlorine pesticides, mg/kg	Polychlorinated biphenyls, mg/kg	Polychlorinated terphenyls, mg/kg	Organotin compounds, mg/kg	Cs-137, Bq/kg	Sr-90, Bq/kg
Sediments excavated from the dredging site										
Minimum	2.37	0.077	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	3	2.8
Maximum	7.15	0.116	<0.015	8.75	<0.0001	<0.0001	<0.005	<0.01	31	6.3
Average	4.79	0.096	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	15	4.3
Monitoring after placement of dredge spoil										
Minimum	3.10	<0.01	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	21	2.4
Maximum	5.47	0.117	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	<36	5.1
Average	4.00	0.05	<0.015	<5	<0.0001	<0.0001	<0.005	<0.01	28	–

CONCLUSIONS

No significant impact on bottom sediment quality was detected in the nearshore area or in the area where dredge spoil is permanently stored in Luga Bay. Monitoring results are in compliance with the national EIA assessment.

Sediment placement did not exert a significant impact on the content of pollutants listed in the governmental decree dated 12.30.2015 No. 2753-p. in bottom sediments of Valshtein bank dumping area in Luga Bay. Therefore the project was in compliance with the dumping permit requirements.

5.2.2 Marine water quality

Monitoring of turbidity and water quality associated with dredging, dredge spoil disposal at the temporary and permanent storage sites, backfilling and near-shore pulling 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 standard and other standards[6].

METHODOLOGY

Sea water monitoring cycles in the near-shore area were performed on a monthly basis at 11 monitoring locations (see Chapter 5.1.1) and at 5 additional locations on the final stage in November, for a total of 16 locations. In total, 164 samples were collected during 2019 in the project aria. Water samples were analysed by an accredited laboratory for common physicochemical properties of the water.

6 “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”

Turbidity monitoring was conducted at two near-shore monitoring stations during the same period (April–November 2019). Current speed and direction, temperature and turbidity data was acquired using an Automatic Buoy Station (ABS).

In addition, in accordance with dumping permit conditions, water quality samples were taken at 3 locations within the Valshtein bank permanent spoil storage area in Luga Bay. Sampling took place prior to, during and after the end of soil placement operations, from April to June 2019. In total 42 samples were collected within the dredged soil placement monitoring programme.

RESULTS

The intervention works in the shallow coastal area led to a temporary increase in water turbidity (measured by ABS), which was comparable to the natural fluctuations caused by sea swell. Instrumental measurements performed directly in the project area, at a distance of 500 metres from the open trench or backfilled pipeline, confirmed that the values of the monitored parameters were comparable with relevant baseline values, including the values obtained in the current period (at baseline location) and during the surveys performed in 2018, 2015 and 2016.

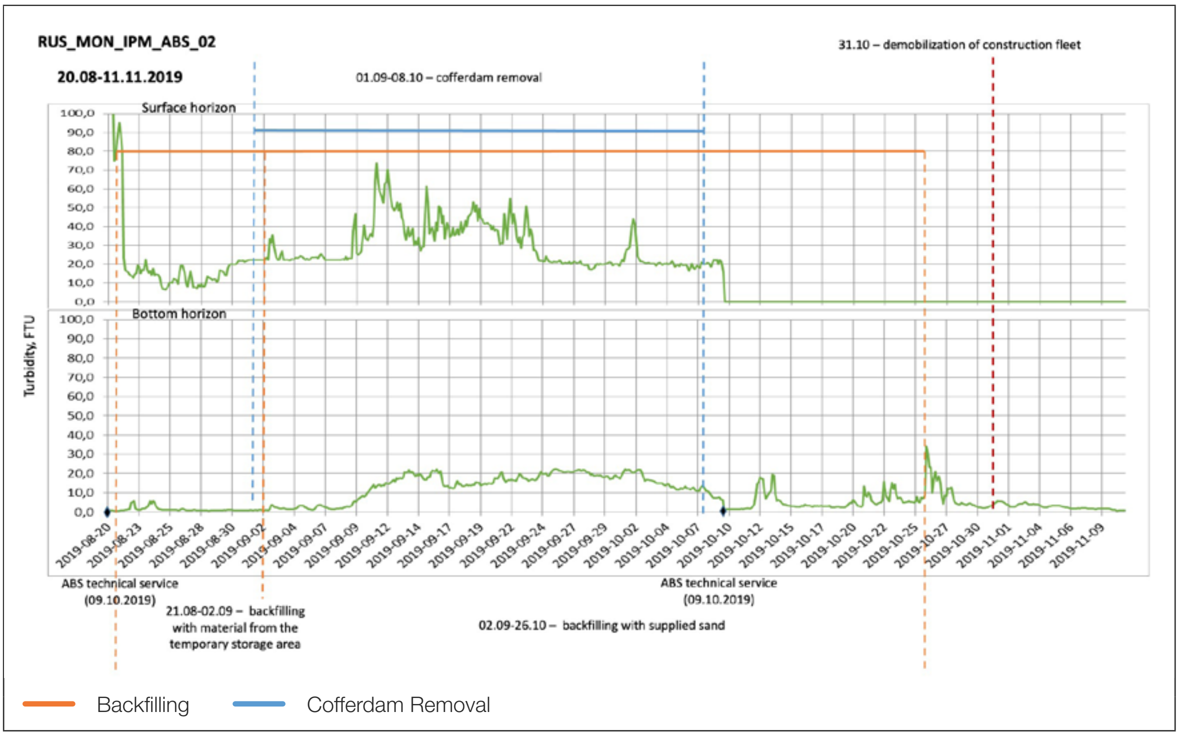


Figure 41. *Dynamic of turbidity (measured by ABS) during backfilling and cofferdam removal.*

Also, turbidity measured in terms of suspended solids (mg/l) displayed some fluctuations, with peaks in May (approximately 5 mg/l) and November (approximately 10 mg/l). Between June and October, turbidity remained below 2 mg/l. All measures were within the recommended values for commercial fishery water bodies (10 mg/l).

Monthly monitoring performed from April to November confirmed that water temperature dynamics were in line with natural seasonal patterns with a minimum in April and a maximum in August. Also, the monitoring confirmed that all hydrochemical indicators (pH, BOD, dissolved oxygen, concentration of nutrients) was mostly the result of the local weather situation and photosynthesis activity. For example, the highest BOD values (up to 2.6 MPC) were recorded during the periods of most intensive photosynthetic

activity (April, June and August). In September, when photosynthesis faded, while water temperature remained rather high, the content of dissolved oxygen reached its minimum and in the bottom layer dropped below the standard established for commercial fishery water bodies (by 1–1.05 times), but remained within the sanitary-epidemiological standard.

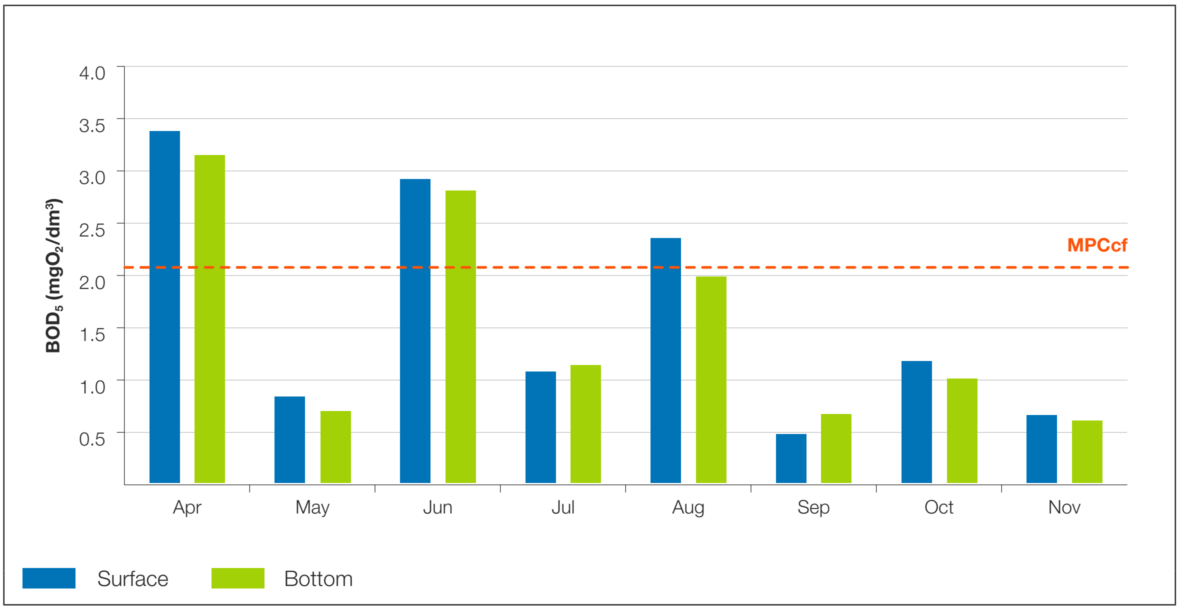


Figure 42. *Dynamics of average BOD5 (mgO_2/dm^3) for the survey period from April till November 2019. Red line shows MPC established for commercial fishery water bodies (2.1 mgO_2/dm^3).*

The content of contaminants was found to be low throughout the whole period of monitoring in the waters of the near-shore section of the Gulf of Finland: no exceedances of the MPCs established for commercial fishery water bodies were recorded for benz(a)pyrene and most heavy metals (arsenic, zinc, cadmium, cobalt, nickel, lead and mercury). The maximum number of cases where measured concentrations of monitored contaminants were higher than the method's detection limit was observed during the April baseline survey, which was mainly due to the inflow of these substances during the spring flood with mainland runoff. During that period, particular MPC exceedances were recorded for iron (up to 1.8 MPC), copper (up to 4 MPC) and zinc (up to 6.5 MPC). Concentrations of other contaminants were low and below the MPCs established for commercial fishery water bodies.

During the construction period (from May to November) local minor MPC exceedances were recoded for oil products (up to 2.2 MPC) and chromium (up to 1.9 MPC), which were sporadic and found only in one or two seawater samples out of 22 regularly taken samples. The hygienic exposure threshold of the oil products content was not exceeded (GN 2.2.5.1315–03). At the survey stage in 2016, MPC exceedance of oil products (up to 1.3 times) was registered in several particular nearshore locations. There are no reasons to conclude that these exceedances had any relation to the pipeline construction operations.

Additional monitoring of water quality not included in the monitoring programme: Adaptive turbidity monitoring

To ensure compliance with environmental requirements during dredging activities, Nord Stream 2 AG in 2019 continued with adaptive turbidity monitoring (started in 2018). For the 2019 campaign, seven monitoring buoys were deployed – two at reference locations (near the Estonian border and at the closest spawning habitat) and five near the work area (four at the dredging location and one at the temporary soil storage area), see Figure 43.

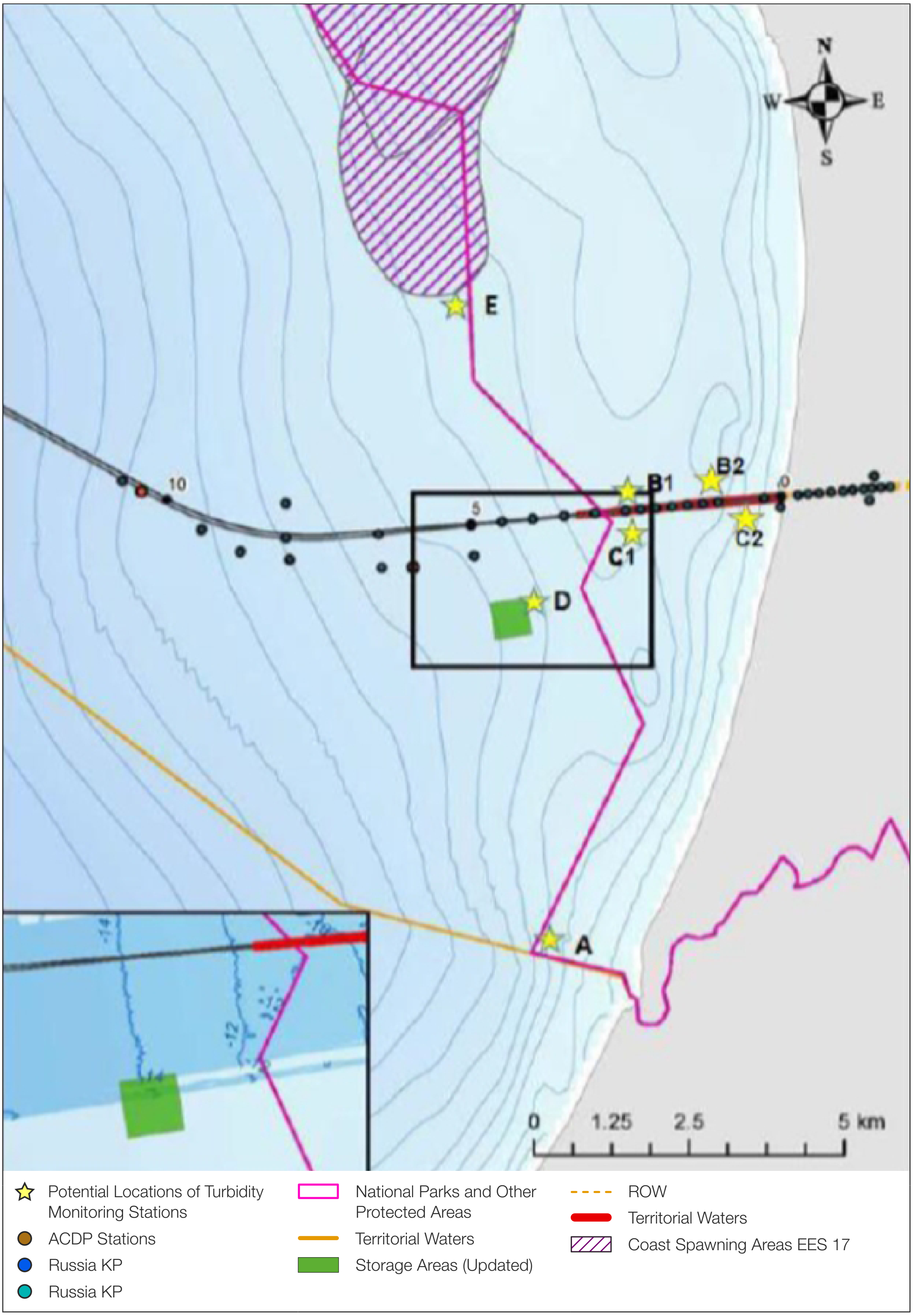


Figure 43. *Location of monitoring buoys for adaptive turbidity monitoring.*

The buoys measure turbidity levels at 15 minute intervals and submit data via the GSM network to a dedicated website. Turbidity is measured in NTU (Nephelometric Turbidity Unit) and correlated with TSS (Total Suspended Solids, mg/l) by water sampling in April, August, September and October 2019. The contractual requirements dictate that as a running average, the dredging activities shall not increase beyond some given thresholds[7]. On a daily basis, NSP2 was provided with a 24 hour overview of the turbidity levels and explanation of any deviations. Analysis of weekly overviews was included in the RDMC weekly reports. Weekly information was presented in the form of graphs for each turbidity buoy.

The data was analysed in order to account for singular erroneous readings and throughout the entire dredging period the works were subject to only one dredging exceedance, which was alleviated when the dredger moved out of the area as the dredging operation proceeded further down the trench. This exceedance was however later explained by an erroneous correlation with the data from the previous year.

The ambient turbidity values in the monitoring area also showed a large natural variation over the two years. This large variation highlights the importance of setting a turbidity limit related to a concentration above background values. Also selecting two background locations at considerable distance from each other allowed the works to be subject to the most representative background locations rather than being dependent on local conditions.

Additional monitoring of water quality not included in the monitoring programme: satellite-based turbidity monitoring

In 2019, Nord Stream 2 continued to work with EOMAP to monitor turbidity during nearshore dredging works. The main objective of the study was to assess the satellite-based turbidity and related suspended matter concentrations and their seasonal changes.

During 2019, a total of 58 high and medium resolution satellite images for the period from March to November 2019 were acquired, processed and delivered to the online portal. The spatial resolution ranged from 10 metres to 300 metres. The same location was revisited on average every 5 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 analysis of turbidity and total suspended matter revealed values up around 1.5–4 NTU (or 5–10 mg/l TSM), with occasional peaks that rarely exceeded 10 NTU/20 mg/l. Higher values were observed close to the shore and at locations where dredging and backfilling works were ongoing, but always remained within the natural range and were only on small spatial scales, with no large plumes being visible. The results also showed that increased turbidity values were also related to environmental phenomena such as heavy storms, river inflow during snow melt periods, and algal bloom events.

CONCLUSIONS

Measured turbidity levels during the whole construction period were in line with expected values and within EIA assessment (modelling). Impact on average turbidity level, comparable with seasonal fluctuations, was registered by ABS measurements only during cofferdam removal. This also shows that the cofferdam successfully prevented the significant increase of turbidity and general impacts on water quality during the main construction activities in shallow waters.

7 The background turbidity shall not increase by more than 50 mg/L at the dredge monitoring points. If TSS exceeds 75 mg/L above background levels for 1 hour at one of the dredge monitoring points the Contractor is to notify NSP2. When the TSS exceeds 100 mg/L above background levels for 6 hours at one of the dredge monitoring points NSP2 will instruct Contractor to cease dredging

Concentrations of pollutants were in some cases above the MPC for water bodies of fishery value, however these observations appeared to be temporary.

5.2.3 Benthic flora and fauna

The purpose of monitoring was to assess if benthic communities were affected by the construction activities (directly and indirectly) and to confirm that the scale of impact was within EIA calculations. Monitoring focused on the potential impacts caused by sediment resuspensions that originate during both temporary and permanent placement of the dredged soil.

METHODOLOGY

Monitoring of benthic communities was performed in July (during pipe-pulling and after the end of dredging, which happened in May) and in November (after the end of construction activities). In 2018, benthic communities were monitored in spring. Monitoring was performed at 5 locations at 1,500 metres from the pipeline route to the north and to the south (see Figure 38). The temporary storage area itself was not monitored in 2019 (while it was monitored in 2018), because it was in use for project. In order to evaluate potential impacts from the soil disposal in the temporary storage area, 5 locations in the proximity of the temporary storage area were monitored. All these locations were also monitored during the baseline surveys in 2016 and 2018.

In addition, 3 locations in the area for permanent placement of dredge spoil in Luga Bay and a background location outside of Valshtein bank were sampled after the end of dumping operations, in line with the requirements of the dumping permit (see Figure 39).

RESULTS

In July, macrozoobenthos was characterized by poor diversity of species and included 8 species belonging to five taxonomic groups: oligohetes, polychaetes, crustaceans, bivalves and nemerteans. Macrozoobenthos varied significantly – from 240–4,280 ind/m^2, averaging at 1,736 ind/m^2, in abundance, and from 0.56–29.25 g/m^2, averaging at 7.4 g/m^2, in biomass. The lowest abundance and biomass were recorded at the shallowest coastal stations, where polychaetes dominated, while at the further and deeper water stations, where *Limecola balthica* bivalves developed intensively, the abundance and especially biomass increased dramatically. In July 2019, macrozoobenthos quantitative indicators in the survey area were significantly lower compared with the deep water stations, due to hydrological and morphometric characteristics.

In general, the species composition, the structure of the dominant complex and the biomass of zoobenthos in July 2019 reflected typical summer conditions in the Russian sector of the Gulf of Finland. The closeness of the obtained zoobenthos abundance values and those measured in the summer of 2016 and 2018 indicate that dredging operations performed in April–May 2019 did not have any significant negative impact on the state of zoobenthos.

In November, macrozoobenthos was characterized by poor species diversity and included seven taxons belonging to five taxonomic groups: bivalves, oligochaetes, polychaetes, crustaceans and hydroids. Macrozoobenthos abundance and biomass demonstrated a mosaic distribution pattern: abundance varied from 23–77 ind/m^2, averaging at 55 ind/m^2, and biomass varied from 0.05–7.98 g/m^2, averaging at 3.15 g/m^2.

The composition of the dominant groups of zoobenthos was different, but at most stations dominant in numbers were polychaetes, while bivalves were dominant in biomass. At one observation point, there were no shellfish, and the lowest biomass was measured for polychaete ($<$ 0.05 g/m^2). Such significant decrease in biomass was visible mostly at stations R_02_1500mN and R_03_1500mN, while at stations

located at shallow depths and to the south of the work area (R_01_1500mN, R_01_1500mS, R_02_1500mS), biomass increased 3 times on the average (see Figure 44).

According to the EIA, the main impact on zoobenthos during pipeline construction was the deposition of suspended particles from a turbidity plume formed during dredging and related activities, while the cloud migrated in water flow, and therefore large areas were potentially being covered with sediments. Identification of stations with worsened zoobenthos indicators in 2019 (R_02_1500mN and R_03_1500mN) correlates with the preliminary estimates of turbidity cloud propagation during excavation works at the temporary dumping site.

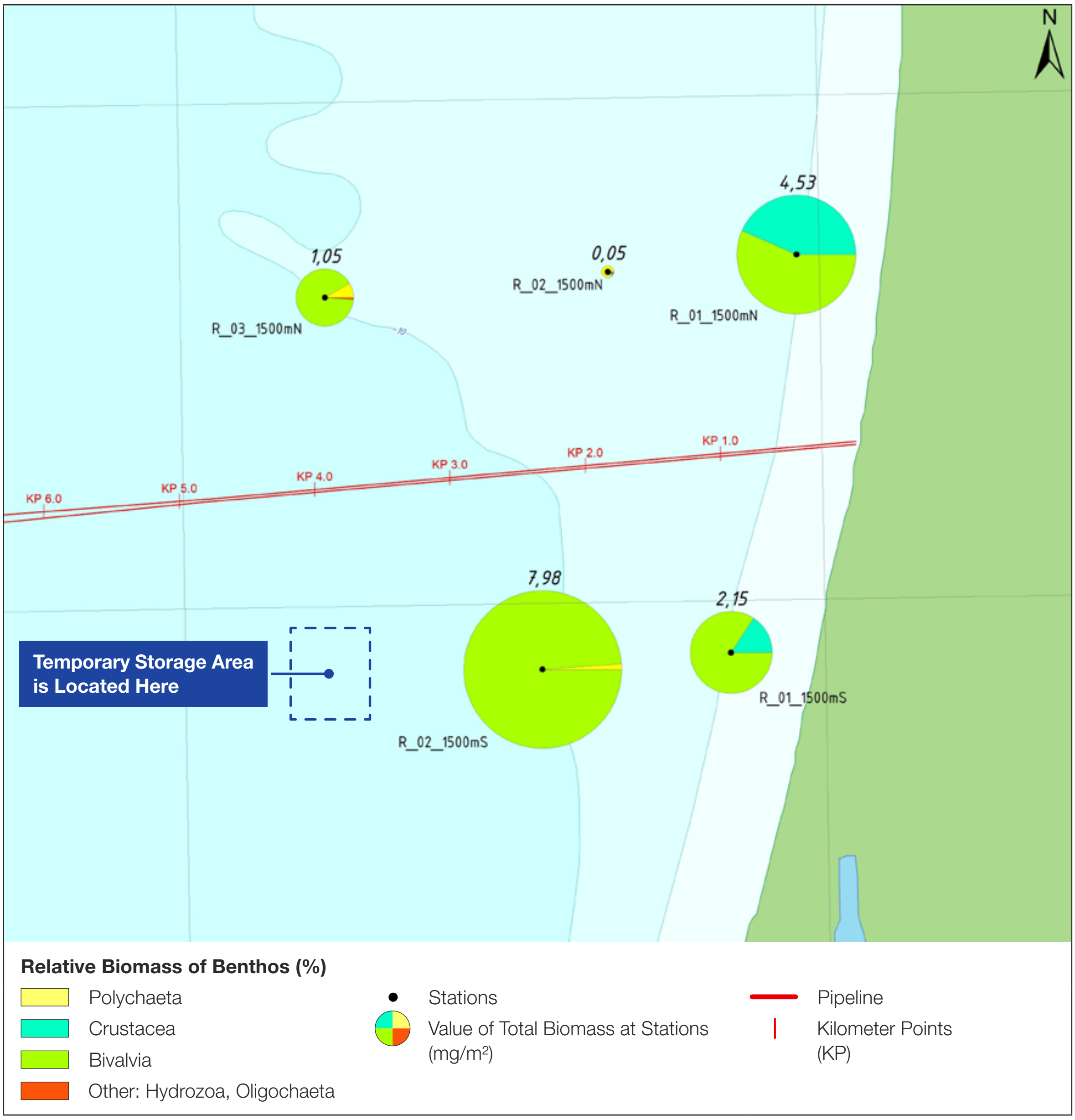


Figure 44. *Relative biomass of monitored benthos in November 2019.*

According to the modelling results related to backfilling operations, suspended matter in concentrations higher than 1 mg/l can propagate more than 500 metres from the discharge point, and the thickness of deposited sediments may reach from 5 to 1 mm at distances from 1.2–2.0 km respectively. It is

suspected that the impact caused by the re-deposition of this sand layer less than 6 mm thick does not affect the diversity of macrozoobenthos species. However, operations of soil removal, backfilling and cofferdam removal were performed simultaneously and therefore could produce a cumulative impact. Taking into account that submarine currents of northern quadrants are prevalent in the area, suspended sediments and turbidity distribution could be shifted towards stations R_02_1500mN and R_03_1500mN, where a pointedly negative reaction on the part of benthic organisms was recorded as the only identified indicator of changes in the habitats.

At the other surveyed stations, quantitative and structural indicators of zoobenthos corresponded to those previously recorded during the 2015 and 2016 baseline survey as well as during the 2018 pre-construction monitoring (albeit taking into account interannual variability and a generally mosaic pattern of distribution of benthic communities in the coastal area).

Macrozoobenthos communities in the eastern part of the Gulf of Finland are generally characterised by significant interannual fluctuations in abundance and biomass. The development of benthic fauna within coastal san dBAnks is limited by hydrodynamic factors (water swell, especially during storms) and strongly depends on local factors. The lowest quantitative indicators of bottom communities during the surveys conducted before, during and after construction activities (2016, 2018, and 2019) were recorded at the shallow water stations. Macrozoobenthos quantitative indicators tend to increase with depth. Sand and gravel soils occurring in the shallow depths in the eastern part of the Gulf of Finland are more affected by water swells and therefore are not a suitable substrate for the development of macrozoobenthos.

The observed decrease in the abundance of macrozoobenthos during the monitoring performed in November 2019 (after the end of construction activities) compared to previous monitoring performed during pipe pulling in July 2019 could be caused by seasonal dynamics and by the natural mosaic pattern of macrozoobenthos distribution. In addition and as mentioned above, local impacts likely related to soil excavation and backfilling and cofferdam removal were also recorded.

With regards to the monitoring of the permanent dredge spoil placement area, macrozoobenthos was represented by only six species of benthic organisms including oligohaetes, polychaetes, crustaceans and bivalves. In the soil placement area, abundance (23–533 exemplar/m^3) and biomass (4.76–92.43 mg/m^3) of macrozoobenthos were higher than at background station (16 individuals/m^3, 5.52 mg/m^3). In terms of biomass, bivalves (*Limecola balthica*) were dominating and sub-dominant werecrustaceans (*Saduria entomon*). During the last several decades, considerable variability of macro-zoobenthos quantitative indicators was noted in the water area of Luga Bay on the whole. Compared with long-time annual average values observed in in the Luga Bay area, the macrozoobenthos abundance was lower in June 2019, while biomass values were at about the same level /30/, /31/.

CONCLUSIONS

It was confirmed that benthic communities in the area were affected by backfilling of the trenches to the levels assessed in the EIA. The areas that were more impacted were those at a deeper water depth and northern locations. Based on recommendation from the independent environmental consultant Nord Stream 2 plans to extend monitoring of benthos into 2020 to confirm recovery of benthic communities.

5.2.4 Plankton

The purpose of monitoring was to assess if plankton communities were affected by the construction activities (directly and indirectly) and to confirm that the scale of impact was within EIA calculations.

METHODOLOGY

Monitoring took place together with monitoring of benthic communities. Bacterio-phyto – and zooplankton communities were studied in July (after the end of dredging and during pipe-pulling) and in November (after the end of the construction activities). Monitoring was performed at 6 locations 1,500 metres from the pipeline route to the north and to the south (see Figure 38), including the area for the temporary storage of dredged soil. All monitoring locations were the same as in the baseline surveys of 2016 and 2018.

The area for permanent dredge soil placement was also monitored in the same locations where the macrozoobenthos survey previously took place. Phytoplankton and photosynthetic pigments were studied as well as zooplankton complex at beginning of June, ten days after the last soil disposal operation (see Figure 39).

