5. MONITORING ACTIVITIES

This chapter describes the environmental monitoring activities performed during 2010. Monitoring was performed related to the following construction activities: munitions clearance, rock placement, cable mattress installation, pipelay with an anchored lay barge and pipelay with DP lay barge. Also long term water quality as background information has been monitored throughout the year starting from November 2009. Monitoring of munitions clearance started on 6th December 2009, when the clearance operation started.

Long term water quality monitoring and munitions clearance monitoring are included in this annual 2010 monitoring report starting November 2009. Monitoring in the reporting period has focused on seabed morphology, water quality, sediment contaminants, noise and pressure wave monitoring, fish, birds, benthos and marine mammals as well as condition of wrecks, barrels and cables. As the monitoring of munitions clearance is already presented in detail in a separate monitoring report "Nord Stream Munitions clearance in the Finnish EEZ, Final monitoring results on Munition by munition basis" /6/ and its addendum /7/, this annual monitoring report includes only a summary of those monitoring activities. Monitoring targets and stations during 2010 are presented in Table 5.1, Table 5.2, Figure 5.1, Figure 5.2 and Appendix 1-2. Monitoring activities have been conducted according to the approved environmental monitoring programmes /2/ /3/ /5/ unless stated otherwise.

Table 5.1 Monitoring activities during 2009 and 2010 included in the monitoring programmes for munitions clearance /3, 5/

Monitoring stations and targets during munitions clearance in 2009 and 2010		
Currents	49 munitions	Munitions clearance
Water quality	CONTROL1-2	Long term monitoring
	VOM1-4	Munitions clearance
	VOHE1	Munitions clearance, close to HELCOM station
	FIX1-2	Transboundary monitoring during munitions clearance in Russia
Sediment content	VOM1-3	Munitions clearance
	VOHE1	Munitions clearance, close to HELCOM station
Benthos	BENT3	Munitions clearance
Seabed morphology	49 munitions	Munitions clearance
Cables	7 cables	Munitions clearance
Wrecks	12 wrecks	Munitions clearance
Barrels	73 barrels	Munitions clearance
Fish, birds, marine mammals	49 munitions	Munitions clearance
Noise and pressure waves	Noise1-4	Munitions clearance, phase 1
	Noise2-4	Munitions clearance, phase 2

Table 5.2 Monitoring activities during 2010 included in the monitoring programme for pipeline construction and operation /2/

Monitoring stations and targets during pipeline construction activities in 2010		
Water quality	CONTROL1-2*	Long term monitoring
	FIX3	Transboundary monitoring during dredging in Russia
	VOFIXIW1-3	Rock placement
	LAY1	Pipelay with DP lay barge
	LAY2	Pipelay with anchored lay barge
Sediment content	SED2**	Rock placement
Benthos	BENT2**	Rock placement
HELCOM benthos monitoring stations	LL5, LL6A and LL7 with two parallel stations A and B	HELCOM station monitoring related to pipelines on the seabed
Seabed morphology	40 IW locations	Rock placement
	Pipeline	Pipelay
Mattress installation	18 locations	Installation of mattresses on seabed for cable crossings
Cable crossings	9 locations	Monitoring of pipelay onto the cable crossings
Wrecks	8 wrecks	Pipelay with anchored and DP lay barge
Barrels	4 barrels	Pipelay with DP lay barge

* Monitoring has started in 2009 and continued in 2010 ** Relates to VOFIXIW1 for water quality monitoring