RESULTS

Higher values of bacteria-plankton abundance registered in July when the pipe was pulled, were substantially within the range of inter-annual variations and were likely the result of seasonal warming of the water column. The increase in the content of certain groups of bacteria compared to the background values could be the result of increased hydrobiological activity or could be associated with a higher anthropogenic load. The possible impact of this type of construction operations was short-lived and did not cause a radical reorganization of bacteriacenosis. Backfilling of trenches did not affect the state of bacteria-plankton.

Phytoplankton monitoring revealed that the lowest biomass values were registered during pipe-pulling in July 2019 at R_03_1500mS, at the temporary soil placement area (see Figure 45). Similar results were also recorded for species abundance.

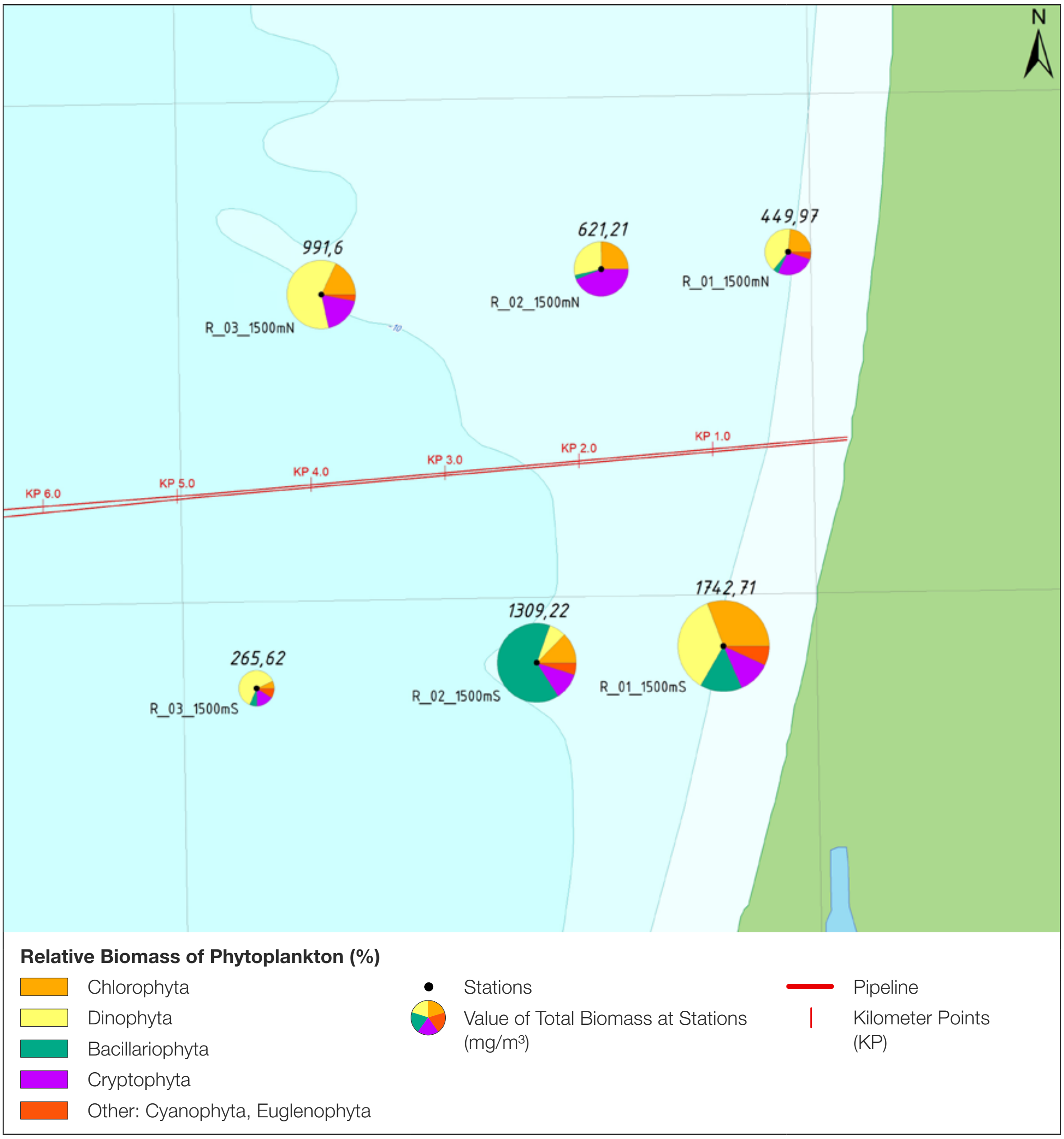


Figure 45. *Biomass of phytoplankton monitored in July 2019.*

This indicates that dredging operations performed in April–May 2019 produced a local-scale negative impact on the condition of phytoplankton in summer. However, after the end of backfilling in November, a recovery of the quantitative characteristics of phytoplankton was observed, and no negative impact on the abundance and biomass was confirmed (see Figure 46). Therefore, the measured impacts were fully in line with the EIA.

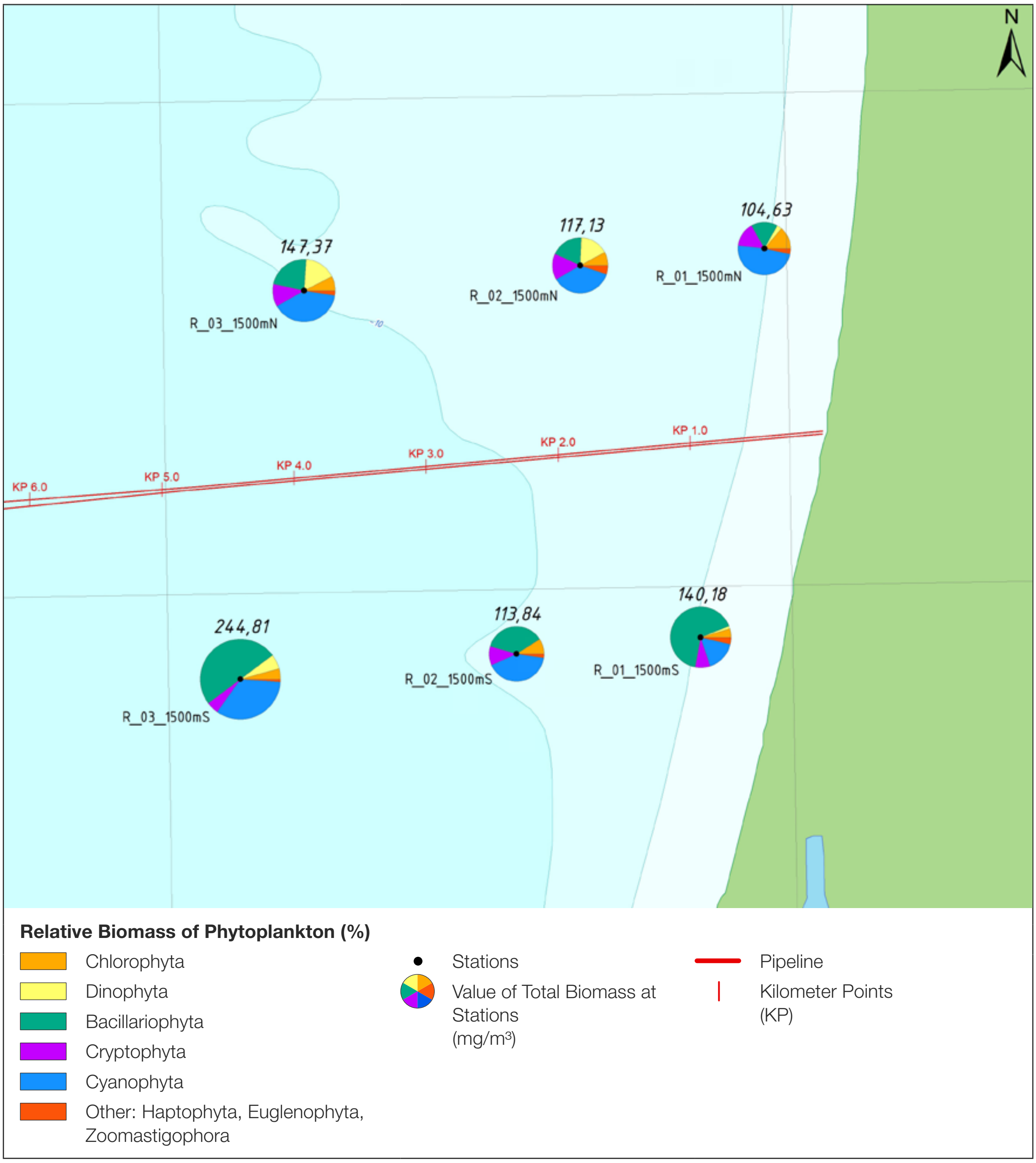


Figure 46. *Biomass of phytoplankton monitored in November 2019.*

In general, quantitative indicators of phytoplankton development were within the range of seasonal variability. The highest diversity of species was found for green and diatoms algae, and the pigment composition was mainly represented by chlorophyll “a”.

All zooplankton species found in the coastal area, including the dominant ones, were typical for the Gulf of Finland. Copepods and cladoceran crustaceans dominated both in abundance and biomass. The highest abundance and biomass values were recorded at coastal, shallow water stations. No impact of construction operations on zooplankton structure and quantitative indicators was detected.

In Luga Bay (Valshtein bank area) after the permanent dredged soil placement activities had finished, the phytoplankton was represented by 49 species from 7 divisions wherein the greatest species diversity was found for green and diatom algae. In terms of species abundance, freshwater species were dominating. Dominant groups were diatoms and euglena algae were sub-dominant. Average abundance was 11,895 cell/l and average biomass was 2,013 mg/m^3. Concentrations of photosynthetic pigments varied in the following ranges: chlorophyll "a" – 3.02–7.41 µg/l, chlorophyll "b" – 0.67–1.49 µg/l, chlorophyll "c1+c2" – 0.37–0.60 µg/l. Based on phytoplankton biomass and chlorophyll "a" concentration, the trophic state of the water body studied in June 2019 can be characterized as transitional state between mesotrophic and eutrophic levels. In June 2019, the quantitative indicators of phytoplankton development (abundance, biomass, concentration of photosynthetic pigments) in the permanent dredged soil storage area were within the limits of seasonal variability.

Zooplankton monitored in the permanent dredged soil placement area was represented by 18 species and taxons of higher range, characteristic for spring season. *Keratella quadrata*, *Eurytemora affinis*, larvae of polychaetes (Polychaeta), juvenile forms Cyclopoida, *Evadne nordmanni*, *Pleopis polyphemoides*, *Synchaeta baltica* and *Limnocalanus grimaldii* were dominating. In terms of abundance, rotifers were dominating, in terms of biomass copepods dominated, while polychaetes were sub-dominant, which is characteristic for the water area studied. Average zooplankton abundance was 2,446.5 exemplar/m^3 and biomass was 16.82 mg/m^3. The measured abundance and biomass were within the ranges characteristic for zooplankton in the water area of Luga Bay.

CONCLUSIONS

Low-scale and short-term impact of dredging on phytoplankton complex was observed in the project area, with the recovery of the phytoplankton conditions already recorded in the post-construction survey undertaken in November 2019. These results were in line with the assessment presented in the EIA.

5.2.5 Fish

Monitoring of spawning (ichthyoplankton study) and monitoring of juvenile salmon migration were undertaken with respect to seasonal conditions specific of those events.

Monitoring of fish communities in the project area took place at the same time as the hydrobiological survey – in July and November. The November monitoring also covers the potential adult salmon migration through the project area.

METHODOLOGY

During the expected juvenile salmon migration season, from April to June, monitoring of juvenile salmon catches was carried out using three gill nets at three locations 500 metres to the south of the pipeline route, monitoring their migrations from the river mouth to the sea. Catches were made every seven days between 21st April and 12th June. Monitoring of adult salmon migration took place during autumn with a similar methodology as in 2018. Monitoring using gill nets was performed at four stations, two of which were located on a profile crossing the pipeline route approximately 2 km from the shore (1500 m to the South and to the North from the pipeline route), and two stations coinciding with the locations for monitoring of ichthyoplankton.

Ichthyoplankton monitoring was carried out at the end of May 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 in the project area 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 80 net fishing sessions were carried out in 2019.

RESULTS

Spring migration of juvenile salmon from the Narva river to the northern part of the Gulf of Finland through the project area was not confirmed by the monitoring data. No individual was caught during the expected migration period /32/.

In May 2019, ichthyoplankton in the near shore area was represented by eggs and larvae of the spring-spawning Baltic herring. Species composition and abundance of ichthyoplankton were typical for springtime in the Gulf of Finland (see Figure 47).

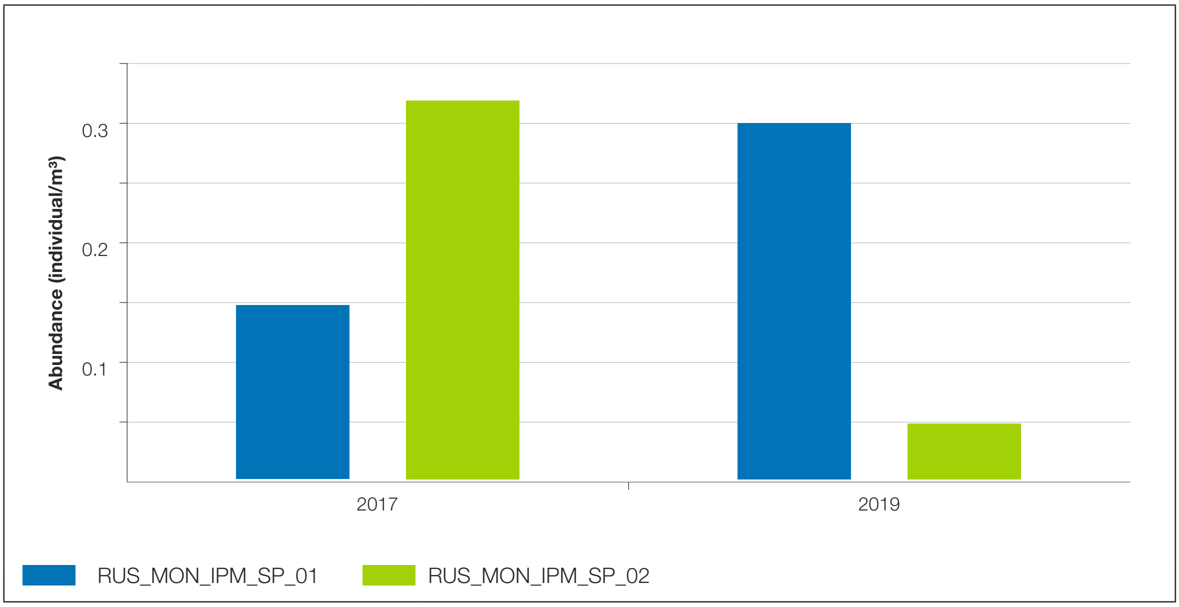


Figure 47. *Comparison of ichthyoplankton abundance in May 2017 (background survey) and in 2019 (during dredging)*

Ichthyofauna analysis data obtained in July 2019 and in autumn 2019 do not significantly differ from those obtained in June 2018. Structural indices of species diversity indicate stability of ichthyofauna at stations located in the area of construction operations: overall, the boundaries of the spawning areas were maintained, ensuring continuation of spawning (see Figure 47). Comparison of the indices measured in 2019 with those recorded during the previous surveys did not reveal any substantial differences. This leads to the conclusion that these processes have a long-term character. According to specialists' evaluations, dredging and backfilling operations in the coastal zone of Narva Bay had no impact on the structural or quantitative indicators of ichthyofauna.

The monitoring data also did not confirm an autumn migration of salmon through the project area. Two individuals were caught to the north of the pipeline route, however both of them were attributed as non-fertile /24/.

CONCLUSIONS

Spawning of Baltic herring was not impacted by the project and neither were the seasonal salmon migrations. Ichthyofauna of the project area itself demonstrated high tolerance of the construction activities without displaying any specific reaction. The results were in line with the assessment presented in the EIA.

5.2.6 Birds

METHODOLOGY

In May and in June, in addition to the monitoring of onshore birds (see Chapter 3.1.5) and the vessel observations (see Chapter 5.4.3.), avifauna monitoring was undertaken in the near-shore area. Observations took place on 15th May and 25th June in parallel with other monitoring works. It was assessed that this took a total of 6.5 and 5 working hours respectively.

RESULTS

A total of 1,408 birds representing 12 species from 4 orders were sighted on 15th May 2020: anseriformes, charadriiformes, pelecaniformes, ciconiiformes. Most observations regarded birds from the Anatidae Family (Anseriformes Order), namely white-fronted goose (*Anser albifrons*) and common scoter (*Melanitta nigra*), see Figure 48. 583 individuals of white-fronted goose were spotted during the survey, i.e. 39.5% of the total number of birds seen. 465 individuals of common scoter were spotted during the survey, i.e. 33.0% of the total number of birds seen. Both the white-fronted goose and the common scoter are birds migrating via the White Sea-Baltic flyway. Other species of that order were less common: 38 pink-footed geese, 76 long-tailed ducks and one common goldeneye (*Bucephala clangula*) were sighted.

Large aggregations of geese (about 560 individuals) were spotted in transit though the survey area and some 800 migrating marine ducks were seen resting and feeding within the area being monitored. Since the birds were seen from far away (500 metres and more), it was not possible to identify them, so these data were not included in the overall occurrence analysis.

Most abundant among representatives of the laridae family (charadriiformes order) were black-headed gulls (*Larus ridibundus*). 87 individuals were spotted during the observation period, i.e. 6.2% of the total number of birds seen. Black-headed gulls (*Larus ridibundus*), mew gulls (*Larus canus*) and common terns (*Sterna hirundo*) were observed in small numbers – around 10–20 individuals.

Great cormorants (*Phalacrocorax carbo*) were relatively rare: 86 individuals were spotted, i.e. 6.1% of the total number of birds seen. Heron accumulations were spotted in the lower course and delta of river Rosson, which flows into the Narva river near the coast of the Gulf of Finland. Some of the total 33 grey herons (*Ardea cinerea*) registered during the survey were seen flying over the waters of the Gulf of Finland. Nine great egrets (*Ardea alba*) were spotted in the river delta.

Three out of the total twelve bird species recorded during the survey are on various Red Lists, including two species which are on the Red List of the International Union for Conservation of Nature (IUCN) and two species are on the HELCOM Red List (Table 14).

Table 14. *Red list birds' species encountered during near-shore monitoring*

No.	English name	Scientific name	RB of RF	RB of LR	IUCN Red List	HELCOM Red List
1	Long-tailed duck	*Clangula hyemalis*			VU	ENw
2	Common scoter	*Melanitta nigra*				ENw
3	European herring gull	*Larus argentatus*			NT	
	Total		**–**	**–**	**2**	**2**

Figure 48. *Melanitta nigra, migrating though project area.*

A total of 88 birds representing 7 species from 3 orders were observed on 25th June 2020: charadriiformes, pelecaniformes and ciconiiformes. Since no migratory event was taking place during this monitoring campaign, the number of birds observed was significantly smaller compared to the May monitoring campaign. Most of the birds sighted belonged to the charadriiformes order – 82 individuals or 93% of the total number of birds seen. Encountered most often were common black-headed gulls (*Larus ridibundus*) – 42 sightings or 47.7%. Ranking second in terms of occurrence frequency were European herring gulls (*Larus argentatus*, NT, IUCN list) – 30 sightings or 34.1%. Ciconiiformes order was represented by grey heron (*Ardea cinerea*) five sightings of which were recorded. One species from the Pelecaniformes Order, the great cormorant (*Phalacrocorax carbo*), was also sighted once.

CONCLUSIONS

Monitoring of birds recorded the occurrence of a migratory event, in line with the expected seasonal dynamics. No direct impact from the construction activities was observed.

5.2.7 Marine mammals

In accordance with the monitoring programme, there was no specific marine mammal monitoring during dredging and associated activities. In addition, no mammals were observed during construction in the project area. More about vessel seal observations is discussed in Chapter 5.1.4.

5.2.8 Cultural heritage chance finds

No chance finding of cultural heritage objects was encountered during dredging and associated activities in Russia.

5.3 Post-lay trenching

Post-lay trenching along the NSP2 route in 2019 was only carried out in Sweden. The monitoring was performed to demonstrate that there is no impact on the protected areas and protected species.

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

Trenching of both pipelines (A and B) took place in two zones (1 and 2) close to the shallow banks Hoburgs bank and Norra Midsjöbanken (within the Natura 2000 area (see Figure 49).

Table 15. *Overview of monitored parameters during post-lay trenching in Sweden*

	Marine water quality	Ship traffic
2019	S	S

S – Sweden

This chapter presents the water quality and ship traffic monitoring results that refer to post-lay trenching activities in Sweden.

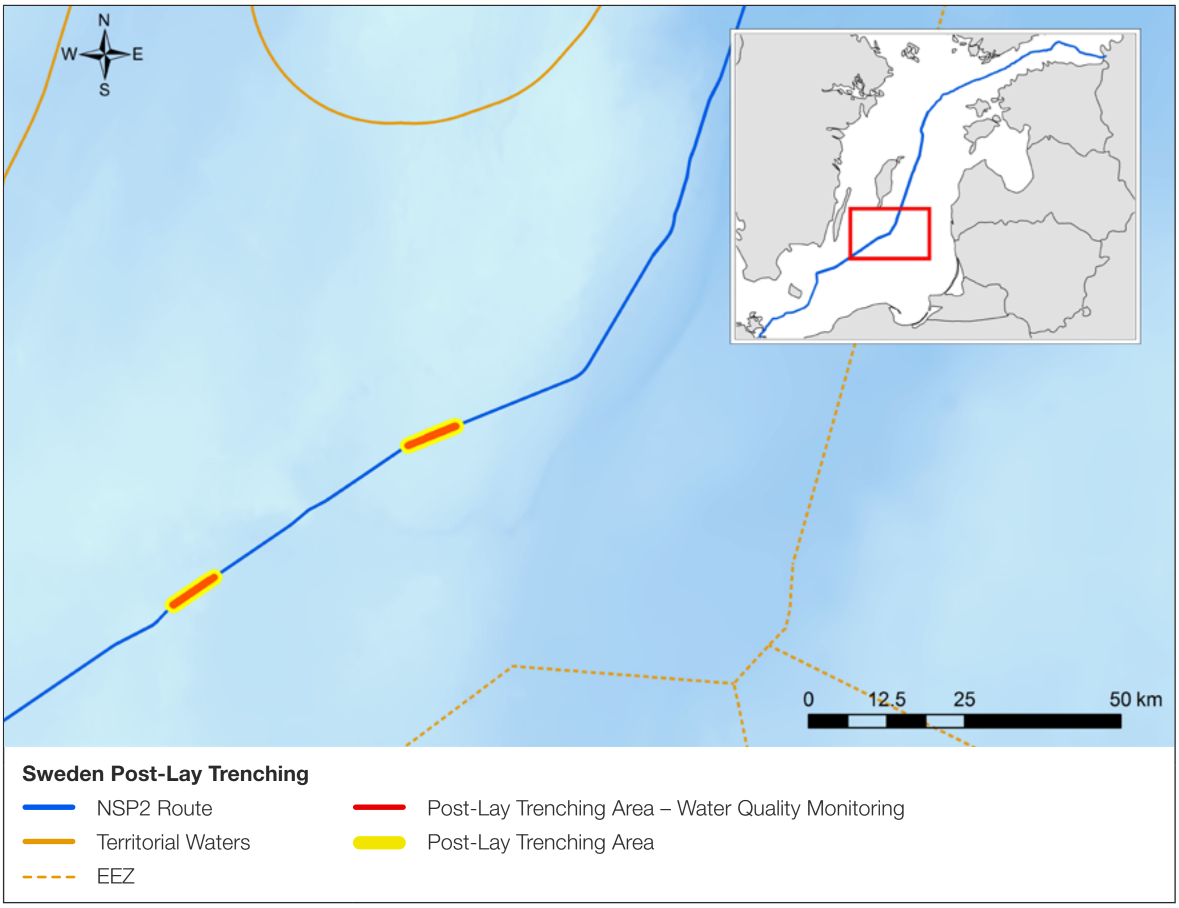


Figure 49. *Environmental monitoring associated with post-lay trenching.*

Monitoring of turbidity during post-lay trenching in Swedish waters showed that increased sediment concentrations in the water were limited to the close vicinity of the construction sites, which supports the results of mathematical modelling. No sediment plumes were identified near the protected Hoburgs bank and Norra Midsjöbanken (see Chapter 5.3.1). Monitoring of shipping confirmed that there was no hindrance to shipping traffic when post-lay trenching was being carried out (see Chapter 5.3.2). The trenching vessels followed the communication and reporting procedures that had been agreed with the shipping authorities. There were no accidents or incidents involving maritime traffic, including fishing vessels.

5.3.1 Marine water quality

Turbidity is a measure of suspended sediments in water columns. The purpose of the monitoring programme was to control and verify that the project's trenching activities did not result in high sediment concentrations (15 mg/l above the natural background values) reaching the valuable shallow Hoburgs bank and Norra Midsjöbanken, which are within the Natura 2000 area "Hoburgs bank and Midsjöbankarna".

If the alarm thresholds of turbidity in the water were exceeded and the near-bottom currents were in the direction of the banks, suitable mitigation measures were to be initiated. This could for example be: slowing down the speed of trenching, delaying the start of the next trenching section, pausing work awaiting lower turbidity levels or shifting the order of sections to be trenched.

METHODOLOGY

Measuring equipment was mounted on a submersible carousel during monitoring in the trenching zones. The carousel was towed at a height of five meters above the seabed behind the turbidity monitoring vessel during trenching. Data was immediately accessible to the surveyor who could take the appropriate mitigation measures if turbidity levels were excessive and the currents were in the direction of the banks. The carousel included nine water sampling bottles to allow sampling if and when the NTU numbers were at or above specific values.

Turbidity was measured in NTU (Nephelometric Turbidity Unit). However, the SSC (Suspended Sediment Concentration) is the value used when comparing the monitoring results with the threshold values in this control programme. To translate NTU to SSC, a conservative factor of 2 was used, hence 2 NTU = 1 SSC (1 mg/l).

The water samples were analysed in a laboratory and the SSC value calculated. This provides the verification of the actual correlation between NTU and SSC.

The monitoring vessel sailed transects through the sediment plume around the plough measuring turbidity as NTU. In the event of the alarm concentration limit near the trenching site being exceeded (> 35 mg/l–70 NTU), depending on the speed and direction of the current, control transects would immediately be performed between the pipeline and the nearest bank. An ADCP (Acoustic Doppler Current Profiler) was used to provide the speed and direction of the current in order to predict the movement of the sediment plume from the trenching activities.

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

The monitoring of turbidity was performed by DHI for Zone 1 and 2 in the two lines (A and B) respectively, between 5th November and 5th December.

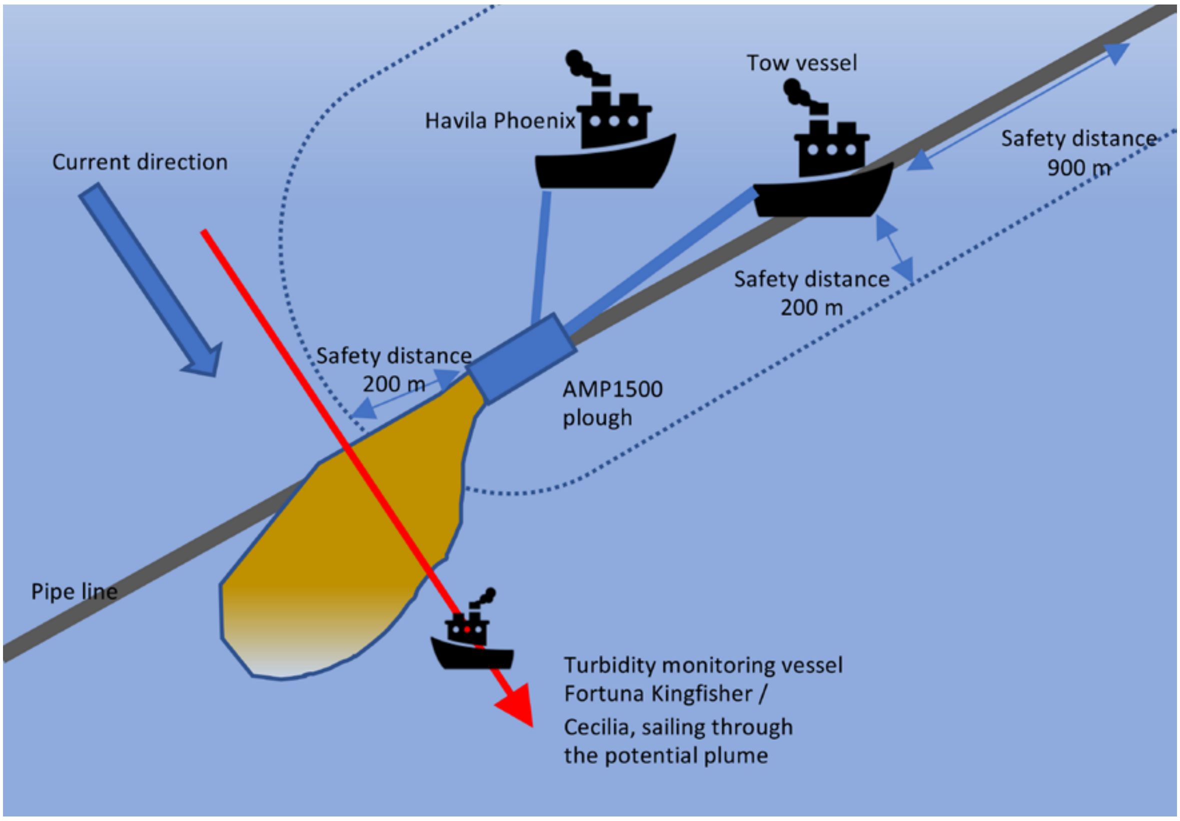


Figure 50. *Schematic overview of the monitoring of turbidity during trenching. Please note that the sediment plume is exaggerated for illustration purposes only. Image by DHI, 2020.*

RESULTS

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

There were no indications that high concentration sediment plumes would be able to reach the banks, with respect to both the currents and concentration of sediment in the plume directly behind the plough, with most values around 4–12 mg/l. The highest value behind the plough was at Zone 2 and was measured to be 24.7 mg/l, significantly below the alarm threshold value of 35 mg/l, and this with a weak current towards the north east, hence away from the bank areas. With a current of 2–10 cm/sec, it would take 13–14 hours for the plume to reach the bank north of the pipeline, and dispersion and dilution would lower the concentrations to background levels.

CONCLUSIONS

The monitoring of turbidity during trenching works in Sweden showed no indications of high concentration sediment plumes near the sensitive banks, with respect to both currents and the SSC in the plume directly behind the plough. Most values were between 4–12 mg/l, the highest value measured was 24.7 mg/l (Zone 2, Line B) during a weak current towards the north east (not toward the banks). The results are in line with previous assessments made in the environmental report and the NSP monitoring results.

To ensure that the background concentrations along the borders of Hoburgs bank and Norra Midsjöbanken were not rising, several background monitoring transects along these banks were performed. Background concentrations along the banks varied from 0.5–1.2 mg/l, regardless of when they were measured. This is verification that the trenching activities did not increase the concentration of sediment at the banks at any point.

5.3.2 Ship traffic

The purpose of the control and monitoring related to marine traffic in Sweden was to verify that the agreed efforts and measures to minimize the risk of collisions or other accidents (involving commercial shipping traffic and/or vessels carrying out trenching activities for the project) were implemented and that they were efficient.

The monitoring activities for maritime traffic focused on the information provided by NSP2 to the authorities, up-front as well on a day-to-day basis that the trenching vessels were in the areas they reported and that third-party vessels passing the trenching vessels respected the safety zone round the vessels.

METHODOLOGY

Monitoring activities focused on demonstrating that information has been provided to the authorities as agreed (Activity 1), that the construction vessels such as post-lay trenching vessels and monitoring vessels operated as intended (Activity 2) and that safe passage for third-party vessels was possible (Activity 3).

The safety zone round the trenching vessels was 700 metres. More details on the methodology is provided in Chapter 5.1.6.

RESULTS

Activity 1

Analysis of the correspondence between NSP2 and authorities/other stakeholders showed that NSP2 provided notifications (in an agreed format) to the authorities for trenching activities in time (one month before). In addition to those notifications, the authorities also received daily notifications from the trenching and monitoring vessels so that the authorities were kept informed about progress of the trenching and its completion.

Activity 2

Analyses of the AIS data showed that overall there was a good coherence between notification information and actual work performed.

The permit includes a commitment that NSP2's construction vessels should use a predetermined route between the shallow banks south of Gotland and use shipping lanes as far as possible to avoid birds being disturbed. The analysis of AIS data shows that there was a good adherence to this by the various construction vessels. Only some vessels that were involved in the trenching campaign did on some occasions deviate from using the pre-determined channel or official shipping lanes. However, this did not take place during the period when there was a high density of wintering birds in the area, so the potential effects of these few vessel movements were deemed insignificant.

Activity 3
The monitoring of third-party vessel movements showed that the safety zone around the trenching vessel and the towing vessel was respected and that no passing ships were within this zone at any time.

CONCLUSIONS
The monitoring of shipping during post-lay trenching in Sweden shows that there is overall a good coherence between notification information and actual work performed. The analysis of historical AIS data has proved that trenching vessels were moving where they reported to be and that official shipping lanes generally were used. The trenching vessels followed the communication and reporting procedures that had been agreed with the shipping authorities. There were no accidents or incidents involving maritime traffic, including fishing vessels. The impact on maritime traffic is thus confirmed as being minor, localised and of a short-term nature.

5.4 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 reshape the seabed locally 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 was planned for Russia, Finland, Sweden and Denmark (see Table 16). In 2019, rock placement took place in all of the four above countries.

Table 16. *Overview of monitored parameters during rock placement*

	Marine sediment quality	Marine water quality	Underwater noise	Birds	Marine mammals	Cultural heritage	Ship traffic
2019	R	R, F	S	R	R	D*, F*, R*	D, S, F**, R**

R – Russia; F – Finland; S – Sweden; D – Denmark
Notes:
* Cultural heritage chance find procedure in place – no monitoring required
** Ship traffic monitoring was not included in the monitoring programme. Ship traffic safety is ensured by compliance with relevant permit requirements.

Rock placement locations and the monitoring stations are shown in Figure 51.

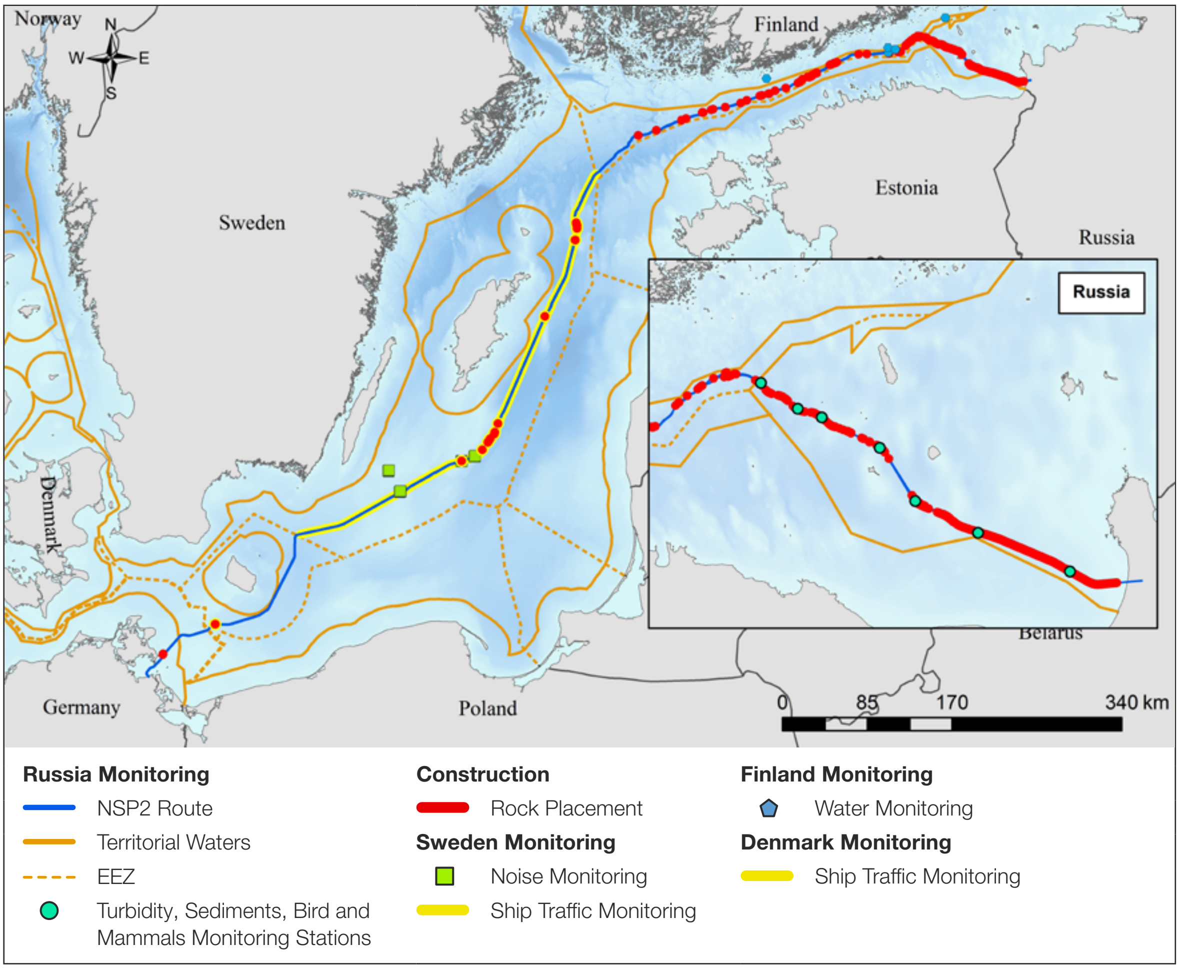


Figure 51. *Environmental monitoring associated with rock placement.*

Seabed sediment quality (see Chapter 5.4.1) and water quality (see Chapter 5.4.2) were not affected by the construction activities. Furthermore the measured pollutant concentrations, which were generally low, are not attributable to the Nord Stream 2 project and are in line with the literature data. Sea birds and marine mammals were not affected by the construction activities (see Chapter 5.4.4 and 5.4.5). Underwater noise from rock placement (see Chapter 5.4.3) was lower than or comparable to ship noise, with a comparable frequency spectrum and performed during a short period of time: underwater noise did not have an impact on marine mammals. Cultural heritage objects (see Chapter 5.4.6) were not disturbed during construction activities and no chance finds were discovered. Monitoring of shipping traffic (see Chapter 5.4.7) demonstrated that the rock placement vessels performed properly and safely. No incident reports have been produced from the rock placement vessels, meaning that third-party vessels did not intrude in the safety zones that had been set up for those vessels.

5.4.1 Marine sediment quality

The purpose of the monitoring was to ensure that resuspension of sediments due to rock placement would not cause an increase in marine sediment pollution. Marine sediment quality was monitored in Russia.

METHODOLOGY

Seven typical (or standard) monitoring locations were identified in the EIA based on modelling results. Those locations characterise sections of the pipeline route with similar hydrological and lithological conditions (see Figure 52).

According to water licence requirements, monitoring started at least one week prior to the start of the berm installation (with the exception of one station where, due to weather conditions, monitoring started on the same day as the rock placement activity) and was completed between 8–12 days after completion of the berm installation. All locations were monitored during line A free span corrections.

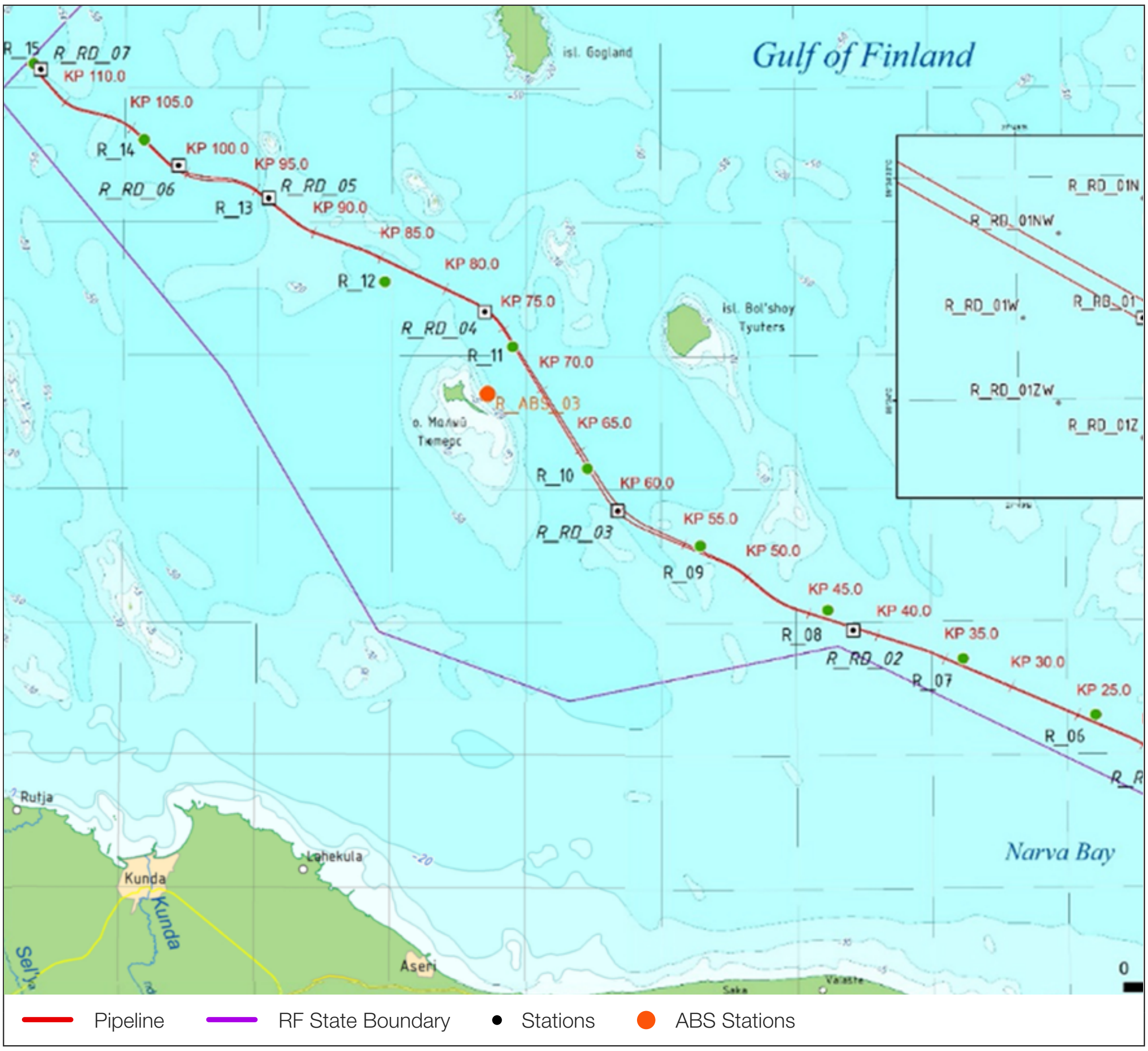


Figure 52. *Monitoring locations of sediment quality in Russia.*

RESULTS

Following analysis of the particle size distribution of bottom sediments samples, prevalent soil types are silty soils composed mostly of clayey and loamy fractions. The content of organic pollutants (oil products, benz(a)pyrene) in samples was found to be low.

The interval of recorded concentrations of heavy metals was comparable with relevant regional baseline values given in the "Atlas of geological and environmental-geological maps of the Russian sector of the Baltic Sea". Calculation of total pollution indexes (Zc, see Chapter 5.1.1). In relation to the baseline values taken from the literature, the results of the environmental baseline survey 2015–2016 and the baseline monitoring confirmed the absence of any contamination and led to the classification of the bottom sediment contamination level as "low polluted", in accordance with the criteria set out in SanPiN 2.1.7.1287–03.

Although the comparison of these results with the relevant regional standards /16/, taking into account recalculation to normalized bottom sediments, also confirms the absence of contamination in most sediment samples taken during the final monitoring, local peaks of zinc, cadmium, nickel, iron and manganese concentrations were recorded at the following locations:

- RD_04, RD_06 – during baseline survey (10 days prior to rock placement) attributed to Class I "low contaminated";
- RD_03, RD_06 – at final stage attributed to Class I "low contaminated";
- RD_02 – during baseline survey attributed to Class II "Moderately contaminated", but later increased to Class III "Highly contaminated".

Therefore bottom sediment monitoring during the performance of rock placement revealed rather wide variations in heavy metal concentrations and local instances of maximum concentrations at individual stations. This was not assessed to be as a result of any anthropogenic impact. Most likely it had been determined by the following two factors:

- Peculiarities of granulometric composition of bottom soils at these stations. Thus, bottom sediments at RD_03 and RD_02 were composed of clayey and silty material – more than 98% and 60% respectively. As a rule, bottom sediments of heavy granulometric composition are richer in microelements compared to sandy and loamy sediments. At the same time, the "Atlas of geological and environmental-geological maps of the Russian sector of the Baltic Sea" represents average data on the geochemical baseline for heavy metals covering the entire spectrum of the bottom sediments of the eastern part of the Gulf of Finland, with various particle size distribution patterns – from sandy to clayey;
- The possible presence of ferromanganese concretions, which are widespread in the Gulf of Finland, in the bottom sediment samples. According to the literature /33/, /34/, ferromanganese concretions accumulate manganese and iron, as well as a wide range of accompanying macro – and micro-elements, including P, Ca, Co, Zn, Ni, As, Pb and others, with varying degrees of intensity. As a result, local concentrations of these metals may be dozens of times higher than average regional baseline values.

CONCLUSIONS

Analysis of seabed sediments showed that in general levels of organic pollutants and heavy metals in seabed sediments were comparable with the baseline values and literature data from the region confirming absence of contamination in most sediment samples. However, a number of samples showed increased levels of heavy metals concentrations which may be a result anthropogenic activities, peculiarities in granulometric composition of the sediments as well as generally wide spread presence of ferromanganese concretions typical for the region.

5.4.2 Marine water quality

Water quality was monitored during rock placement in Russia and in Finland. In Russia the purpose of monitoring was to ensure that natural turbidity levels have not been affected when gravel berms were installed along the pipeline route to correct free spans. In Finland only long-term monitoring at the control stations and at the Sandkallan protected area (protected for its reefs habitat) took place in 2019; monitoring of individual berms was completed in 2018.

METHODOLOGY

Russia

Seven typical (or standard) monitoring locations were identified in the EIA based on modelling results. Those locations characterise sections of the pipeline route with similar hydrological and lithological conditions (see Figure 52).

According to water licence requirements, monitoring started at least one week prior to the berm installation (with the exception of one station where, due to weather conditions, monitoring started on the same day as the rock placement activity) and was completed between 8–12 days after completion of the berm installation. All locations were monitored during line A free span corrections.

Turbidity was measured by standard sampling in three horizons and by optical sensor within vertical profiling. Sampling and profiling were provided in 10 sub-locations):

- in eight quadrants around the vessel performing rock placement, at a distance of 500 metres (i.e. north,north-east, east, etc);
- directly at the vessel's position after completion of the work and the vessel's departure;
- in the event of a turbidity plume being detected, samples were taken along its length up to a distance of 1,000 metres or more from the vessel.

Finland

In 2019 in Finland, water quality was monitored at the three long-term monitoring stations: two control stations located along the coast, far away from any construction activities, and at the Sandkallan protected area, Natura area protected for its reef habitats and close to which different construction activities took place. Monitoring at these locations started in April 2018 and continued throughout 2019.

At Sandkallan a triple monitoring array was used in a triangular configuration around the southern border of the protected area and each array measured salinity, temperature, oxygen and turbidity at three water depths (2, 5 and 15 metres above the seabed). In addition, one array was equipped with an ADCP current profiler that measures current speed and direction through the water column. Only one monitoring array was installed at the control stations.

RESULTS

Russia

The monitoring during rock placement showed that water turbidity varied in the range from < 1.0 to 5.6 FTU. Higher turbidity values were characteristic mostly of the surface layer and were determined by hydrobiological factor.

Monitoring did not confirm the existence of any impact of the berm installation on seawater turbidity at six of the seven stations. A possible impact revealed at one station was short-lived, (it was not detected in the final stage of monitoring – ten days after the event) and had not lead to the exceedance of the MPC established for suspended solids content in commercial fishery water bodies (see Table 17)

Based on the EIA modelling, it was assessed that the area affected by particular rock placement session would be limited to 2,400 × 2,400 metres. The “plume” of suspended solids generated by rock placement would be drifting in the bottom layer. The maximum distance a “plume” would have to travel before suspended solids concentration could fall below 10.0 mg/l (MPC for commercial fishery water bodies) was calculated as 886 metres.

Based on the results of the monitoring performed at seven locations during rock placement, the concentration of suspended solids in the bottom layer exceeded 10.0 mg/dm³ only at one point – at the station RD_04 (O), which was located at a distance of 500 metres from the rock berm (see Table 17).

None of the measurement points located at a distance of 1,000 m from the rock berm showed the concentration of suspended solids exceeding 2.0 mg/dm³. Therefore, based on the results of the monitoring, it can be concluded that suspended solids content in the bottom layer did not exceed the estimated values.

Table 17. *Turbidity measurements results for the station RD_04*

Horizon	Indicator	Turbidity, FTU			Suspended solids, mg/dm³		
	Survey stage:	before	during	after	before	during	after
Surface	Average	1.5	2.4	1.3	1.1	1.1	4.1
	Min	< 1.0	1.0	< 1.0	0.5	0.6	0.6
	Max	2.2	5.6	1.8	2.8	1.6	14.3
	1000m		2.3			0.6	
Intermediate	Average	–	1.2	–	0.8	1.1	1.2
	Min	< 1.0	< 1.0	< 1.0	< 0.5	0.6	0.6
	Max	1.0	1.6	2.5	1.4	1.5	2.1
	1000m		1.4			0.9	
Additional*	(North)		1.4			0.9	
	(South)		1.0			3.0	
Bottom	Average	–	1.4	–	0.7	3.5	1.5
	Min	< 1.0	< 1.0	< 1.0	0.5	0.6	1.0
	Max	< 1.0	2.4	2.7	1.1	**14.0***	2.1
	1000m		2.0			0.7	

* Additional sampling was carried out for the sub location in horizons, where deviations were detected via optical sensors

Finland:
No impacts from construction activities were detected in water quality at the long-term monitoring sites Control 1, Control 2 and Sandkallan during 2019. However, slightly increased turbidity up to 10 FNU was observed at the deeper monitoring stations of the Sandkallan site in July–August (see Figure 53). This was connected to anoxic conditions, in which iron and manganese are soluble in water. When the anoxic water meets first traces of oxygen, iron and manganese start to form insoluble oxides observed as turbidity. The strong halocline measured at this station prevents the transport of oxygen from the surface water leading into anoxic conditions recorded regularly below the depth of 60 metres.

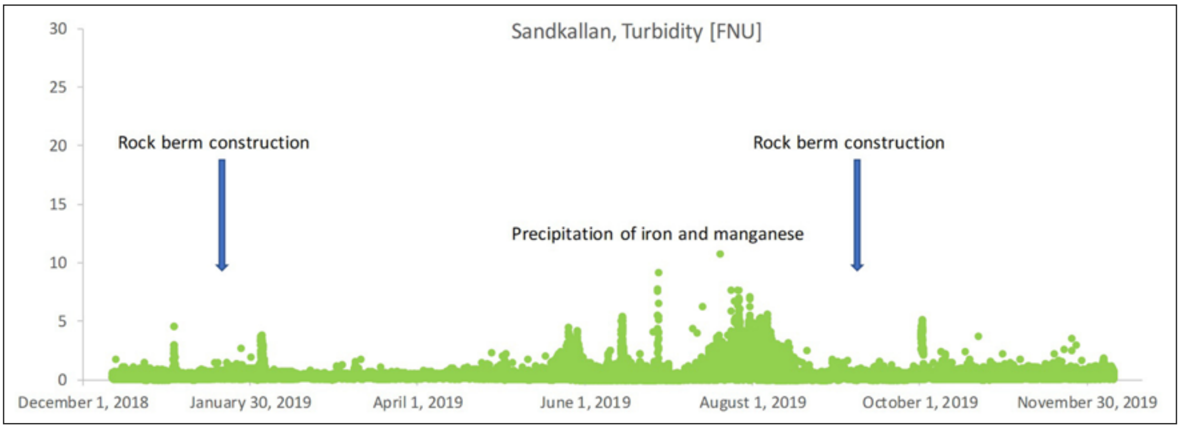


Figure 53. *Turbidity measured at the three Sandkallan stations in 2019. Three rock berms were constructed within the radius of 10 km of the monitoring stations, indicated by blue arrows; two on January 7 and January 9 (only one arrow due to scale), the third on September 6. In summer, turbidity caused by precipitation of iron and manganese was observed.*

CONCLUSIONS

There were very limited, if any impacts on water quality attributable to rock placement activities in Russia and in Finland. In Russia water turbidity increases in the neighbourhood of gravel berm installation were recorded only by optical sensors and only in the bottom layer. It was not confirmed by any other instrument measurements. Impact on the content of suspended solids in the bottom layer was only local and short-lived and did not exceed the expected magnitude. In Finland, no increased turbidity attributable to construction activities was recorded in the proximity of the Sandkallan protected area.

5.4.3 Underwater noise

Due to concerns about disturbing the behaviour and masking effects on harbour porpoises, monitoring of underwater noise (during rock placement work in Sweden) has been conducted to further verify the conclusions in the Environmental Study and expert opinions presented during the public referral, regarding the potential impact of NSP2 construction activities on harbour porpoises in the Natura 2000 area.

METHODOLOGY

Monitoring of underwater noise during rock placement was carried out applying the same methodology that was used to monitor underwater noise during pipelay. For further information, please refer to Chapter 5.1.2.

RESULTS

As mentioned in Chapter 5.1.2, noise from passing vessels ranged from 165.9–192.5 dB re 1 µPa over all stations and deployments. Most passages however were detected and analysed at station A, where a major marine traffic route passes close by.

Rock placement was recorded by two instruments at station D. The computed source level for rock placement reached 180(± 3) dB re 1 µPa and thus remained below the source levels for pipelay (see Chapter 5.4.2) and in the range of passing vessel noise (165.9–192.5 dB re 1 µPa).

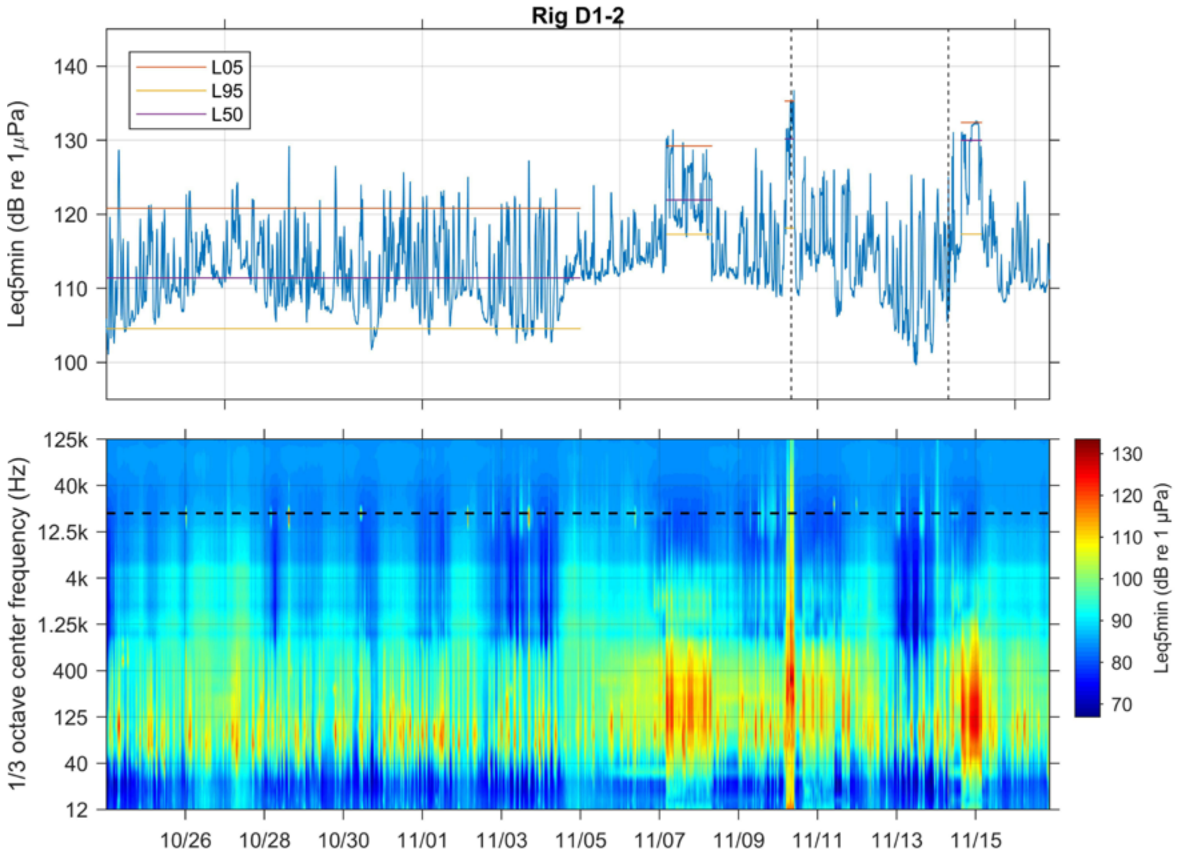


Figure 54. *Rock placement took place on the 10th of November which caused a short peak of noise.*

CONCLUSIONS

Underwater noise from rock placement was lower than or comparable to ship noise, with comparable frequency spectrum and performed during a short period of time.

All in all, the observations support the assumptions on which the original assessment was made, indicating that with respect to harbour porpoises the integrity of the Natura 2000 site was not compromised by rock placement work.

5.4.4 Birds

Bird observation was performed during each offshore field monitoring campaign and is therefore not associated with a specific construction activity. Impacts on birds are therefore summarized in the section dedicated to pipelay (see Chapter 5.1.3).

5.4.5 Marine mammals

Marine mammal observation, similar to bird observation, was performed during each offshore field monitoring campaign and is therefore not associated with a specific construction activity. Impacts on marine mammals are therefore summarized in the section dedicated to pipelay (see Chapter 5.1.4).

5.4.6 Cultural heritage

According to the countries' monitoring programmes, a survey of known cultural heritage objects was required prior to and after the construction activities in Sweden and in Finland. In Denmark, the monitoring programme focuses on the identification and management of chance finds during construction and operation of the NSP2 pipelines.

In addition, a cultural heritage chance find procedure was in place in all countries where rock placement took place, namely Russia, Finland, Sweden and, as already mentioned, Denmark. During rock placement, no unknown cultural heritage objects were found.

In Finland, monitoring of cultural heritage prior to the construction activities took place in 2018 and is therefore not covered in this report. Monitoring of Cultural Heritage in Denmark and in Sweden is discussed in Section 5.1 Pipelay.

5.4.7 Ship traffic

Ship traffic was monitored during rock placement activities in Sweden and Denmark. In Finland and Russia monitoring of ship traffic is not included in the monitoring programme: NSP2 however ensured that it would be compliant with requirements related to ship traffic, such as safety zones, which were defined in accordance with the local authorities. Such compliance is described in the Annual report in Finland /35/ and in notices to mariners and reporting to relevant authorities in Russia.

In general, the monitoring of ship traffic in Denmark and Sweden followed the same approach and methodology. For Denmark, monitoring of ship traffic is discussed in Chapter 5.1 Pipelay; the following chapter discusses the monitoring of ship traffic associated with rock placement in Sweden.

METHODOLOGY

Monitoring activities focused on demonstrating that information has been provided to the authorities as agreed (Activity 1), that the construction vessels such as the rock placement vessels operated as intended (Activity 2) and that safe passage for third-party vessels was possible (Activity 3).

The safety zone round the rock placement vessel was 500 metres. More details on the methodology is provided in Chapter 5.4.6.

RESULTS

Activity 1

The analysis of the correspondence between NSP2 and the authorities showed that the authorities were informed about all rock placement activities following the agreed procedure, both for daily notification from the vessel as well as monthly construction updates. It was agreed that NSP2 would provide monthly reports to the authorities to keep them informed about planned activities four weeks in advance. NSP2 would also send authority notifications from the vessels 24 hours before they entered the Swedish EEZ or 48 hours before the actual work started.

Activity 2

Monitoring of ship traffic in AIS data was used to document proper and safe behaviour of the rock placement vessels. Rock placement activities matched the AIS data for the rock placement vessels as reported by Nord Stream 2 AG.

The analysis of historical AIS data has proved that rock placement vessels were moving at a significant distance from the banks and that official shipping lanes generally were used.

Activity 3

AIS data for commercial ships have been gathered and analysed to show ship tracks from the commercial vessels when passing the safety zones round the rock placement vessels. The observed ship tracks from the commercial ships showed that the commercial ships were able to recognise the rock placement vessels and their safety zones in due time to plan their journey safely around the rock placement vessels.

CONCLUSIONS

No incident reports have been produced from the rock placement vessels, meaning that third-party vessels did not intrude in the safety zones for those vessels.

6 Post-construction monitoring – Germany

No offshore construction requiring environmental monitoring took place in Germany in 2019. Therefore, all monitoring activities in German waters in 2019 were regarded as post-construction monitoring.

Documentation of the environmental conditions after completion of the offshore construction work (dredging and pipelay) serves the purpose of monitoring the restoration quality of the habitat types as defined by the EU Habitat Directive. It is also implemented to verify the predicted seabed intervention footprint. After completion of offshore construction, a high-resolution multi-beam survey was conducted ±50 metres either side of the trenches in June 2019, in order to verify the seabed bathymetry as well as the reinstatement quality of reef sections. The bathymetry survey will be repeated once annually until 2022 in order to evaluate the stability of the trench backfill/habitat reinstatement.

Furthermore NSP2 monitors the regeneration of the impaired habitat types under the EU Habitats Directive in Greifswald Lagoon and Pomeranian Bay from 2019 until 2022, in order to show that regeneration will be completed within the predicted period of about four years. The prediction was based on results of the Nord Stream Monitoring Programme 2006/7 (baseline) and Nord Stream recovery monitoring 2011–2016 results /36/.

Beside the monitoring of benthic habitats, monitoring programmes for marine mammals and seabirds were continued in 2019. Surveys of grey seals, harbour porpoises and wintering seabirds aim to follow their local population trend after offshore construction. The duration of these surveys differed among species since the potential effect in terms of quality and duration was species-specific.

All monitoring investigations followed the national offshore EIA standard STUK4 /37/. Since this German national standard for environmental offshore investigations was already applied during the Nord Stream Monitoring Programme, some trend analysis meanwhile cover a period of 14 years.

An overview of monitoring parameters during the post-construction surveys and their locations are shown in Table 18 and in Figure 55.

Table 18. *Overview of monitored parameters post construction monitoring in Germany.*

	Bathymetry	Marine sediment quality	Benthos	Marine mammals	Birds
2019	G	G	G	G	G

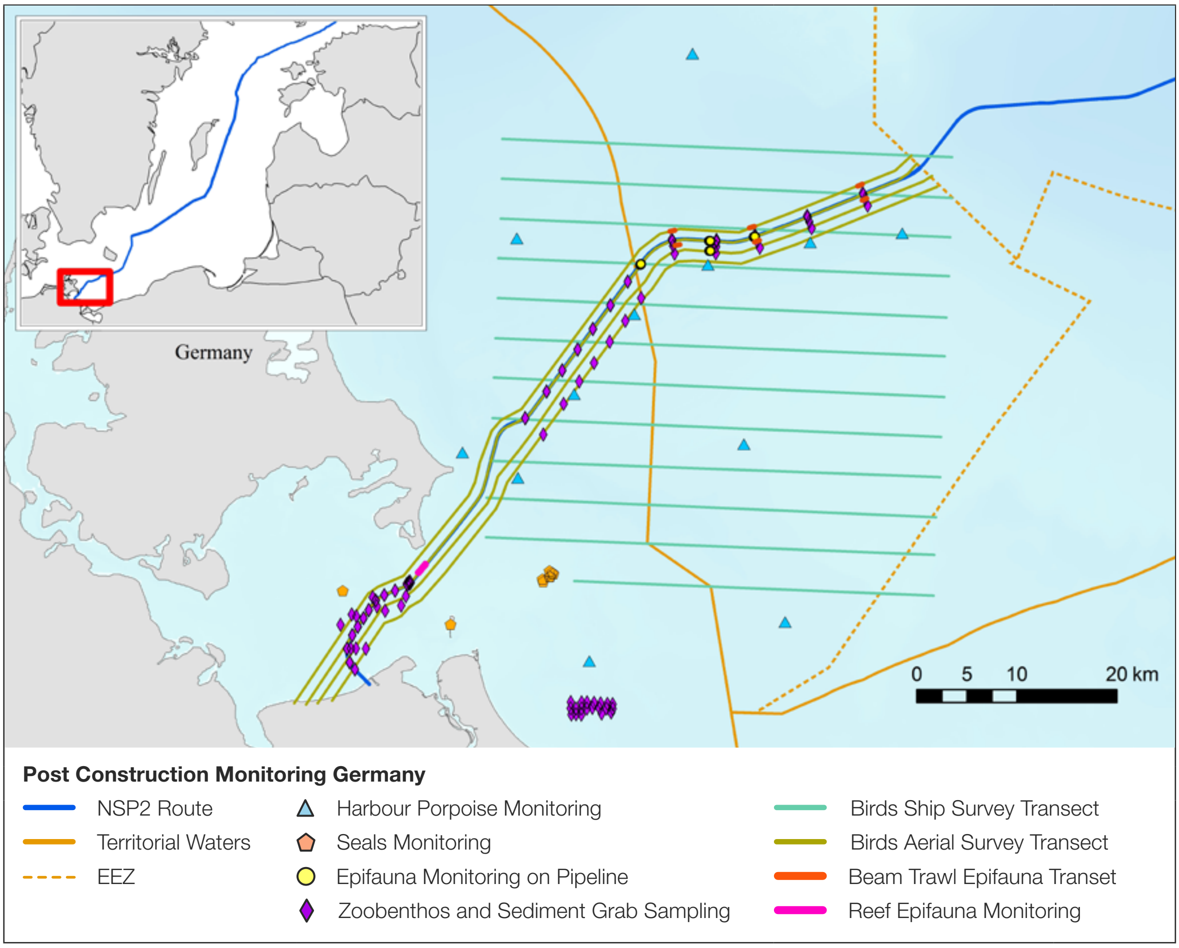


Figure 55. *Post-construction monitoring locations in 2019 in Germany.*

Post-construction monitoring undertaken in German waters showed that the impact on the seabed due to construction (dredging, pipelay, and backfilling) was in line with the assessment (see Chapter 6.1.1). Exclusive use of backhoe dredgers during dredging inside protected Natura 2000 habitats proved to be a successful mitigation measure allowing minimisation of spatial footprint. No contamination of the seabed sediments was observed (see Chapter 6.1.2). The forecast insignificant eutrophication effect through temporary mobilisation of phosphate during works leading to sediment disturbance was lower than assessed. Analysis of benthos (see Chapter 6.2.1) revealed an early stage of reinstatement for all benthic communities. Monitoring of seabirds (see Chapter 6.2.3) and marine mammals (see Chapter 6.2.2) showed that there were no permanent impacts on their abundance and distribution during the first year after construction.

6.1 Monitoring of abiotic environment

6.1.1 Bathymetry

High-resolution multi-beam surveys were conducted in 2016 as part of the technical planning phase and again prior to start of construction in spring 2018. Daily bathymetry surveys provided one of the most important quality control measures for offshore construction during dredging, pipelay and backfilling, in order to ensure the technical design parameter and to implement the planned environmental mitigation measures (minimisation of footprint and reef reinstatement). In spring 2019 a first post-construction survey was conducted to verify the quality of trench reinstatement (vertical tolerances and reefs) and to balance the spatial footprint of the extensive seabed intervention works.

METHODOLOGY

Balancing the seabed intervention footprint

The impact area was balanced by comparing high-resolution survey data obtained prior to start of construction, after trenching and again after backfilling of trenches, respectively. Difference plots were computed by application of a GIS to identify vertical alterations > ± 20 cm in seabed bathymetry (post – versus pre-construction). Computed areas of change were assigned to trench sections, protected Natura 2000 habitat types, and Natura 2000 sites, respectively. Classed footprint areas were compared to spatial footprint predictions made in the application documents /38/. In addition, a series of 40 alignment charts was computed for visualisation of status quo of seabed reinstatement.

RESULTS

The predicted spatial footprint of trenches in German territorial waters was estimated at 137 ha. The predicted spatial footprint of the temporary sediment storage area off the island of Usedom in German territorial waters was estimated at 310 ha. The post-construction GIS analysis revealed a realised spatial footprint of trenches in German territorial waters of 174 ha and a spatial footprint of the temporary sediment storage area off the island of Usedom in German territorial waters of 235 ha, respectively. Hence, the overall footprint was slightly smaller than predicted. The total footprint of trenches inside protected Natura 2000 habitats almost matched the forecast: 51 ha affected versus 47.5 ha predicted.

All reefs were reconstructed as planned by placing autochthonous glacial stones and pebbles on top of backfilled trenches (see example in Figure 56).

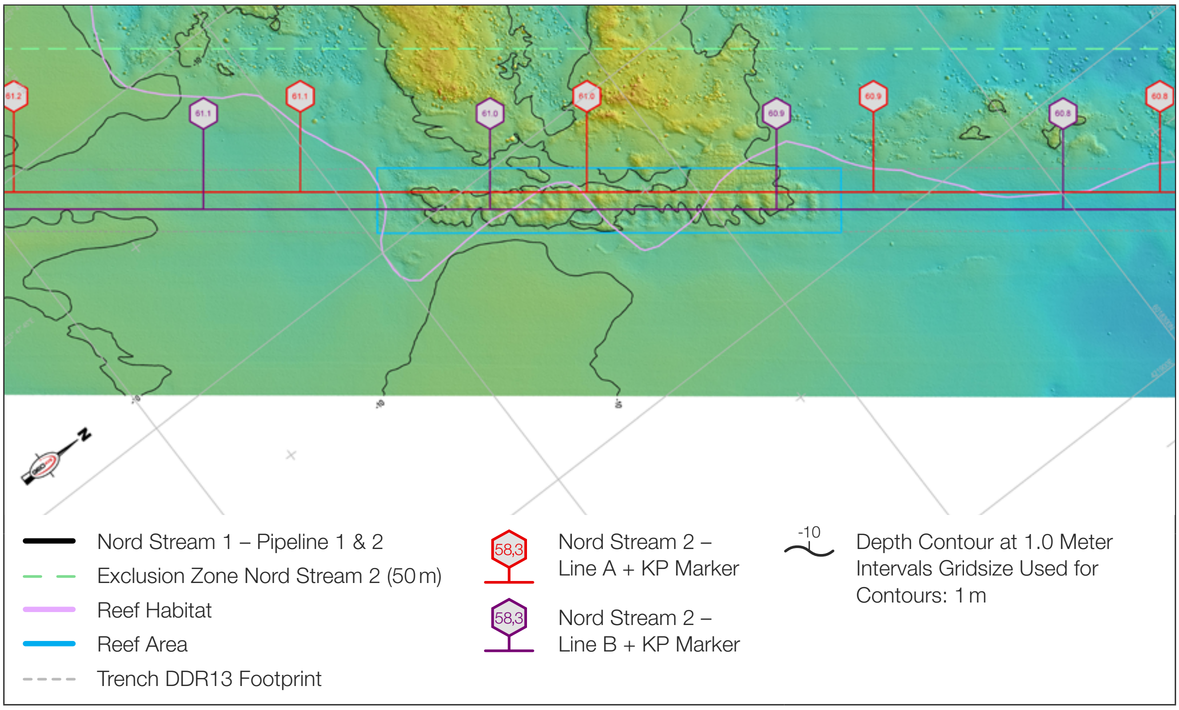


Figure 56. *Example of an alignment chart for the visualisation of reef reinstatement after dredging, pipelay and backfilling in the Pomeranian Bay.*

CONCLUSIONS

The bathymetry monitoring revealed that the seabed impact due to dredging, pipelay and backfilling matched the predictions of the technical plan. Especially the exclusive use of backhoe dredgers during dredging inside protected Natura 2000 habitats can be concluded to have been a successful mitigation measure (minimisation of spatial footprint).

According to the experience from the NSP Project, it is expected that fauna and flora of the entire impacted seabed area will recover within about two to four years. No permanent impact will remain. Pre-conditions for a successful recovery of reef fauna are properly set.

6.1.2 Marine sediment quality

To evaluate geophysical sediment parameters (median grain size, silt content, loss on ignition), 276 sediment samples taken by means of a van Veen grab will be collected annually in spring along with macrozoobenthos samples from 2019–2022 (see Figure 55). In addition, a number of chemical sediment parameters (nutrients, trace metals as well as organic pollutants) were analysed for 41 samples taken in 2019 in order to verify if any chemical pollution of surface sediments occurred as a result of dredging and pipelay works. Furthermore, sediment properties are visually characterized according to DIN EN ISO 14688-1 and recorded in field protocols.

METHODOLOGY

Physical sediment parameters

Grain size distribution will be determined according to DIN EN ISO 17892-4 (mesh sizes according to DIN ISO 3310-1, Part 1). The particulate organic matter content of the sediment will be determined by loss on ignition according to a method established by the German Federal Institute for Hydrology. This methods differs from DIN 18128 to the extent that the sediment is ignited for 3 hours at 485 °C (instead of 1 hour at 550 °C). This routine will be applied due to a common high portion of carbonates in marine sediments which oxidize at temperatures above 500 °C and thus would lead to an overestimation of the particulate organic matter content.

Chemical sediment parameters

Chemical parameters of sediment samples were analysed in an accredited laboratory. The constant engagement of the same accredited laboratory since 2006 guarantees that the lab routines are identical to those employed earlier by NSP and NSP2. Sediment analysis followed German laboratory standards for the assessment of dredged material /39/.

The trace metals arsenic, lead, cadmium, chromium, copper, nickel, mercury and zinc were determined for the very fine grain fraction < 20 µm. In addition, concentrations of copper and nickel were analysed also for the total fraction (< 2 mm).

Organic pollutants were measured for the total fraction (< 2 mm). Organic pollutants investigated comprised polycyclic aromatic hydrocarbons (PAH according to EPA), organochlorine pesticides, the sum of organic chlorine pesticides, pentachlorobenzene, polychlorinated biphenyls (PCBs) and organotin compounds.

Furthermore, nutrient contents – total phosphorus and total nitrogen – of the total fraction (< 2 mm) was measured. An elution test according to DIN 38414-S4 determined the leaching or mobility of pollutants within sediment samples. Moreover, the concentrations of total phosphate (P), ammonium-nitrogen and nitrate-nitrogen in the pore water was measured. The toxicity of the sediment elution was tested with a luminous bacteria test.

RESULTS

Physical sediment parameters

Beside the restoration of seabed bathymetry an appropriate reinstatement of the physical sediment parameter (both reefs and soft sediments) is the most important pre-requisite for a fast recovery of the benthic fauna and flora.

In spring 2019, median grain size of the surface sediment layer (inhabited by benthic invertebrates) of the backfilled trenches did not differ from the untouched surrounding, neither inside Greifswald Lagoon nor in Pomeranian Bay (see example in Figure 57). The portion of silt was similar between impact and reference sites as well. Hence, the dredge and backfill plan was successfully implemented during construction. Only the particulate organic matter content was lower in the top layer of the trench sediment inside Greifswald Lagoon in spring 2019 (see Figure 58). This effect was predicted as a result of turbidity through sediment handling. According to the results of the NSP Recovery Monitoring Programme 2011–2016, particulate organic matter will be progressively re-imported through bedload transport and bioturbation within two years after construction.

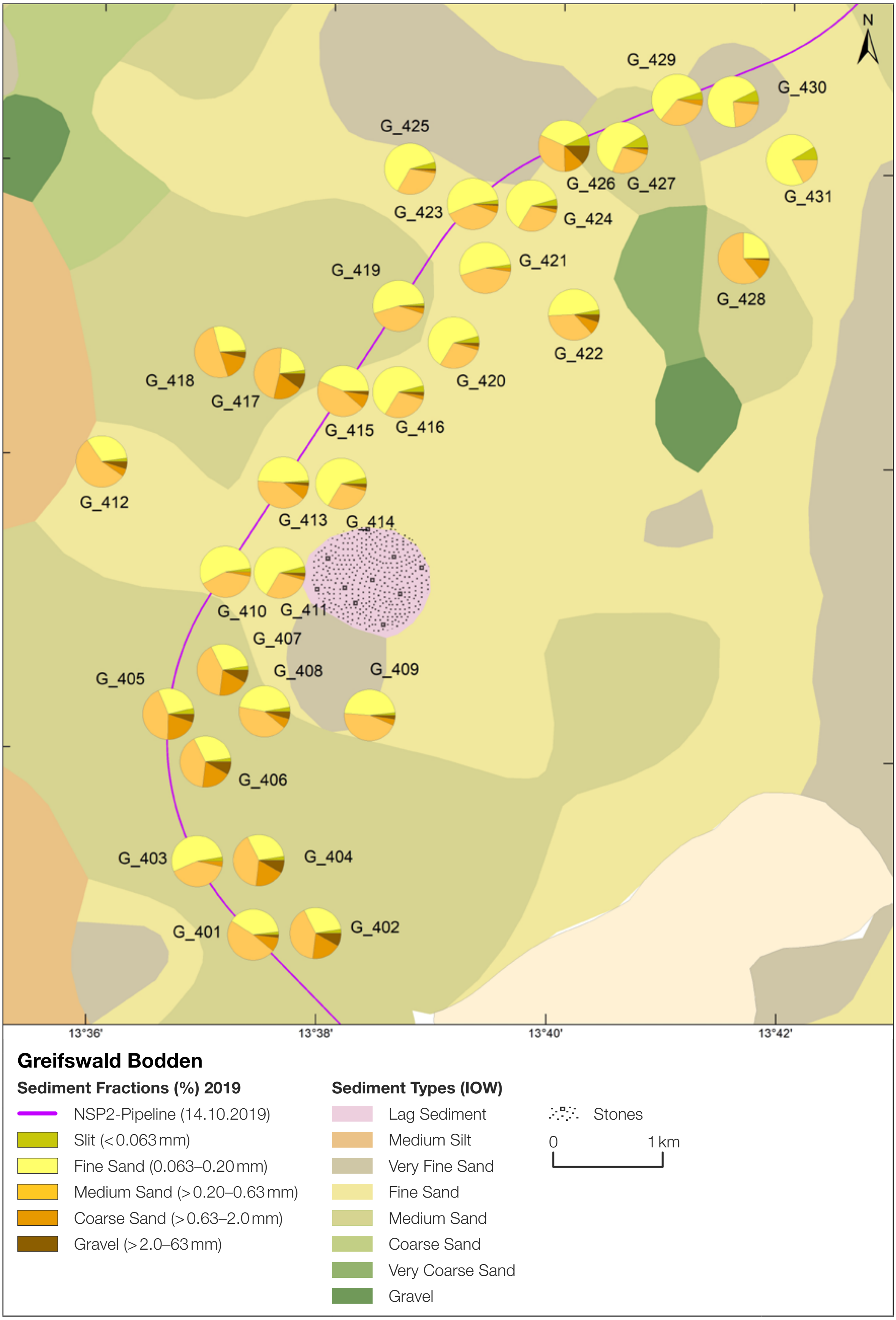


Figure 57. *Pie charts of sediment grain size composition of surface sediments inside Greifswald Lagoon (trench, near trench surrounding, and reference sites, respectively; 93 samples).*

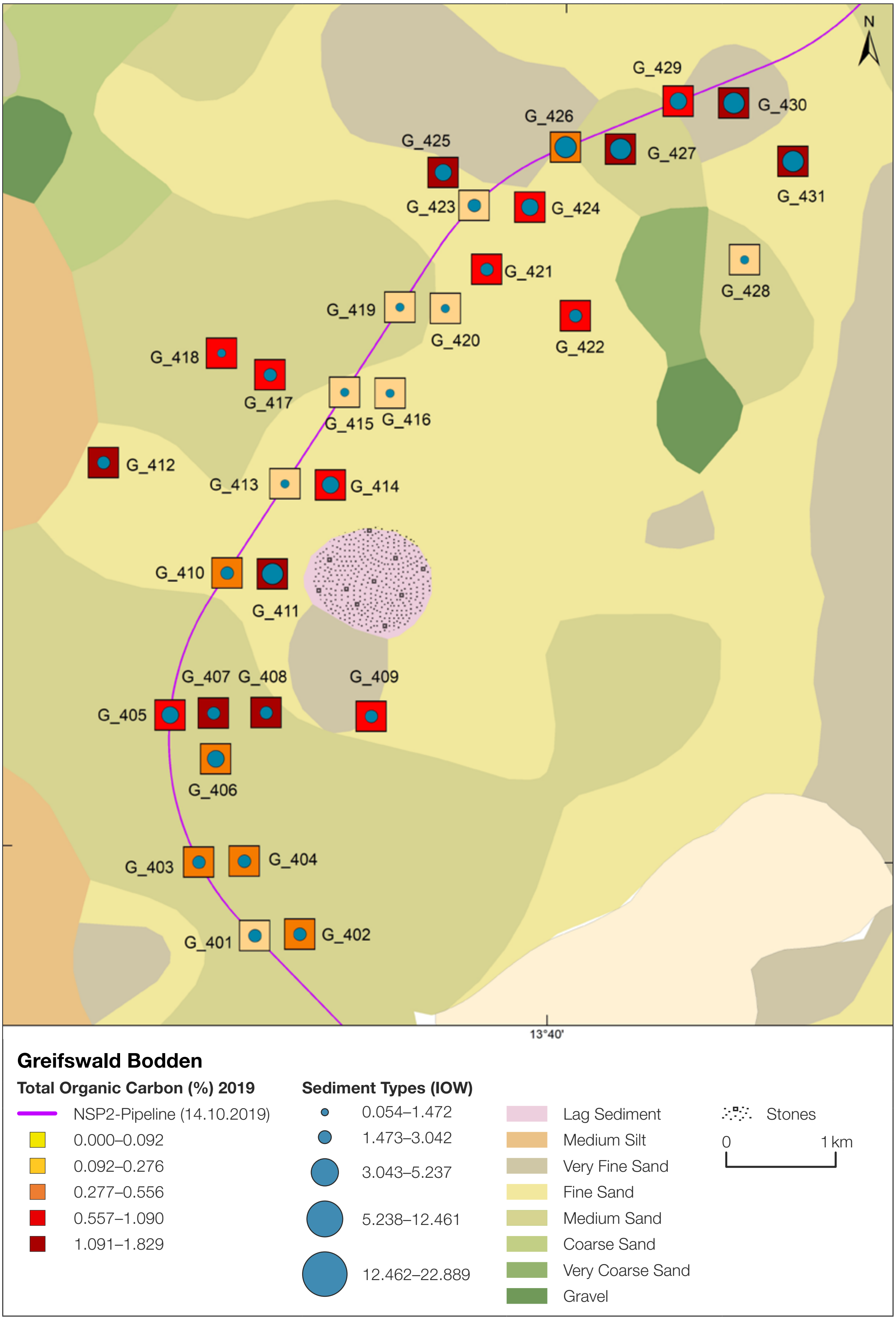


Figure 58. *Silt content and particulate organic matter content of surface sediments inside Greifswald Lagoon (trench, near trench surrounding, and reference sites, respectively; 93 samples).*

Geochemical sediment parameters

Geochemical analysis of 41 sediment samples from spring 2019 did not reveal any significant differences in nutrient content (nitrogen, phosphorus – total and eluate). The similarity in phosphorus concentration between impact and reference sites provides an *a posteriori* indication of a very low remobilisation of phosphate bound in the seabed through sediment handling. Already the turbidity monitoring during seabed intervention works in 2018 revealed that dredging inside Greifswalder Bodden only by backhoe dredgers significantly lowered the extension of turbidity plumes. The overall suspended volume was about 0.5 million m^3. Compared with the NSP offshore installation works in 2010, this represented a reduction in overall turbidity of 50%.

Concentration of trace metals and organic pollutants did not exceed GÜBAK-threshold values indicated for contaminated sediments. Most compounds of organic pollutants stayed below detection limits. This was also the case for medium-size hydrocarbons.

Similarity of pollutant concentrations between backfilled trenches and untouched reference sites in spring 2019 after pipeline installation indicates the success of two mitigation measures:

1. avoiding routing the pipeline through muddy sediments (very low particulate matter content that could be lost through re-suspension, very low pollutant concentration);
2. use of backhoe dredgers for excavation of trenches inside Greifswald Lagoon (significant local reduction of turbidity).

Trend analysis of trace metal concentration in surface sediments inside Greifswald Lagoon from 2007–2019 do not show any changes over time (see Table 19).

Table 19. *Mean concentration of trace metals (mg/kg dry weight) in surface sediments inside Greifswald Lagoon (analysis of the particle fraction <20µm only).*

Trace metal	2007 (n=10)	2011 (n=10)	2016 (n=22)	2018 (n=14)	2019 (n=26)
Arsenic	14.1* (10–19)#	11.3 (6.8–16)	17.9 (11–25)	16.6 (5.5–25)	10.8 (3.6–21)
lead	57.7 (43–81)	44.8 (24–84)	56.8 (41–72)	50.9 (17–73)	35.7 (9–81)
Cadmium	1.13 (0.8–1.7)	0.94 (0.4–1.9)	1.61 (1.2–2.2)	1.17 (0.88–1.6)	0.88 (0.16–2.1)
Chrome	28.6 (22–38)	33.5 (17–63)	40.8 (29–54)	34.1 (24–52)	31.0 (7.8–91)
Copper	44.7 (32–57)	36.7 (22–54)	28.9 (20–60)	32.6 (24–48)	32.3 (6.6–81)
Nickel	36.6 (26–62)	27.8 (17–44)	31.0 (23–47)	30.9 (23–39)	30.6 (6.8–88)
Mercury	0.25 (0.15–0.38)	0.09 (0.06–0.11)	0.18 (0.12–0.23)	0.19 (0.13–0.24)	0.25 (0.06–0.72)
Zinc	202 (150–290)	186 (110–290)	213 (160–270)	176 (130–220)	128 (33–260)

* mean, # min–max

Trend analysis of medium-size hydrocarbons in surface sediments inside Greifswald Lagoon from 2007–2019 revealed that the temporary peak concentration observed after installation of NSP in 2011 did not re-occur after installation of NSP2 in 2019 (see Table 20). This difference may result from the substitution of all grease and hydraulic oils liable to come into contact with sea water with biodegradable environmentally acceptable lubricants (EAL) after the accidental release of grease in May 2018 at the start of offshore construction.

Table 20. Mean concentration of medium-size hydrocarbons (C10–40; mg/kg dry weight) in surface sediments inside Greifswald Lagoon (total fraction).

pollutant	2007 (n=10)	2011 (n=10)	2016 (n=22)	2018 (n=14)	2019 (n=26)
Medium-size HC (C10–40)	30.9* (10–93)#	208 (121–313)	<20	28.2§ (<20–59)	21.5§ (<20–48)

* mean, # min–max
§ consideration of detection limit of 20 mg/kg dry weight for all samples as a minimum.

In the vicinity of the temporary sediment storage area off the island of Usedom, some reduction in trace metal concentration was observed in 2011 after NSP installation and again after NSP2 installation in 2019 (see Table 21). Most likely, these reductions resulted from re-dredging of sediment for backfilling. Re-dredging was done by hopper dredgers using overflow routines. Most pollutants are bound to the very fine particulate organic matter fraction. Thus, re-suspension of this fraction through dredging has caused twice an accelerated export towards the deeper Arkona and Bornholm Basins – the regional sinks for detritus, in 2010 and 2018, respectively. Later on detritus from Oder River runoff accumulates again also in the vicinity of the temporary storage area.

Table 21. Mean concentration of trace metals (mg/kg dry weight) in surface sediments at the temporary sediment storage area off Usedom Island (analysis of the particle fraction <20 µm only).

Trace metal	2007 (n=9)	2011 (n=10)	2016 (n=3)	2019 (n=5)
Arsenic	12.9* (3.8–22)#	8.6 (1.4–28)	38.6 (6.8–88)	8.9 (4.9–12.0)
lead	75.0 (19–180)	23.8 (3.7–70)	51.7 (27–90)	19.8 (12–26)
Cadmium	1.63 (0.6–2.7)	0.44 (0.10–1.00)	0.83 (0.2–1.4)	0.32 (0.2–0.6)
Chrome	41.9 (20–56)	27.4 (4.3–58)	76.0 (38–130)	39.2 (23–54)
Copper	71.4 (39–130)	30.9 (5.6–74)	40.3 (21–75)	68.2 (13–210)
Nickel	34.8 (9.2–60)	19.2 (3.8–44)	86.0 (34–130)	28.0 (16–42)
Mercury	0.54 (0.23–0.95)	0.07 (0.03–0.18)	0.19 (0.07–0.33)	0.07 (0.04–0.12)
Zinc	275 (99–400)	118 (17–390)	229 (87–450)	109 (64–150)

* mean, # min–max

The particulate organic matter concentration of surface sediments in the vicinity of the temporary sediment storage area off the island of Usedom is naturally very low (< 1%, see Figure 59). Reduction of particulate organic matter concentration through re-dredging was about 50%. Hence, the total amount of re-mobilised pollutants was insignificant in comparison with the annual Oder River runoff import.

Concentration of trace metals will progressively increase again towards the natural local import-export equilibrium within about five years.

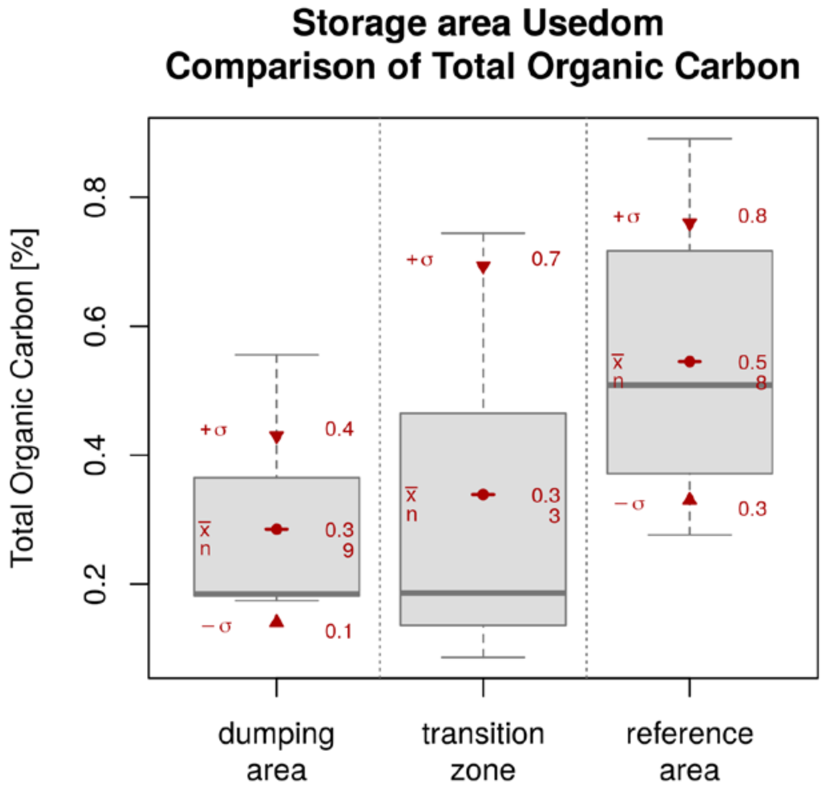


Figure 59. *Particulate organic matter content of surface sediments at the temporary sediment storage area off Usedom Island (storage area, storage area surrounding, and reference sites, respectively; 20 samples).*

CONCLUSIONS

Analysis of geochemical and geotechnical sediment parameters after termination of offshore construction revealed that the temporary impact of offshore construction was restricted to the immediate trench vicinity. Since reinstatement of sediment quality (geotechnical parameters) was successful and no contamination of sediments with pollutants occurred, one can predict a successful recovery of the benthic flora and fauna within two to four years.

The low concentration of medium-size hydrocarbons (decomposition products of oil and grease) in surface sediments proves one more time that the accidental release of up to 145 kg grease inside Greifswald Lagoon in May 2018 did not cause any detrimental environmental effect, since almost the entire amount could be manually recovered within three weeks. Substitution of all grease and hydraulic oils liable to come into contact with sea water with biodegradable environmentally acceptable lubricants may have ensured that the concentration of medium-size hydrocarbons (C10–40) in surface sediments stayed lower than predicted.

Export of pollutants from sediment deposits in the vicinity of trenches and the temporary storage area off Usedom Island through turbidity resulting from seabed intervention works was insignificant.

The comparable concentration of phosphate in surface sediments in trenches and at reference sites after construction in spring 2019 inside Greifswald Lagoon provides an indication that the forecast insignificant eutrophication effect through temporary mobilisation of phosphate during sediment interference works was lower than predicted in the worst case assessment.

6.2 Monitoring of biotic environment

6.2.1 Benthic flora and fauna

Benthic flora and fauna were entirely removed during offshore construction in Germany in the vicinity of about 50 km of trenches in the Territorial waters. About 50% of the trench section runs through protected Natura 2000 SCI sites, aiming at the preservation of endangered benthic habitats: san dBAnks which are slightly covered by sea water all the time (1110), large shallow inlets and bays (1160), and reefs (1170), respectively.

The post-construction GIS analysis revealed a total spatial footprint of trenches in German Territorial Waters of 174 ha. Trench sections crossing protected Natura 2000 habitats affected 51 ha.

All benthic habitats affected by dredging were physically reinstated through designated backfilling operations, aiming at:

- reinstatement of bathymetry with a precision of ± 20 cm,
- reinstatement of geophysical parameters of the surface sediment layer of soft sediments, about 30 cm thick (the life horizon),
- reinstatement of reefs by placement of autochthonous stones and pebbles.

Appropriate physical reinstatement of benthic habitats is the crucial pre-requisite for a successful recovery of benthic flora and fauna within two to four years. NSP Recovery Monitoring 2011–2016 proved that such a mitigation concept can be successfully implemented inside Greifswald Lagoon and in Pomeranian Bay. Natural oceanographic events (prolonged ice periods in winter, seasonal anoxia in summer) together with biological processes (spreading of invasive species) may affect the quality and duration of the recovery dynamics. According to EU and German legislation, NSP2 is obliged to monitor the recovery of the affected benthic habitats and to take remedial action if unforeseen complications may cause prolonged impacts (i.e. trench erosion). Due to the complex structure of benthic habitats along the 82 km of pipeline route in Germany, an array of different investigation methods will be used.

METHODOLOGY

Benthos monitoring from 2019 until 2022 comprises of a number of different investigations (see Figure 55):

- Infauna of soft bottom sediments along trenches in Territorial Waters and in the vicinity of the pipelines laid on the seabed in the EEZ;
- Infauna of the san dBAnk at the marginal well between Greifswald Lagoon and Pomeranian Bay (“Boddenrandschwelle”);
- Epifauna of re-instated reefs at Boddenrandschwelle;
- Epifauna on soft bottom sediments in the German EEZ;
- Epifauna of the pipelines laid on the seabed in the EEZ.

The “Boddenrandschwelle”, a marginal well between Greifswald Lagoon and Pomeranian Bay is a very diverse and dynamic geological structure within Natura 2000 SCI. It was formed by moving glaciers during glaciation and is slowly eroding since the last sea level rise 2,000 years ago. Whereas reefs form the exposed eastern slope of the well, sedimentation of mobilised sand in the sheltered Greifswald Lagoon forms a growing san dBAnk on the western slope. The Boddenrandschwelle harbours a diverse benthic infauna and epifauna which is the food source for many fishes. Local seagrass beds and gravel grounds are used by the western Herring population as spawning habitat annually in spring. Thousands of seabirds aggregate there during the Herring spawning season either to prey on the spawning fish (cormorants, grebes, and mergansers) or the eggs (Long-tailed ducks and Greater Scaups).

Sampling of fauna and flora is accompanied by hydrographic monitoring. Hydrographic monitoring is conducted by permanent remotely-operating sensors deployed right above the seabed at fixed buoys/platforms. Hydrographic monitoring covers the parameter salinity, temperature, oxygen, turbidity, and chlorophyll “a”. One station is operated by NSP2 inside Greifswald Lagoon. Data from two stations in Pomeranian Bay can be obtained from the Federal Maritime Agency BSH Hamburg (MARNET-HELCOM stations operated by the governmental Institute for Baltic Sea Research Warnemünde). Hydrographic data are used for interpretation of biological data.

Infauna of soft bottom sediments/infauna of the san dBAnk at Boddenrandschwelle
To assess spatial patterns of macrobenthic infauna, samples are collected by means of van Veen grabs. Infauna along the pipeline route are sampled at 20 stations in the EEZ and 52 stations in Greifswald Lagoon and Pomeranian Bay after construction in 2018 annually in spring for four successive years (see Figure 55). In the vicinity of the temporary sediment storage area off the island of Usedom, an additional 20 stations are sampled (see Figure 55). Sampling stations are either located within the affected area or at untouched reference sites. At each station three samples are collected.

In the shallow waters of the san dBAnk at Boddenrandschwelle, SCUBA divers collect box core samples along a transect in the vicinity of the backfilled trench and in an untouched reference area at 3–4 metres water depth (18 samples per area, respectively, see Figure 55). The san dBAnk at Boddenrandschwelle will be sampled twice per year in spring and autumn because very small short-lived invertebrate species prevail there and the top sediment itself is highly dynamic.

Sampled sediments are rinsed on board the ship into a tub in which the sediment is floated and sieved in portions over a sieve with 1 mm mesh size (van Veen grab samples) or 0.5 mm mesh size (box corer samples), respectively. The sieve residues are placed in storage containers and preserved with 4% borax-buffered formaldehyde for laboratory treatment using a stereomicroscope. Lab analysis includes species identification, counting of specimen per species and fresh weight measurements. In addition, shell length of bivalves is measured. Finally, the data on benthos infauna obtained is subject to a number of statistical analyses.

Epifauna of soft bottom sediments
To assess the composition of macrobenthic epifauna in the vicinity of the pipeline route in the EEZ, epifauna are sampled by means of a 2 metre wide beam trawl with a mesh size of 1 cm.

Epifauna along the pipeline route in the EEZ will be assessed twice per year in spring and autumn along six transects, three transects are located north of NSP2 and three south of NSP2 (see Figure 55). The three northern transects are located at a distance of 1,000 metres and the three southern transects are located approximately 500 metres apart. The operational NSP pipelines are located approximately 500 metres further south of the southern transects. At each transect station, the beam trawl will be towed for a duration of 5 minutes across the sandy seafloor at a speed of 1 to 3 knots.

After trawling, the content of the cod-end (catch) is completely emptied into buckets, and specimens are identified, counted and weighed on board the vessel. Specimens that cannot be identified at species level at sea, particularly juvenile organisms, are preserved with 4% borax-buffered formaldehyde and transferred into the laboratory for treatment using a stereomicroscope. Lab analysis includes species identification, counting of specimen per species and fresh weight measurements. In addition, shell length of bivalves is measured. Finally, the data on soft bottom epifauna obtained are subject to a number of statistical analyses.

Epifauna of re-instated reefs at Boddenrandschwelle
Two different survey methods are used for the assessment of the epifauna and flora in re-constructed reef areas and related undisturbed reef habitats nearby (reference sites, see Figure 55):

- underwater video and still image surveys by means of a towed underwater video camera system and a drop camera for still images (see Figure 60);
- sampling of epibenthic organisms attached to hard substrate (stones) by SCUBA divers.

The following parameter is quantified from underwater video and still images: stone cover, algae and hydrozoan cover, blue mussel *Mytilus* spec. cover and mussel length. Samples collected by SCUBA divers are preserved with 4% borax-buffered formaldehyde and transferred into the laboratory for treatment using a stereomicroscope. Lab analysis includes species identification, counting of specimen per species and fresh weight measurements. In addition, shell length of bivalves will be measured. Finally, the data on reef epifauna obtained will be subject to a number of statistical analyses.

Figure 60. *Towed underwater video camera system and drop camera for still images.*

Epifauna of the pipeline
The post-construction succession and structure of macrobenthic epifauna growing on the NSP2 pipeline in the EEZ will be monitored by means of two different survey methods:

- underwater video survey by using a ROV;
- scratch sample collection by SCUBA divers.

Underwater video inspection transects is recorded at three different locations on pipeline B from 2019 until 2022 (see Figure 55). Since pipeline installation in Germany's EEZ was not completed in 2018, only two locations were inspected during 2019 monitoring. The following parameter is quantified from underwater video and still images: stone cover, algae and hydrozoan cover, Blue mussel cover and mussel length.

Scratch sampling by SCUBA divers is conducted only at one station at 18.5 metres water depth (see Figure 61). Scratch samples are preserved with 4% borax-buffered formaldehyde and transferred into the laboratory for treatment using a stereomicroscope. Lab analysis includes species identification, counting of specimen per species, and fresh weight measurements. In addition, shell length of bivalves is measured. Finally, the data on soft bottom epifauna obtained are subject to a number of statistical analyses.

In addition, the NSP pipeline installed in 2010 was also investigated one more time in 2019 (see Figure 55). The NSP pipeline is likely to function as a relevant source for various epibenthic species because the natural surrounding comprises soft bottom sediments only. However planktonic larvae of epibenthic species in the open water (pelagial) are to be considered as the prevailing source for hydrozoan, bryozoan, barnacles, and Blue mussels settling on the concrete coating of the pipeline.

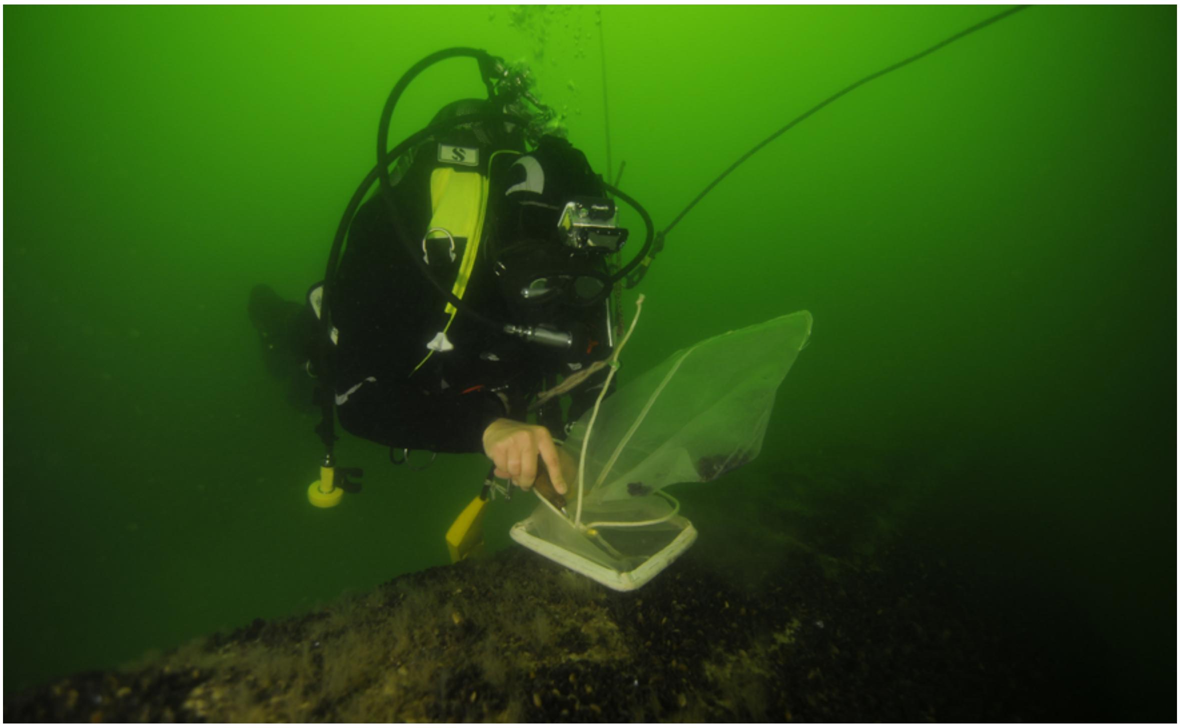


Figure 61. *Scratch sampling by SCUBA diver on the pipeline at 18.5 m water depth.*

Infauna of soft bottom sediments/infauna of the san dBAnk at Boddenrandschwelle

Benthos recovery inside Greifswald Lagoon started immediately after termination of seabed intervention works in December 2018. Five months later, already 25 taxa were discovered in the vicinity of the backfilled trenches. A total of 30 taxa was registered at untouched reference sites (see Table 22). Eight taxa belong to the diverse group of non-indigenous infauna species. All of them have been found in the area in previous years. The Oder estuary belongs to those water bodies in the Baltic Sea which are most exposed to immigration of alien species. The harbours of the Oder estuary and the Pomeranian Bay are known to be a gateway for invasive species from estuaries all around the globe /40/.

Table 22. *Macrozoobenthos infauna taxa inside Greifswald Lagoon in the vicinity of the pipeline trench and at untouched reference sites (n = 2 × 10 stations with 3 replicate samples per station).*

Taxon	Trench	Reference
Bryozoa	**1**	**1**
Einhornia crustulenta	X	X
Cnidaria	**2**	**1**
Campanulariidae gen. sp.	X	–
Gonothyraea loveni	X	X
Crustacea	**5**	**7**
Amphibalanus improvisus	X	X
Bathyporeia pilosa	X	X
Crangon crangon	–	X
Cyathura carinata	X	X
Gammarus sp.	X	X
Neomysis integer	–	X
Rhithropanopeus harrisii	X	X
Insecta	**1**	**0**
Procladius sp.	X	–
Mollusca	**7**	**6**
Cerastoderma glaucum/Cerastoderma sp.	X	X
Ecrobia ventrosa	X	–
Limecola balthica/Tellinidae gen. sp.	X	X
Mya arenaria/Mya sp.	X	X
Mytilus edulis agg.	X	X
Peringia ulvae	X	X
Rangia cuneata	X	X
Oligochaeta	**2**	**3**
Baltidrilus costatus	X	X
Enchytraeidae gen. sp.	–	X
Tubificoides heterochaetus	X	X

Taxon	Trench	Reference
Polychaeta	**7**	**12**
Alitta succinea	X	X
Boccardiella ligerica	–	X
Bylgides sarsi	–	X
Fabricia stellaris	–	X
Hediste diversicolor	X	X
Heteromastus filiformis	–	X
Manayunkia aestuarina	X	X
Marenzelleria sp.	X	X
Marenzelleria neglecta	X	X
Marenzelleria viridis	–	X
Pygospio elegans	X	X
Streblospio shrubsolii	X	X
Sum Taxa	**25**	**30**

Total macrozoobenthos abundance was 50% lower in the vicinity of the backfilled trenches compared to reference sites (2,007 ind./m^2 versus 4,422 ind./m^2). Total macrozoobenthos biomass was almost 90% lower in the vicinity of the backfilled trenches compared to reference sites (11 g AFDM/m^2 versus 95 g AFDM/m^2). The difference in biomass resulted primarily from the near-absence of large-sized soft-shell clams *Mya arenaria* in backfilled trenches which comprise about 80% of the total biomass. The burrowing soft-shell clam is a long-lived bivalve species with a low mobility/small migration volume of individuals > 20 mm shell-length. Hence, this bivalve was observed to have the longest recovery duration among all invertebrate infauna species during NSP's Recovery Monitoring Programme 2011–2016.

Comparable results were observed for the trenches in Pomeranian Bay and for the temporary sediment storage area off the island of Usedom.

Due to the general absence of large burrowing bivalves, the recovery of the infauna of the san dBAnk at the shallow exposed Boddenrandschwelle progresses faster than the recovery of the trench sections at water depths > 5 metres. A total of 35 taxa (including 7 established non-indigenous species) was found during both sampling campaigns (see Table 23). The number of taxa was comparable between sampling areas already in autumn 2019. However, some structural differences remained in autumn 2019. Both total infauna abundance and total infauna biomass were still about 30% lower in the vicinity of the backfilled trench compared to the untouched reference area.

Table 23. *Macrozoobenthos infauna taxa of a sandBAnk at Boddenrandschelle in spring and autumn 2019 (18 samples per area per sampling campaign*

Taxon	Summer 2019		Autumn 2019	
	Trench	Reference	Trench	Reference
Bryozoa				
Einhornia crustulenta	+	+	+	+
Cnidaria				
Campanulariidae gen. sp.	+	–	–	–
Crustacea				
Amphibalanus improvisus	+	–	–	–
Bathyporeia sp.	+	+	+	+
Bathyporeia pilosa	+	+	+	+
Crangon crangon	–	–	+	–
Cyathura carinata	–	+	+	+
Gammarus sp.	+	+	–	–
Gammarus oceanicus	–	+	–	–
Idotea sp.	–	–	+	+
Jassa sp.	–	–	–	+
Jassa herdmani	–	–	–	+
Jassa marmorata	–	+	–	+
Sinelobus sp. nov.	–	–	+	–
Mollusca				
Cerastoderma sp.	+	+	+	–
Cerastoderma glaucum	–	–	+	+
Limecola balthica	+	+	+	+
Mya sp.	+	+	+	+
Mya arenaria	+	+	+	+
Mytilus edulis agg.	–	+	–	–
Peringia ulvae	–	+	+	+
Rangia cuneata	–	–	+	+
Nemertea				
Nemertea indet.	–	–	–	+
Oligochaeta				
Baltidrilus costatus	+	+	+	+
Clitellio arenarius	–	+	+	+
Enchytraeidae gen. sp.	+	+	+	+
Phallodrilinae gen. sp.	–	+	–	+
Tubificinae gen. sp.	–	+	–	+

Taxon	Summer 2019		Autumn 2019	
	Trench	Reference	Trench	Reference
		Polychaeta		
Capitella capitata agg.	–	+	-	–
Hediste diversicolor	+	+	+	+
Marenzelleria sp.	+	+	+	+
Marenzelleria neglecta	+	+	–	+
Pygospio elegans	+	+	+	–
Scoloplos armiger agg.	+	–	–	–
Spionidae gen. sp.	–	–	+	+
Sum Taxa	**17**	**23**	**21**	**24**

Epifauna of soft bottom sediments

The epifauna of soft bottom sediments in Germany's EEZ is characterised by a low species diversity (due to the low salinity of about 8 PSU only and the lack of habitat diversity – no hard bottom substrates), a low total abundance and a low total biomass (seabed at water depth of > 20 m is below the euphotic zone – low benthic and pelagic food supply).

Only 15 species of sessile and vagile epifauna species were found during monitoring in 2019. Sessile species settle on shells of Blue mussels, which commonly drift in small clumps across the sandy bottom. Total abundance of sand bottom epifauna ranged between 0.1–6 ind./m². Total biomass of sand bottom epifauna ranged from 0.2–11 g FM/m². Blue mussels comprised > 90% of total abundance and total biomass of all samples.

As in 2015/2016 (baseline investigation), no differences occurred between the samples collected either north or south of NSP2 in 2019. No differences were observed between samples collected during baseline investigations (2015/2016) and in 2019 (five and ten months after 50% of pipelay in the German EEZ, respectively). At the current stage of the project, changes in soft bottom epifauna are very unlikely. Changes in soft bottom epifauna may occur between NSP and NSP2 pipelines, when NSP2 becomes operational:

- Increase in fouling fauna on pipelines (artificial reef);
- Blocking of bedload transport between NSP and NSP2 pipelines.

Epifauna of re-instated reefs at Boddenrandschwelle

Video inspection of the re-instated reefs at Boddenrandschwelle 8 months after installation works proved that the mechanical reinstatement of the hard bottom structure was successful. Furthermore, the pebbles and stones that had been placed were already overgrown by pioneering flora and fauna: annual red algae, hydrozoans, and barnacles. Spat of long-lived blue mussels *Mytilus* spec. was observed to be abundant as well (see Figure 62).

Figure 62. *Still images of re-instated reefs (left) and untouched reference reefs (right) at Boddenrandschwelle taken eight months after pipeline construction. The major difference between sites is the absence of large-sized blue mussels Mytilus spec. and Bladder wrack Fucus vesiculosus at reinstatement sites.*

As predicted, scratch sample analysis revealed that species number, total epifauna abundance and total epifauna biomass were significantly lower at reinstatement sites. However the number of species registered in scratch samples collected in re-instated reefs was already surprisingly high (see Table 24).

Table 24. *Comparison of status quo of descriptive parameter of epifauna and – flora at Boddenrandschelle in summer 2019, eight months after termination of seabed intervention works.*

Parameter	Re-instated reefs	Untouched reference reefs
Hydrozoan/red algae cover (%)	84	70
number of invertebrate epifauna species	18	23
Total epifauna abundance (ind./m²)	7,167	97,939
Total epifauna biomass (AFDM g/m²)	12.7	208

Epifauna of the pipeline

Settlement of various sessile epifauna species was observed during the first ROV inspection of the NSP2 pipeline in the German EEZ in August 2019. Bryozoa, Hydrozoa, barnacles and spat of Blue mussels were recognised (see Figure 63).

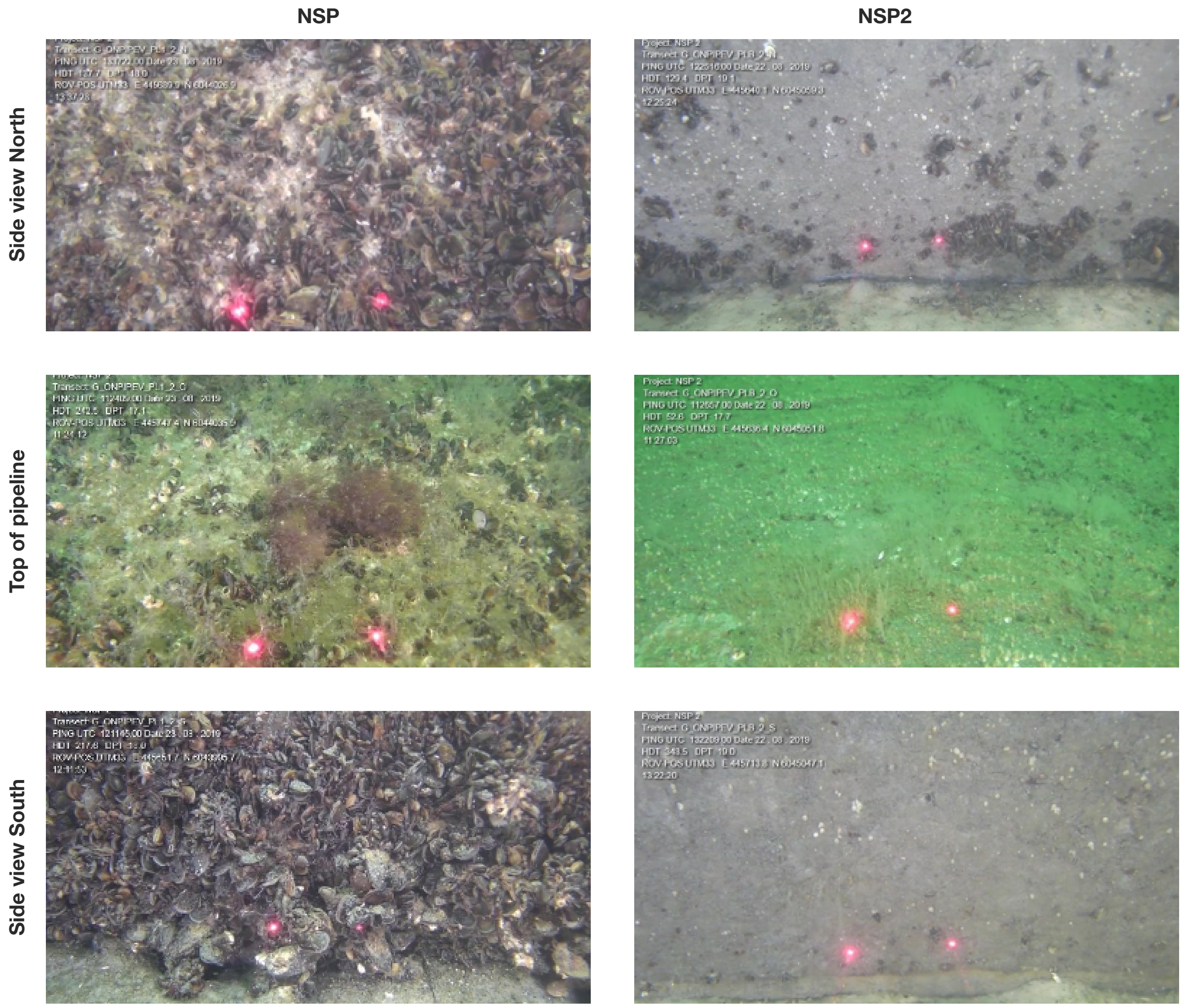


Figure 63. *Still images of biofouling on NSP (left) and NSP2 pipelines (right) taken in August 2019, nine years after NSP pipeline installation and eight months after NSP 2 pipeline installation, respectively.*

A total of 25 epifauna taxa was recorded in the scratch samples from the NSP2 pipeline. In comparison, 41 species were found on the NSP1 pipeline, located 1,000 metres south of NSP2.

Statistical analysis of epifauna communities on the NSP1 pipeline for the period 2011–2019 and NSP2 pipeline for 2019 revealed that epifauna succession on NSP2 seems to be faster than observed for NSP1. Supposedly NSP1 vagile epifauna functions as a source for NSP2 biofouling.

Biofouling epifauna on the NSP1 pipeline was growing for three years until 2013 and unexpectedly declining afterwards. Since there is no natural reason for this unpredicted pattern of succession, it is assumed that bottom trawl fishery "cleans" the NSP1 pipeline from time to time. This hypotheses is supported by the fact that trawl fishery has changed their spatial pattern in the German EEZ since 2013 (VMS tracking data). The few remaining trawlers nowadays are operating predominantly in line with the pipeline route, since they have discovered that the biofouling epifauna has attracted demersal fish (see Figure 64 and Figure 65).

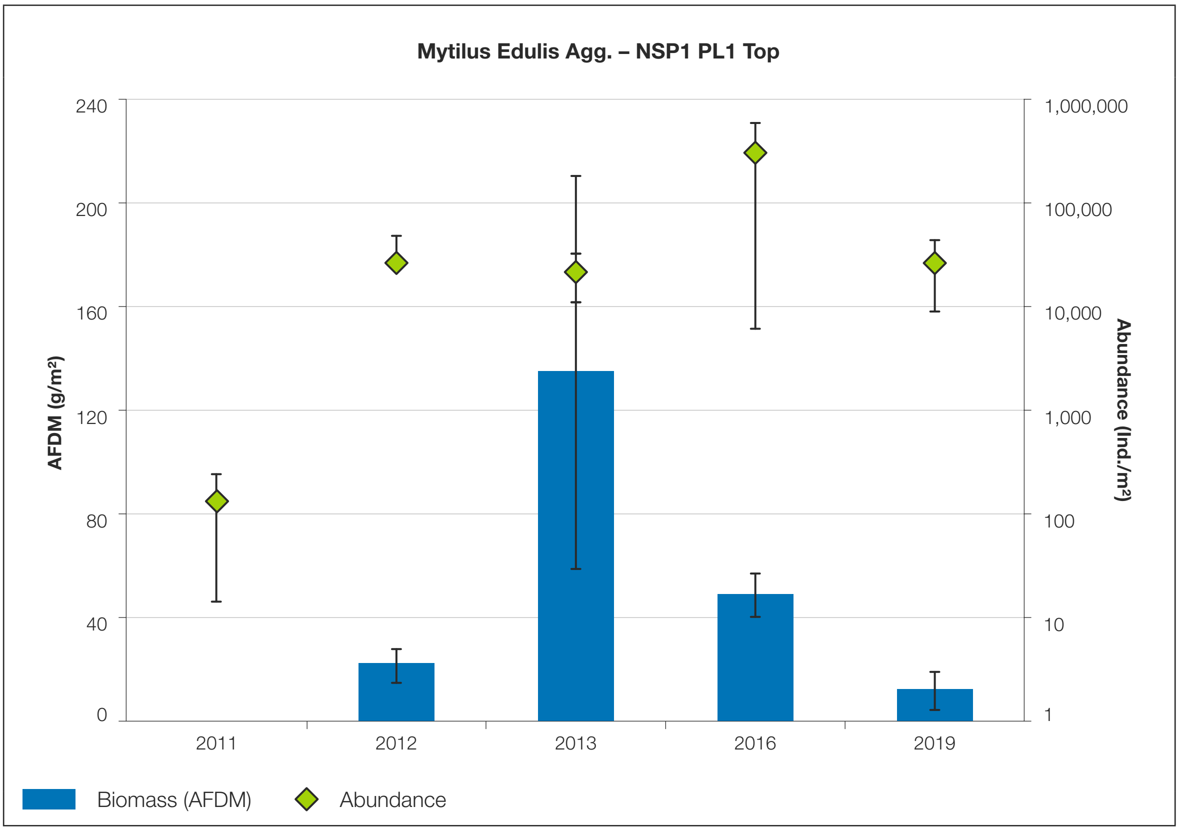


Figure 64. *Trend in biomass of Blue mussels Mytilus spec. Top of NSP1 Pipeline 2011–2019.*

Figure 65. *Demersal fishes are attracted by biofouling invertebrate epifauna growing on the NSP and NSP2 pipelines: Shorthorn sculpin Myoxocephalus scorpius.*

Macrozoobenthos invertebrate fauna surveys, conducted in 2019, revealed an early stage of succession for all benthic habitats under investigation. The findings are in line with predictions made in the permit application documents, which were based on the results of the NSP Recovery Monitoring Programme 2011–2016. Future surveys will continue to document the succession of infauna and epifauna of affected seabed habitats along the pipeline route and on the artificial reef, the NSP2 pipeline installed on the seabed in the German EEZ.

6.2.2 Marine mammals

Two species of marine mammals inhabit the coastal waters of the German section of the pipeline route. 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 /41/. Harbour porpoises 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 /42/. The presence and seasonality of both species were monitored during offshore construction in 2018 and afterwards also in 2019.

METHODOLOGY

Grey seals were monitored by simultaneous monthly counts of individuals in the vicinity of the haul-out sites until April 2019 (see Figure 55). 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 unclear.

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 seven stations located in the vicinity of the pipeline route (see Figure 55). A similar monitoring programme, using the same spatial layout, was conducted between 2010 and 2013 during environmental monitoring for Nord Stream. The approach also mirrors the method applied during the SAMBAH project /43/.

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.

RESULTS

Grey seal

Two haul-out sites were preferred by the seals throughout the monitoring period April 2018–April 2019: san dBAnk “Grosser Stubber” and island “Greifswalder Oie”. Grey Seal abundance followed a typical local seasonal pattern with peak numbers during the Herring spawning season in March/April and a minimum during the moulting period in May/June (see Table 25).

Table 25. *Grey Seals at haul-out sites in Greifswalder Bodden between April 2018 and April 2019.*

Date	Großer Stubber	Greifswalder Oie	Ruden	Seals apart from haul-out sites	total
Apr 18	270	90	2	21	383
May 18	1	19	0		20
Jun 18	6	0	1		7
Jul 18	8	3	0		11
Aug 18	2	11	3		16
Sep 18	8	11	3		22
Oct 18	20	37	3		60
Nov 18	9	21	0		30
Dec 18	3	13	0	2	18
Jan 19	3	32	0		35
Feb 19	9	33	0		42
Mrz 19	50	112	1	2	165
Apr 19	18	37	2		57
Max per site	**270**	**112**	**3**		
total	**407**	**419**	**15**	**25**	**866**

Abundance and seasonality of seals during construction in 2018 and after construction until 2019 was comparable to numbers in 2017 (see Figure 66). No further increase in seal numbers was observed. This may have resulted from an outstanding number of dead seals found along beaches of Mecklenburg-Vorpommern (Germany) and Poland in 2018. More than 300 dead seals were recorded, twice as many as in previous years (HELCOM 2019, /44/). The number of Grey seals continued to increase again at Greifswald Lagoon haul-out sites later in 2019. As a result, 30 seal pups were found at the coastline of Mecklenburg-Vorpommern in spring 2020 – a new record (media reports about governmental seal monitoring by Meeresmuseum Stralsund).

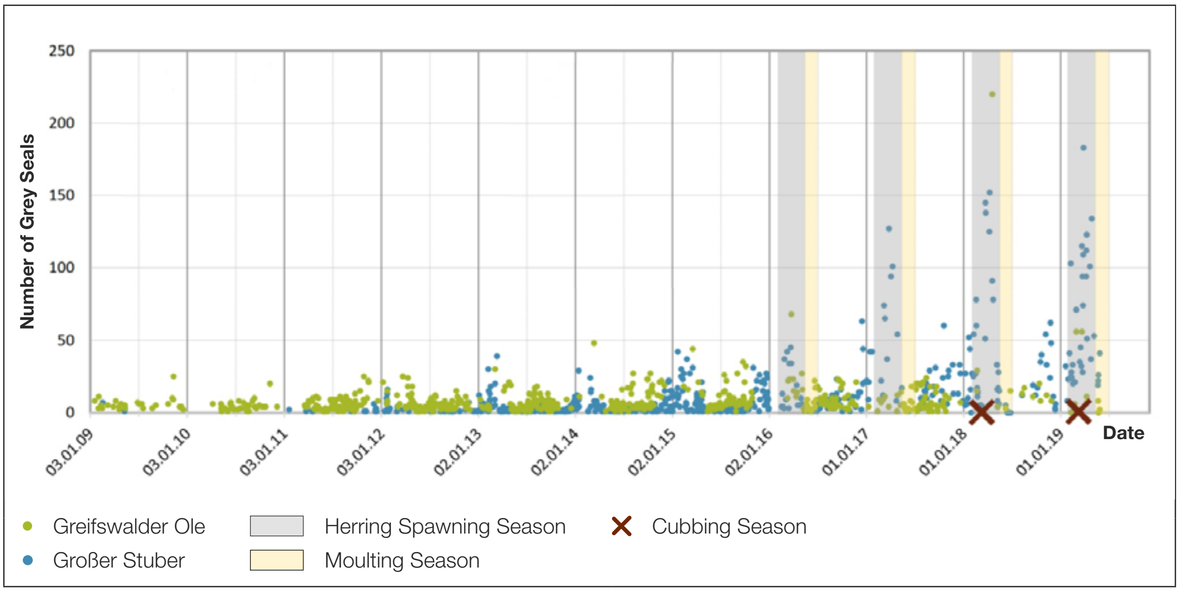


Figure 66. *Long-term trend for Grey Seal numbers at haul-out sites in Greifswalder Bodden, Germany /45/.*

Harbour porpoise

The presence, distribution pattern (see Figure 67) and seasonality (see Figure 68) of harbour porpoises recorded in 2019 mirrored the pattern observed during NSP monitoring in 2013 (two years after construction) and NSP2 Monitoring during construction in 2018. The highest detection rates were registered in the north-west of the Pomeranian Bay and in the vicinity of the pipeline routes. Detection frequency peaked again in October.

The harbour porpoise detection rate continued to increase in 2019. A continuing increase in harbour porpoise activity during summer and autumn in Pomeranian Bay has been observed since 2008 /46/. For the first time since hydroacoustic harbour porpoise monitoring started in Pomeranian Bay, animals already arrived in May (see Figure 68).

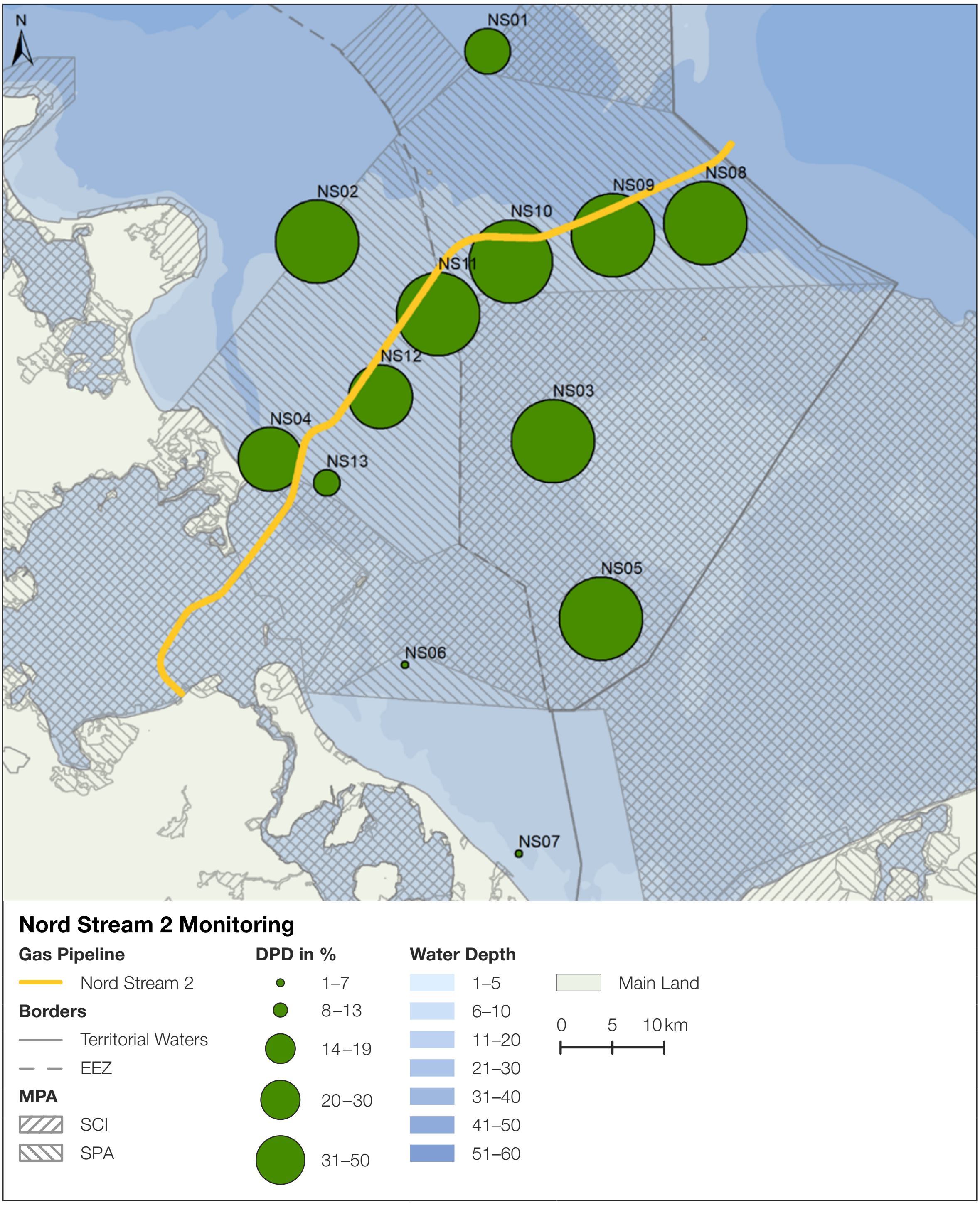


Figure 67. *Mean detection rate per month (% DPD) per station between January and December 2019 in Pomeranian Bay.*

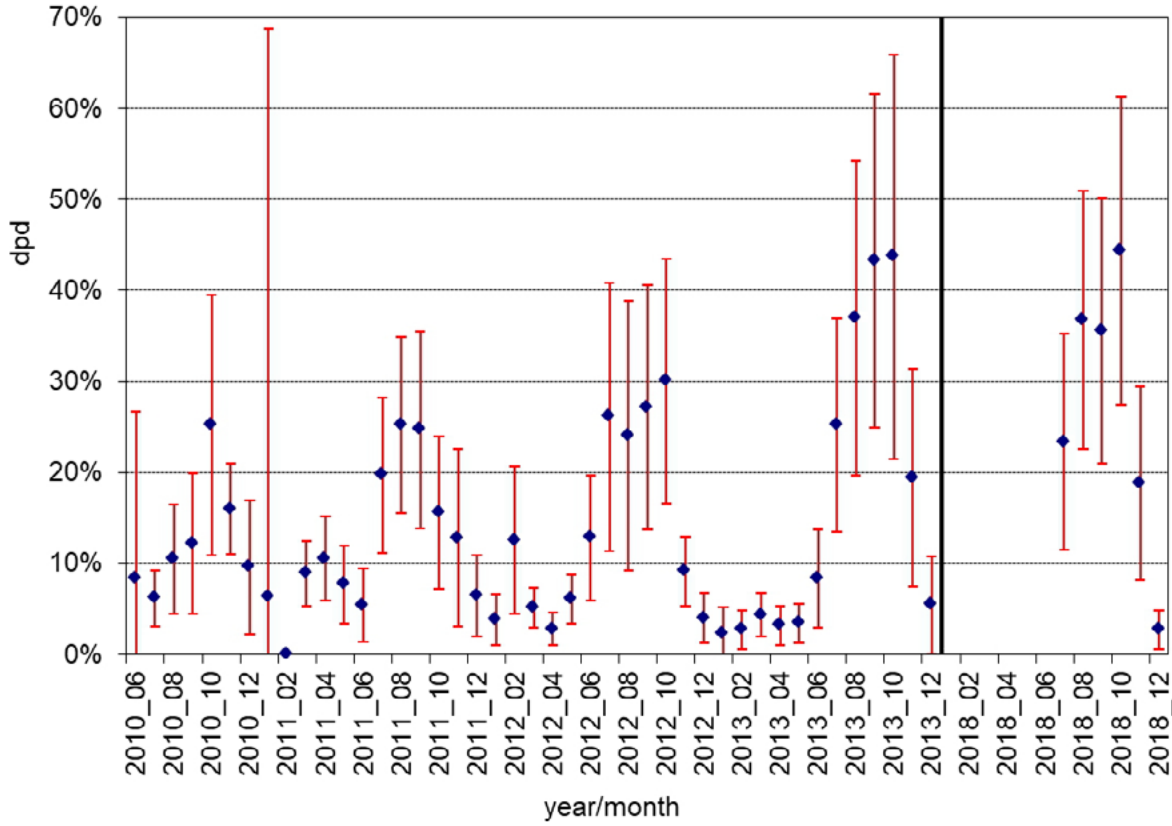


Figure 68. *Trend in mean detection rate per month (%DPD) between 2010 and 2019.*

CONCLUSIONS

Both, Grey seals and harbour porpoises continued to increase in the coastal waters inside Greifswald Lagoon and Pomeranian Bay along the German section of the NSP2 route after offshore construction works in 2018. This finding underlines the minor impact that NSP2 installation had on marine mammals. As predicted, construction monitoring detected indications of some small-scale temporary displacement effects caused by vessel traffic in summer and autumn of 2018. Injuries of the auditory systems, as well as permanent or temporary hearing threshold shifts could be excluded by underwater noise measurements during dredging and pipelay works.

6.2.3 Birds

Pomeranian Bay and Greifswald Lagoon are the most important wintering areas for seabirds in the Baltic Sea /47/. About 5,000 km^2 have been designated in these waters as EU Natura 2000 sites. Three SPAs cover the German part of the Oder estuary and another one covers the Polish part of the bay.

The shallow Pomeranian Bay is the most important wintering area for benthophagous sea ducks in the West Palaearctic. Up to 1 Mio. long-tailed ducks *Clangula hyemalis*, common scoters *Melanitta nigra*, and velvet scoters *Melanitta fusca* may spend the winter season there between November and early May. Sea ducks prey almost exclusively on bivalves, living either attached to stones (blue mussel) or burrowed in soft sediments (clams *Mya arenaria*, tellins *Limecola balthica*, and cockles *Cerastoderma edule*). Since bivalves are long-lived invertebrate species, seabed intervention works will not only affect the benthic fauna, but also their predators: fishes and sea ducks. The impact may last until the food supply harvestable by the sea ducks has recovered. Based on the results of the NSP Recovery Monitoring Programme 2011–2016, this effect may last for two to four years. Since the overall temporary footprint of seabed intervention works in Pomeranian Bay is comparatively low (about 4 km^2 out of 5,000 km^2 of potential feeding habitat), no impact on population trends was observed after NSP installation in 2010/2011 /36/.

Pipeline route sections installed on the seabed may provide a surplus of food for seabirds, because the concrete coating will be subject to biofouling. After some years, the exposed pipelines will be almost entirely overgrown by Blue mussels down to about 30 metres water depth. The developing artificial reef may attract demersal fishes and seabirds. During the NSP Recovery Monitoring Programme 2011–2016 it was observed in 2013 that long-tailed ducks, scoters and grebes aggregated in the vicinity of the exposed NSP pipeline down to a water depth of 22 metres /36/. This effect disappeared again, when trawl fishery started to trawl along the pipelines and repeatedly scraped off the mussel cover.

Greifswald Lagoon is very important for wintering and migrating seabirds as well, because it is the spawning ground for the western Baltic herring population. Both piscivorous and benthophagous seabirds become attracted annually during the spawning season from February until May. Cormorants, grebes, loons, and mergansers prey on spawning herring. Long-tailed ducks and greater scaups *Aythya marila* prey on herring eggs. Especially the marginal well towards the Pomeranian Bay ("Boddenrandschwelle") may host up to 100,000 seabirds at a time in March and April. Therefore the herring spawning season has been precluded from NSP2 offshore construction in Germany. Impacts on seabirds could be entirely avoided inside Greifswald Lagoon through this mitigation measure.

Many seabird species are very sensitive toward vessel traffic. Especially loons and sea ducks are known to keep large distances from ships (Fliessbach et al. 2019). NSP2 Seabird monitoring during construction in 2018 proved wide-ranging displacement effects for these sensitive species of 1.5–3 km as predicted by the EIA. The displacement effect was less prominent for auks. No displacement was observed for gulls.

The NSP2 pipeline route circumvents the high density areas for seabirds on the Oderbank in the central part of Pomeranian Bay. Only in winter 2015/16 was it observed that significant numbers of sea ducks occurred in the vicinity of the planned pipeline route /02/. This resulted from extraordinarily high numbers of wintering sea ducks in the entire Pomeranian Bay during this specific wintering period. Numbers of sea ducks staging in the vicinity of the NSP2 pipeline route appeared to be much lower again in the following winters 2017/18 and 2018/19 /49/, /50/. Thus although sensitive seabird species kept a large avoidance distance from the NSP2 construction vessels and all third party cargo vessels as well, the total number of individuals displaced by NSP2 fleets during pipelay works in November/December was low.

Post-construction seabird monitoring in Germany in 2019–2022 focuses on the overall trend of wintering seabird populations in the area and on analysing small scale effects that may result from dredging works in the vicinity of trench sections (Territorial Waters Germany) and from artificial reef effects for the section of the route where the pipelines were installed on the seabed (EEZ Germany).

METHODOLOGY

Three different survey techniques are applied for seabirds during NSP2 recovery monitoring in Germany between 2019 and 2022:

- Ship line transect surveys to estimate midwinter numbers of seabirds in the western part of the Pomeranian Bay (see Figure 55) once per year in February or March – trend analysis,
- Search flights for flocks of long-tailed ducks and greater scaups inside Greifswald Lagoon during the herring spawning season twice per year in March and April – trend analysis,
- Aerial digital imagery flights for the analysis of small scale impacts in the vicinity of the pipeline (see Figure 55) twice per year in February and April – small scale effect analysis.

Ship-line transect survey

According to the German standard STUK4, ship-based surveys follow the routines detailed by Webb & Durinck /51/ and Garthe et al. /52/, using a 300 metre wide line transect and two observers on either side of the vessel. Platform position is recorded at regular intervals automatically using GPS. The detectability of seabirds decreases with increasing distance from the survey platform resulting in an effective strip width which is smaller than the total transect width /53/. The effective strip width is calculated by application of the distance sampling software package provided by Laake et al. /54/ separately for different sea state classes and flock size classes. Corrected data are used to calculate seabird densities (individuals per km²) for grid cells of 4 × 4 km. The distribution of seabirds will be mapped as seabird densities per grid cell (see Figure 71). Seabird densities are also used to calculate absolute populations in specific sea areas.

The total survey area is 2,256 km² wide, covering the core habitats for wintering seabirds in the German part of Pomeranian Bay (see Figure 71). Both the survey design and the survey method have been applied since 2006 for the NSP and NSP2 environmental monitoring programmes. The large extension of the survey area together with the high level of standardisation of the survey methods meanwhile allows for an analysis of trends in local seabird wintering numbers.

Aerial search flights inside Greifswald Lagoon

Long-tailed ducks and greater scaups feeding on herring eggs inside Greifswald Lagoon cannot be counted by line transect surveys. The birds gather at certain day time roosts in order to avoid predation by sea eagles and greater black-backed gulls and search for fresh herring eggs predominantly at night. Because of the patchy distribution of the sleeping ducks, targeted observer search flights are conducted in order to find the roosting flocks and to photograph and count the number of individuals. This survey routine has been performed since spring 2007. Two search flights per herring spawning season allow for an analysis of trends in local duck populations.

Aerial digital imagery flights

Aerial digital imagery flights allow for the analysis of potential small scale effects in the vicinity of offshore installations and vessels, since individual birds caught in the images can be geo-referenced by GIS. StUK4 /37/, implemented digital imaging as the standard method for the monitoring of staging birds and marine mammals during the pre-construction, construction and post-construction phases of major offshore projects in the German EEZ.

For the digital bird survey, a twin engine Partenavia P68 aircraft is used with a hatch allowing the installation of the camera system (see Figure 69). For image capturing with DAISI, two iXA 180 Phase One aerial cameras are in use. Each camera has a resolution of 5.2 micron and addresses 10.328 × 7.760 pixels (80 MPI) with a dynamic range of > 72 dB. In order to implement this resolution, a CCD sensor with an effective size of 53.7 × 40.4 mm is used as input capture unit. The frame rate is 1.5 seconds in theory but in practice 1.8 seconds per frame. During recording, the cameras are operated with exposure times as short as 1/1,600 second to a maximum of 1/1,000 second and with the central shutter. To achieve a resolution of 2 cm, lenses with image stabilisation (FMC – Forward Motion Compensation) are used (Fast Sync lenses – FS). To obtain the most homogeneous and sharp picture as possible, both cameras are mounted on an AeroStab-Twin stabilizer. This device permanently adjusts the cameras vertically straight down when the aircraft rolls or tilts.

An image mosaic results along the captured transect line, depending on trigger interval and airspeed. To compensate for drift (e.g. caused by crosswinds) of the aircraft and to provide a homogeneous mosaic, the stabilizer pivots the camera system in the direction of the transect line (heading). Figure 70 shows an extract of a mosaic.

The images are screened visually with the image size scale set to 100%. Aerial photographs are divided into grid cells (50–80 cells/image, depending on the image surface after removal of overlapping areas) with a purpose-programmed software application which guarantees an image resolution of 100%, depending on screen size. The software tool allows a complete and systematic manual walkthrough of image files by displaying one grid cell after another on the screen. All objects which indicate a bird or marine mammal are labelled manually in the programme and automatically added to a database. The subsequent evaluation steps include species identification and quantification of pre-sorted objects and the collection of additional information and parameters. At least two experts independently identify species with a specifically designed viewing and input software. The software application for manual species identification makes it possible to measure the size of objects and to enlarge or minimize pictures. There are also various additional entry fields where the respective species and any additional information about seabirds or marine mammals can be included.

The assessment of seabird populations in a study area depends on species-specific density calculations, which can be made from the number of documented individuals in relation to the analysed image area. This procedure is consistent with the basic principle of analysis of visual survey data. In the analysis of aerial photos, factors otherwise correcting for velocity and distance-related observation bias in visual aerial surveys can be omitted.

The NSP2 survey design includes the NSP2 pipelines (installed in 2018), the NSP pipelines (installed in 2010/2011), and two reference transects, partially covering 50 Hz wind farm power cables. The complexity of the survey design will require sufficient sample sizes for statistical modelling. Species-specific sample sizes obtained by the surveys in 2019 were too small for any statistical approach.

Figure 69. *Survey platform for digital seabird surveys: Partenavia P68c. Detail views of the camera system.*

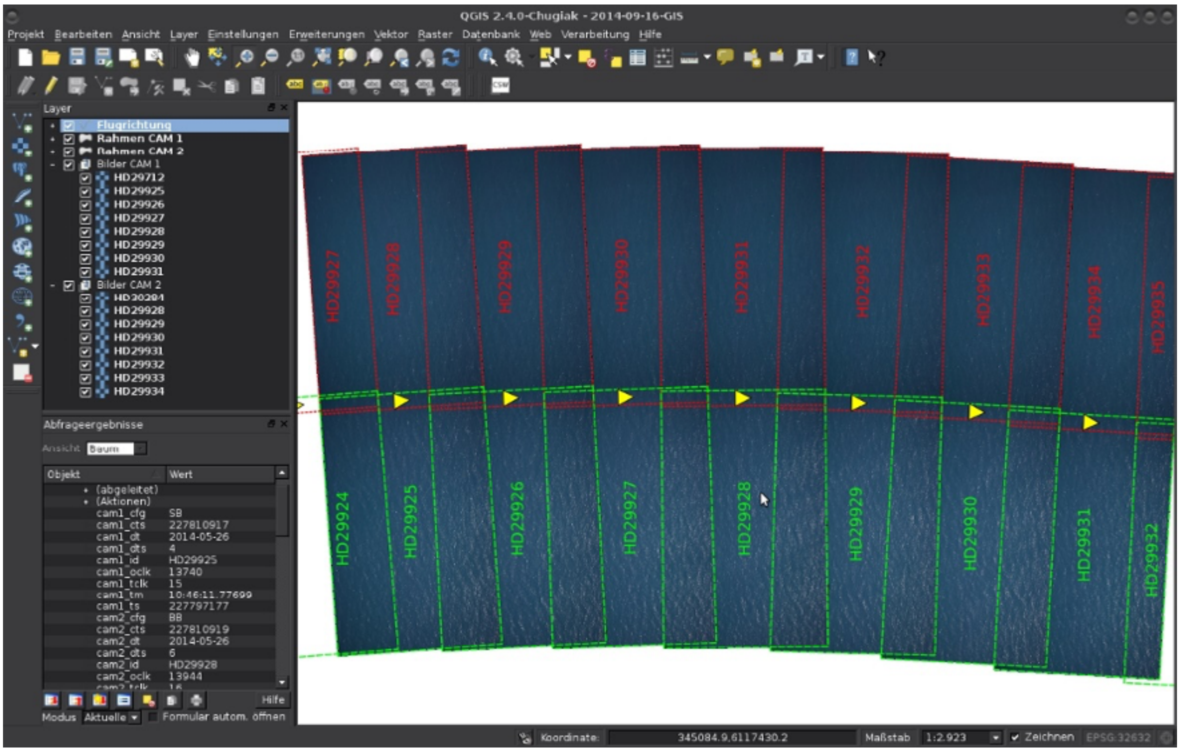


Figure 70. *Example of a photographic mosaic of overlapping georeferenced image pairs (starboard camera: red, portside camera: green, flight direction: yellow arrows).*

RESULTS

The complexity of seabird data collected by the 2019–2022 NSP2 recovery monitoring programme in Germany does not allow for an extensive presentation as part of this overall monitoring report. The NSP monitoring focuses especially on ten seabird species. We selected the long-tailed duck as an example: it is the most abundant seabird species in Pomeranian Bay and Greifswald Lagoon in winter. All Natura 2000 offshore SPA sites in the region aim to protect this species. It is one of the most important wintering area in the entire West Palaearctic. As a benthophagous species, long-tailed ducks are potentially most likely to be impacted by seabed intervention works.

It was estimated that a total of 112,000 long-tailed ducks stay within the Ship line transect survey area in February 2019 (see Figure 71). This figure was comparable to the estimates recorded since 2013 (see Figure 72). As observed during the years 2011–2016, the number of staging long-tailed ducks inside Greifswald Lagoon comprised 10,000–20,000 individuals during the herring spawning season in March/April. As a consequence of the mild winter, herring spawning already started in February in 2019. Long-tailed duck numbers might have been higher inside Greifswald Lagoon in February, as indicated by the results of aerial digital imagery surveys.

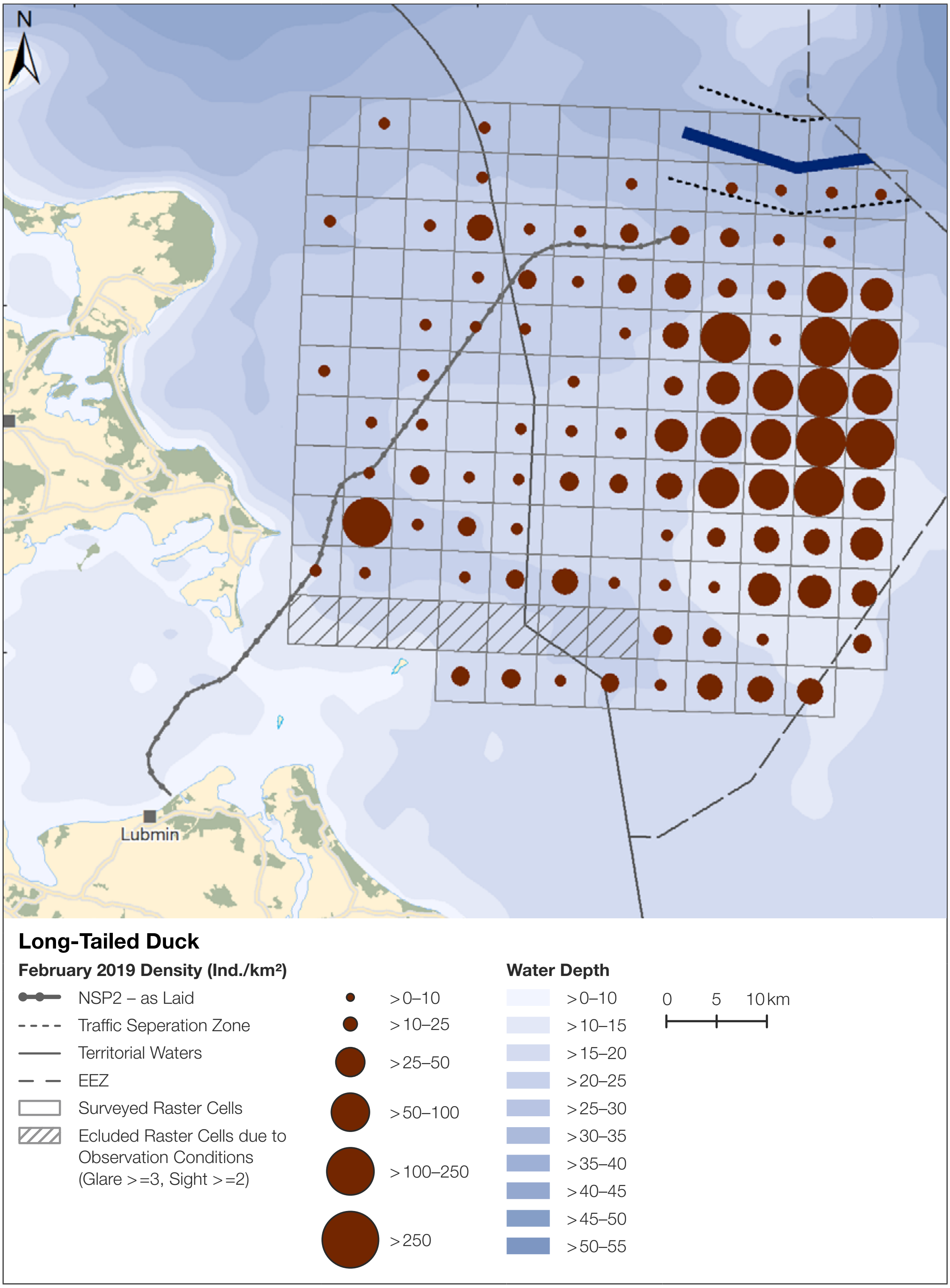


Figure 71. *Distribution of long-tailed ducks Clangula hyemalis in the Pomeranian Bay in February 2019. Line transect survey by ship.*

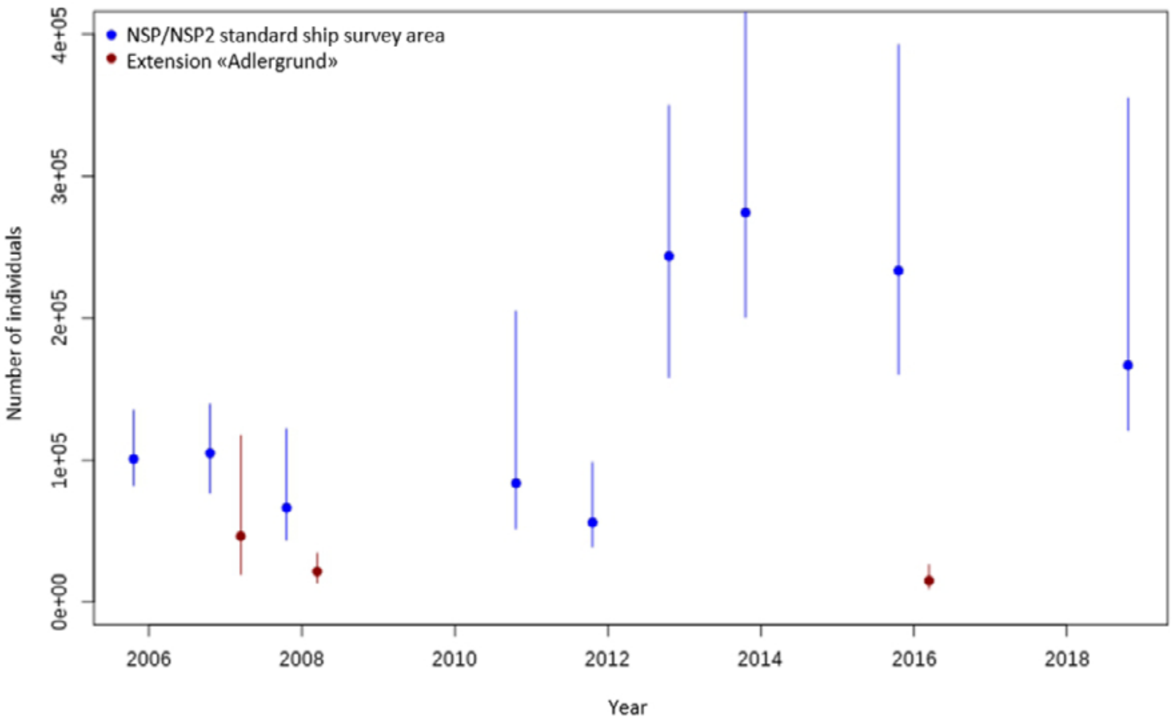


Figure 72. *Trend in numbers of long-tailed ducks Clangula hyemalis in the NSP/NSP2 survey area for line transect ship surveys (2.256 km^2) in the Pomeranian Bay from 2005 to 2019 in winter.*

The distribution pattern of long-tailed ducks recorded in the vicinity of the NSP2 and NSP pipelines by digital imagery in spring 2019 (4,600 and 3,200 individuals, respectively) was quite different from the pattern recorded in spring 2016 /36/. The unusual early start of the herring spawning season already attracted many long-tailed ducks inside Greifswald Lagoon in February, whereas the birds were concentrated in the western Pomeranian Bay in February 2016. Statistical modelling neither found any avoidance (pipeline installed in trenches) nor any attraction effect (pipeline on the seabed).

CONCLUSIONS

Seabird monitoring in winter 2019 did not reveal any prominent changes which might have been related to the installation of the NSP2 pipelines in summer and autumn 2018.

7 Unplanned events

Four activities occurred in 2019 that have been described as unplanned events: two in Finland and two in Russia. In Finland, two minor oil leaks, of 20 litres and 40 litres occurred in July and in August: no measurable environmental impacts occurred as a result of the unplanned events, and the authorities did not request that any action be taken due to the incidents. No unplanned events occurred in 2019 in Germany, Sweden or Denmark.

In Russia the first incident was a diesel leak at the area of the diesel generators at the Landfall Russia. The second one was the identification of wastewater discharges from the Russia facility to the Rosson River, which were outside the discharge permit conditions, originally identified in November 2018 but which continued into 2019. The diesel leak incident is described in this chapter and the incident with the water discharges is detailed in Chapter 3.2.1.

A diesel leak was reported at the area of the diesel generators at the Landfall Russia accommodation camp in February 2019. This spill resulted in the loss of containment and release of diesel into the ground with an impact on the localised ground water and a potential to impact a nearby amelioration channel. Precise volume of diesel released was unknown, but estimated at around 5,000 litres.

The immediate responses by the Company included the following:

> Contaminated groundwater was pumped out from around the generator area and disposed by licensed contractor at registered waste sites until the generator concrete pad and underlying contaminated soil could be removed;
> Contaminated gravel was removed from under the generator area so that no contaminated gravel is in contact with groundwater/runoff water;
> Monitoring pits were dug to evaluate the linear spread of the contamination “plume” and to establish its distance/quantities from the generators;
> A specialist contractor engaged to take water samples from the pits dug at various distances from the concrete pad and have them analysed at laboratories;
> The State Hydrographic Institute was engaged to assess any plume development and to identify any remedial measures required to mitigate the impact; and
> A specialist contractor was engaged to install piezometers to measure flow in the immediate terrain and evaluate any plume spread now and going forward.

Follow-up responses were as follows:

> New integrated fuel storage and generator pad installed with bunding, including specification of generator sets to include built-in secondary or tertiary containment;
> Removal of original generator and concrete pad;
> Removal/disposal of the hardstanding and gravel base of the existing facility;
> Clean-up of adjacent area – removal and disposal of contaminated soil and ground water;
> Ongoing environmental monitoring to verify that any residual contamination is at tolerable levels;
> Implementation of remedial corrective actions including measures to improve contractor management and ensuring HSES quality standards and reporting procedures are adhered to; and
> Monitoring of groundwater continued for six months after remediation of the site was completed, and it was stopped in December 2019, as the site was conclusively shown to be free of any hydrocarbon contamination.

In conclusion, all remediation actions were closed-out, and follow-up monitoring of soil and groundwater confirmed that the impact on the area was very limited and did not extend to the nearby amelioration channel. Therefore no long-term adverse impacts and no impacts outside the borders of the NSP2 construction site were identified.

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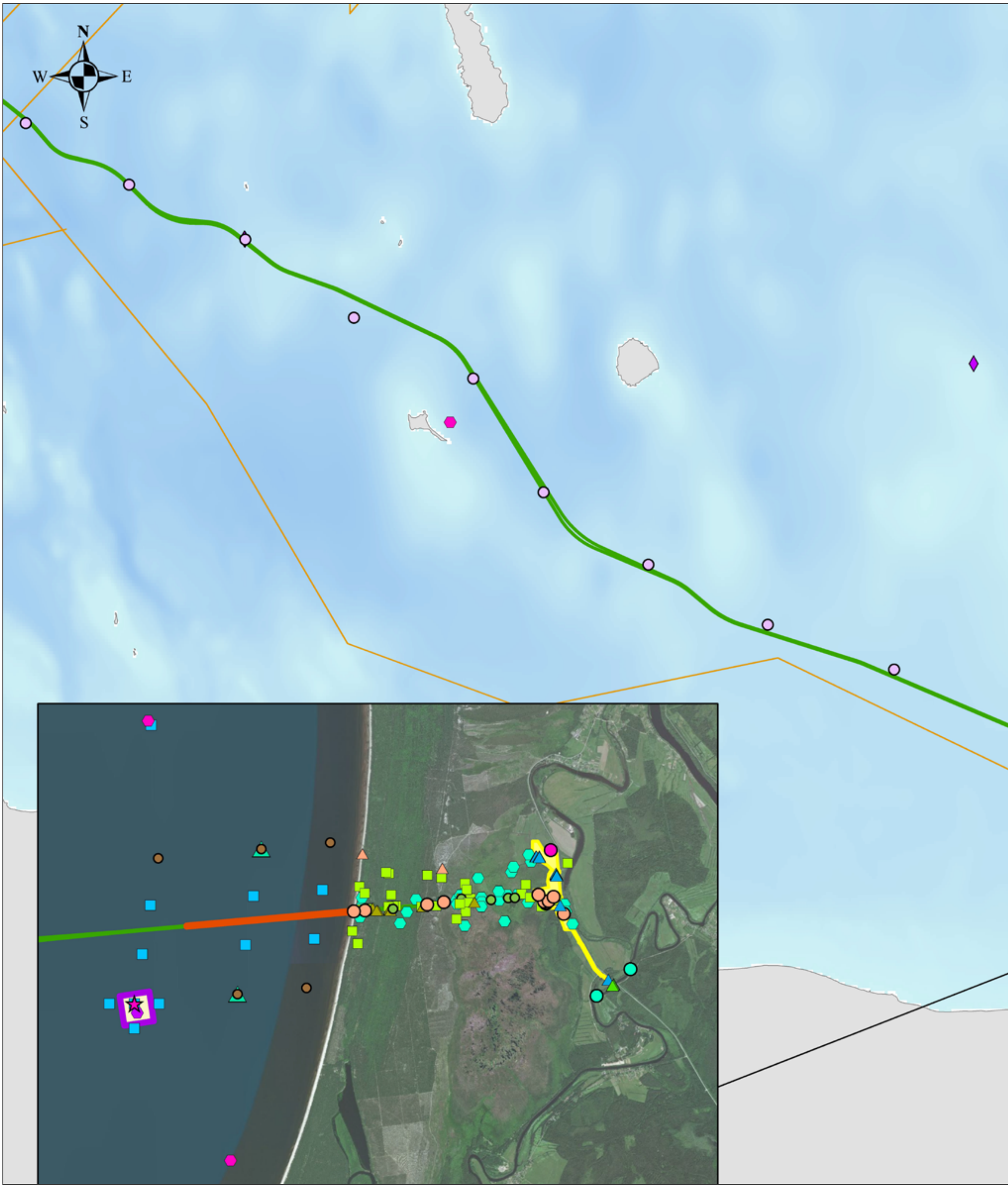
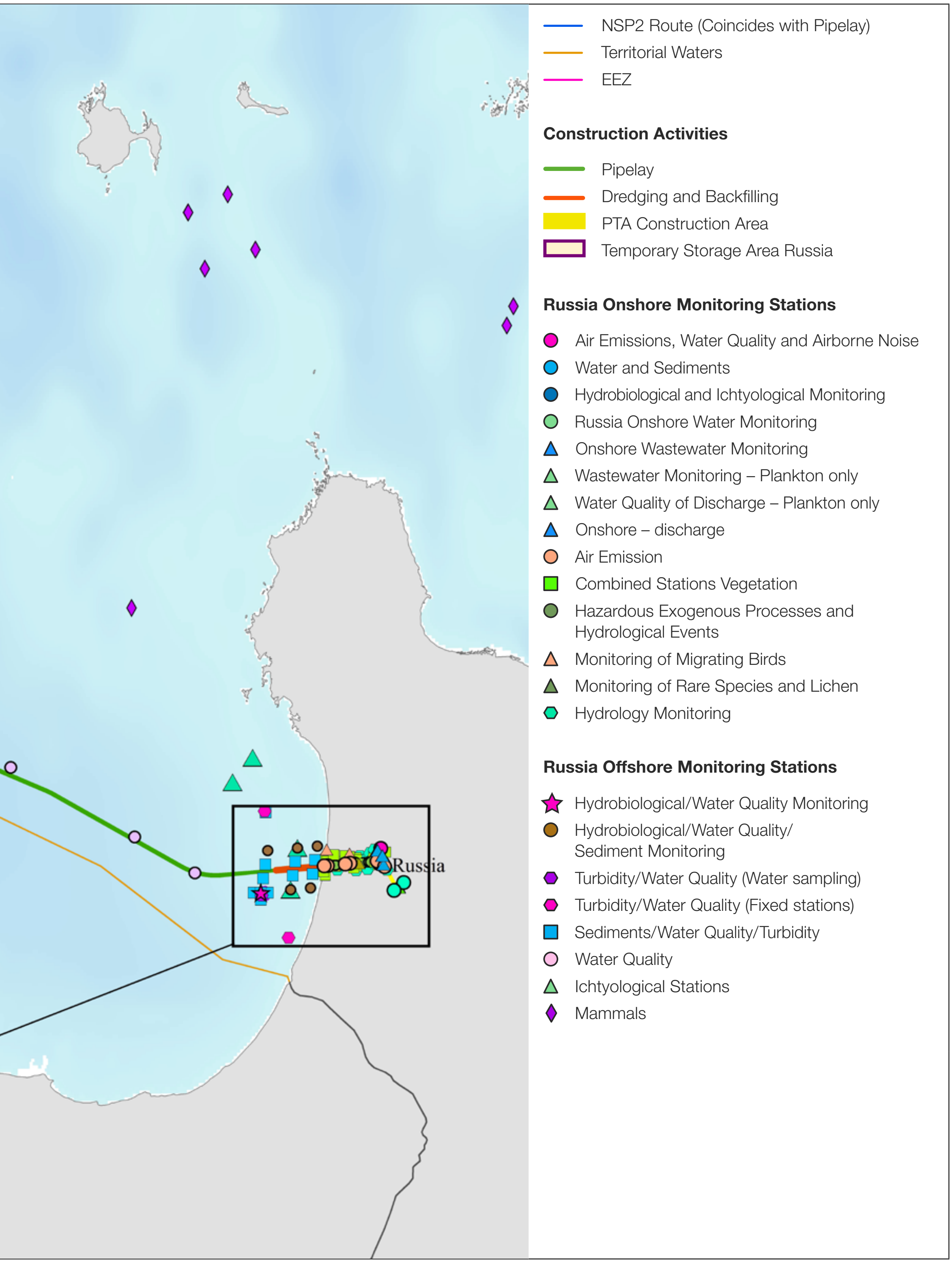
9 Appendices A–E

9.1 Appendix A

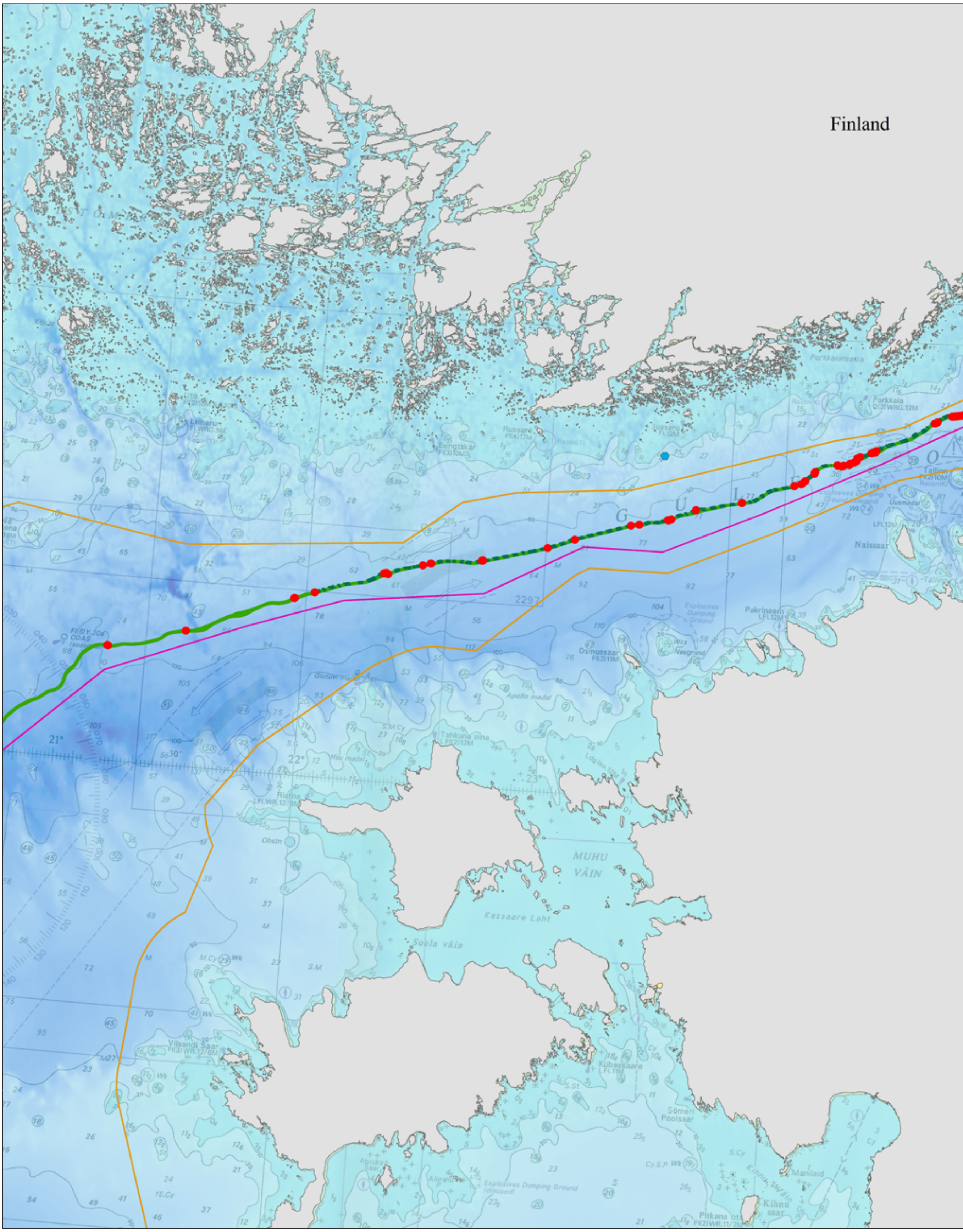
Construction activities and environmental monitoring in Russia

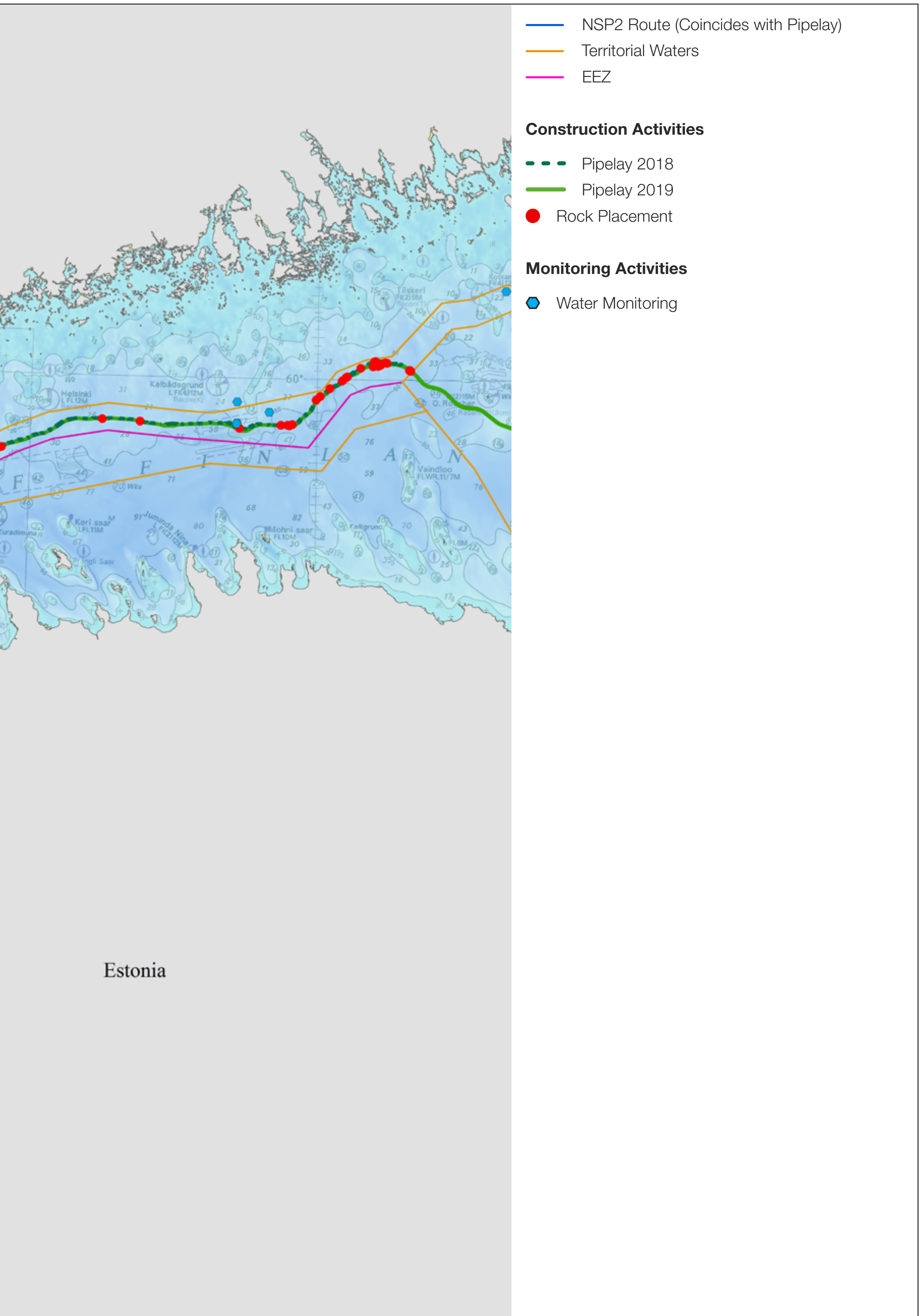



Russia
NSP2 Route (Coincides with Pipelay)
Territorial Waters
EEZ
Construction Activities
Pipelay
Dredging and Backfilling
PTA Construction Area
Temporary Storage Area Russia
Russia Onshore Monitoring Stations
Air Emissions, Water Quality and Airborne Noise
Water and Sediments
Hydrobiological and Ichtyological Monitoring
Russia Onshore Water Monitoring
Onshore Wastewater Monitoring
Wastewater Monitoring – Plankton only
Water Quality of Discharge – Plankton only
Onshore – discharge
Air Emission
Combined Stations Vegetation
Hazardous Exogenous Processes and Hydrological Events
Monitoring of Migrating Birds
Monitoring of Rare Species and Lichen
Hydrology Monitoring
Russia Offshore Monitoring Stations
Hydrobiological/Water Quality Monitoring
Hydrobiological/Water Quality/ Sediment Monitoring
Turbidity/Water Quality (Water sampling)
Turbidity/Water Quality (Fixed stations)
Sediments/Water Quality/Turbidity
Water Quality
Ichtyological Stations
Mammals

9.2 Appendix B

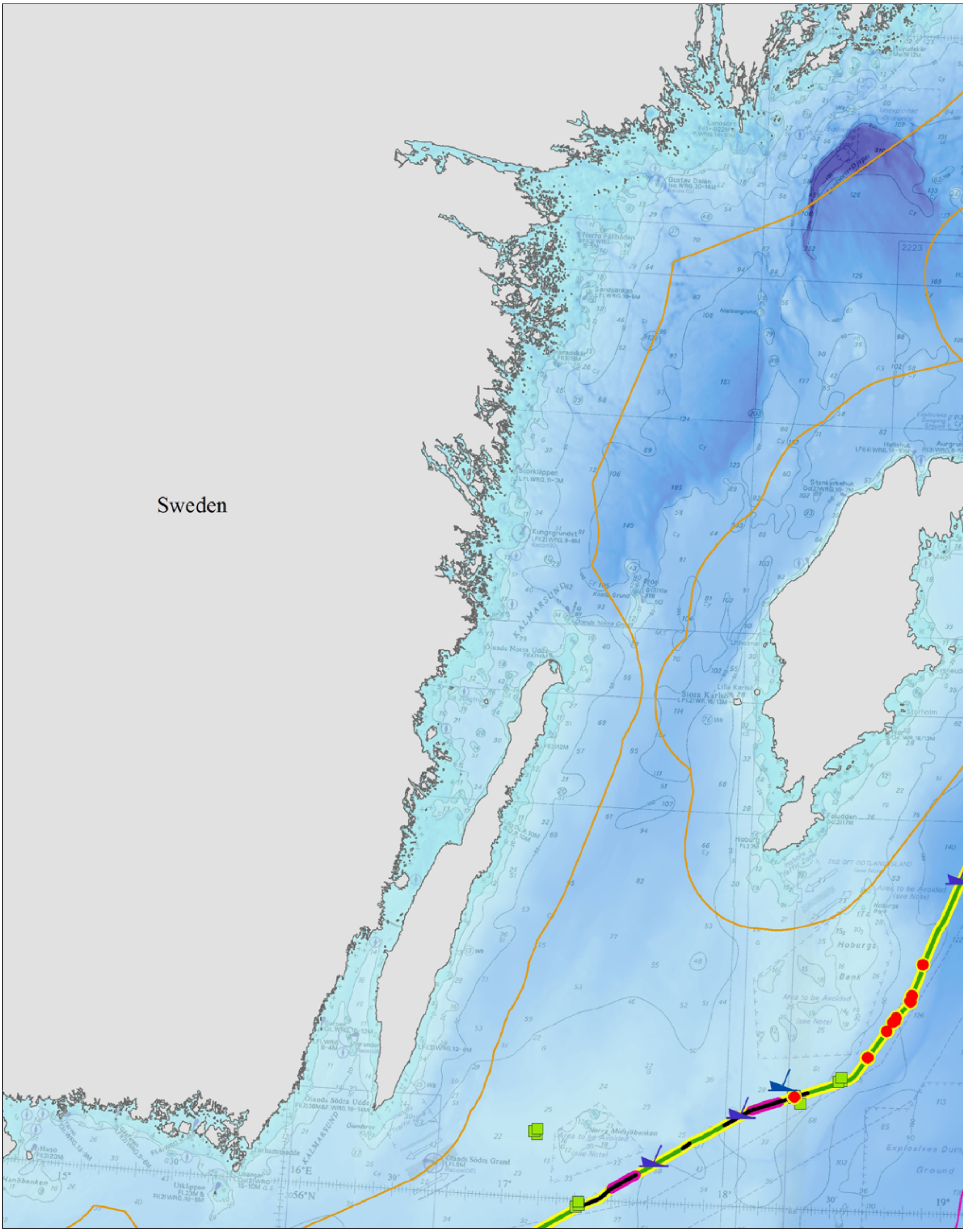
Construction activities and environmental monitoring in Finland

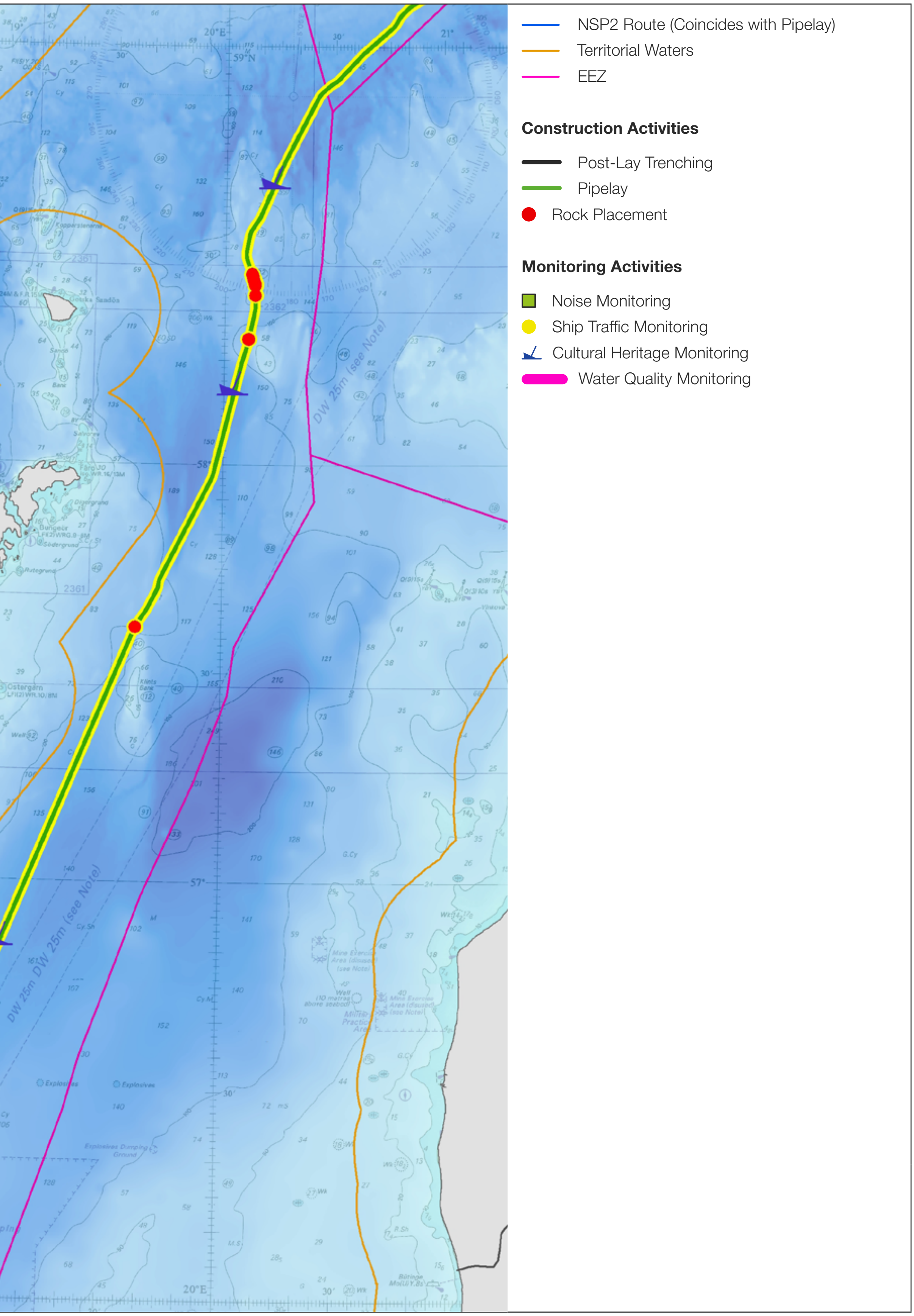



Estonia
Helsinki
Kalbådagrund
Keri saar
Vaindloo
Mohni saar
NSP2 Route (Coincides with Pipelay)
Territorial Waters
EEZ
Construction Activities
Pipelay 2018
Pipelay 2019
Rock Placement
Monitoring Activities
Water Monitoring

9.3 Appendix C

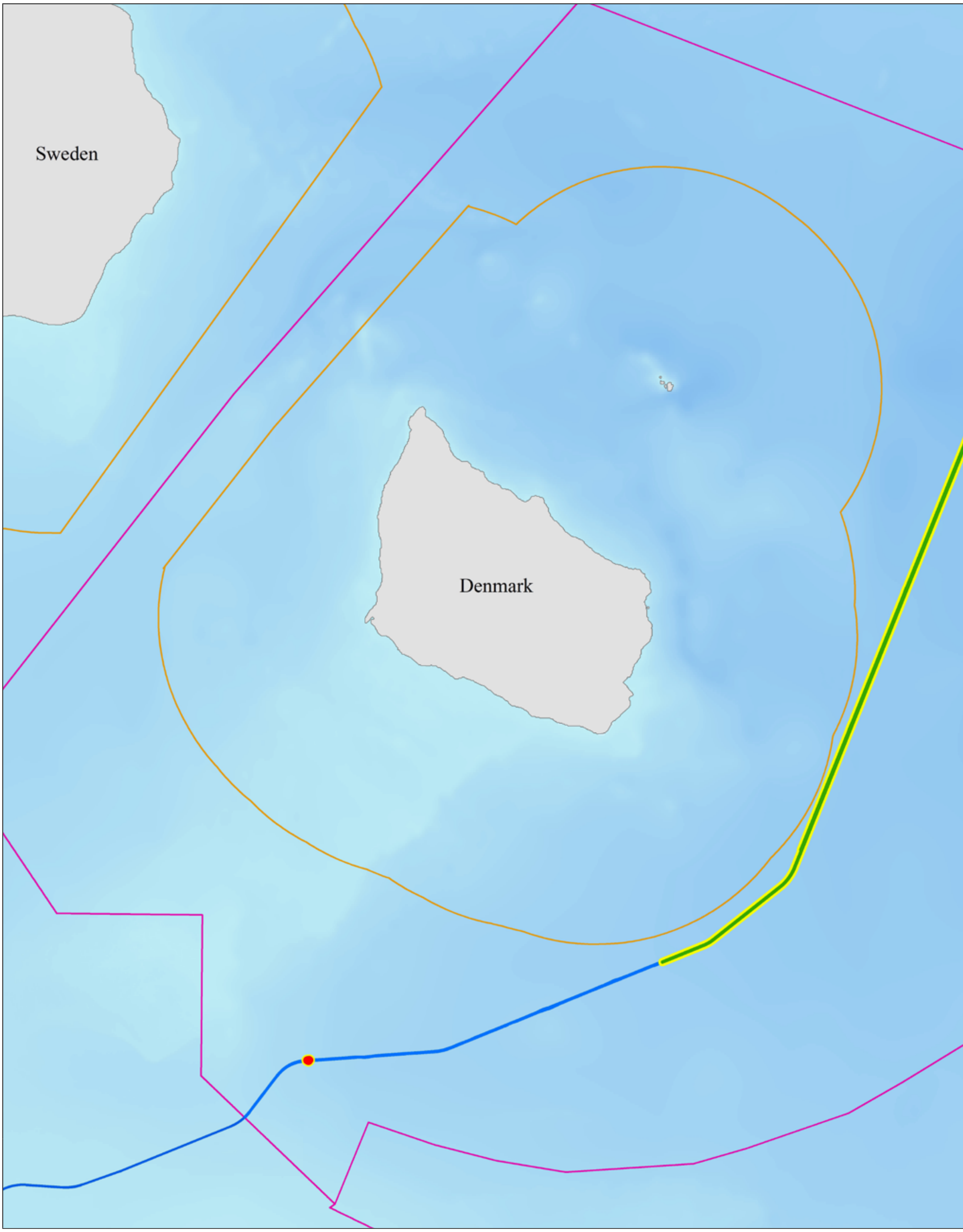
Construction activities and environmental monitoring in Sweden

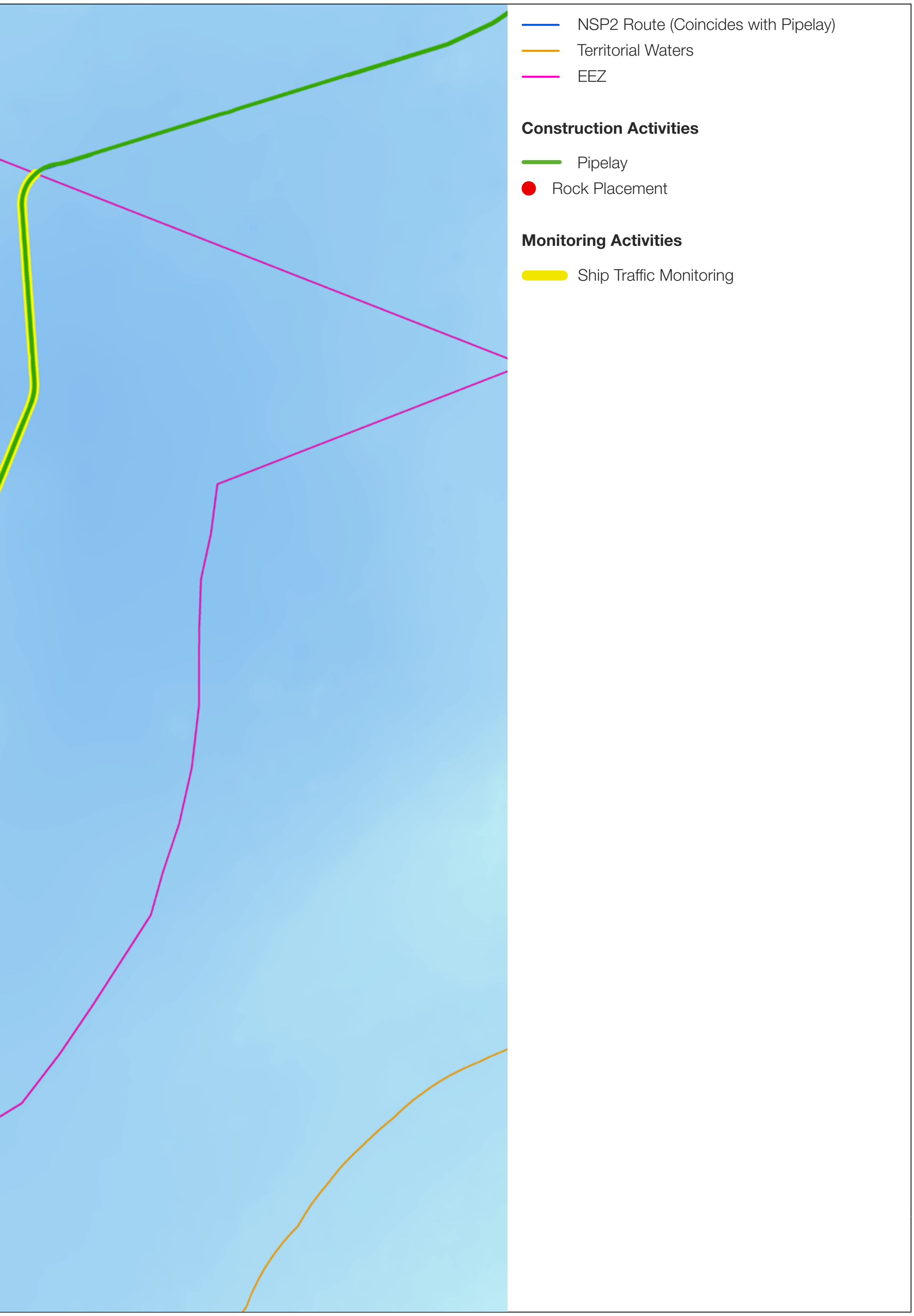



NSP2 Route (Coincides with Pipelay)
Territorial Waters
EEZ
Construction Activities
Post-Lay Trenching
Pipelay
Rock Placement
Monitoring Activities
Noise Monitoring
Ship Traffic Monitoring
Cultural Heritage Monitoring
Water Quality Monitoring
DW 25m (see Note)

9.4 Appendix D

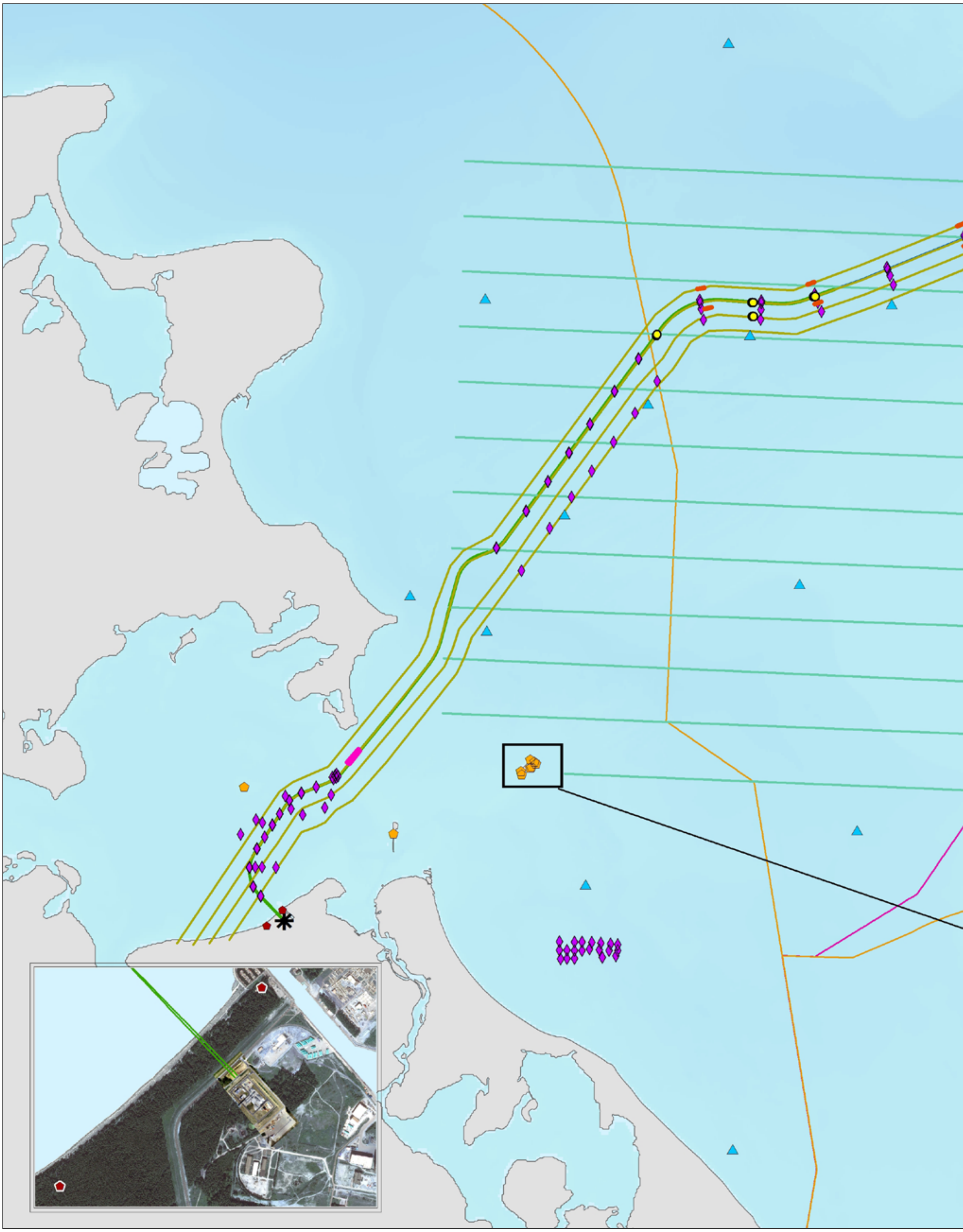
Construction activities and environmental monitoring in Denmark

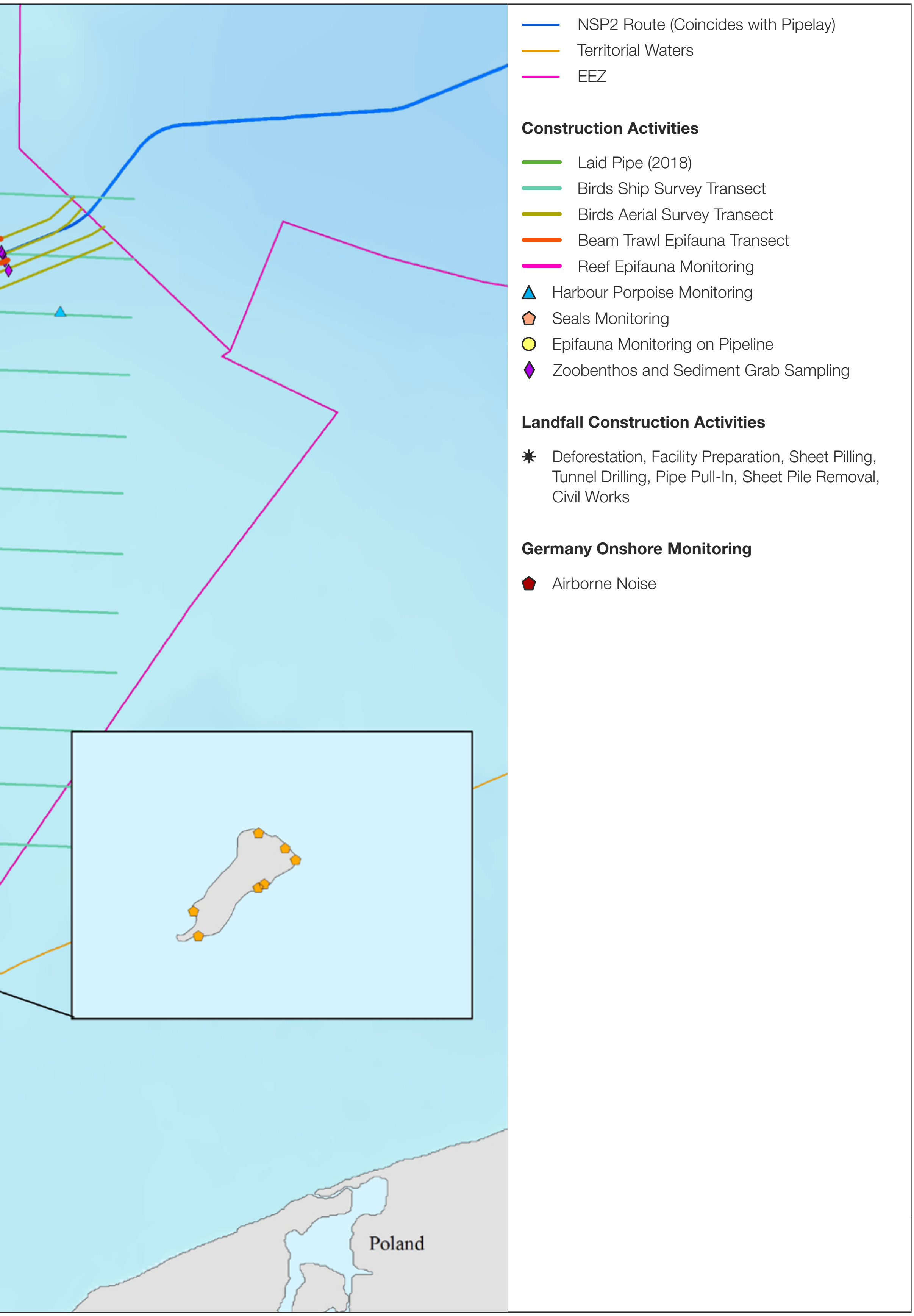



NSP2 Route (Coincides with Pipelay)
Territorial Waters
EEZ
Construction Activities
Pipelay
Rock Placement
Monitoring Activities
Ship Traffic Monitoring

9.5 Appendix E

Construction activities and environmental monitoring in Germany




NSP2 Route (Coincides with Pipelay)
Territorial Waters
EEZ
Construction Activities
Laid Pipe (2018)
Birds Ship Survey Transect
Birds Aerial Survey Transect
Beam Trawl Epifauna Transect
Reef Epifauna Monitoring
Harbour Porpoise Monitoring
Seals Monitoring
Epifauna Monitoring on Pipeline
Zoobenthos and Sediment Grab Sampling
Landfall Construction Activities
Deforestation, Facility Preparation, Sheet Pilling, Tunnel Drilling, Pipe Pull-In, Sheet Pile Removal, Civil Works
Germany Onshore Monitoring
Airborne Noise
Poland

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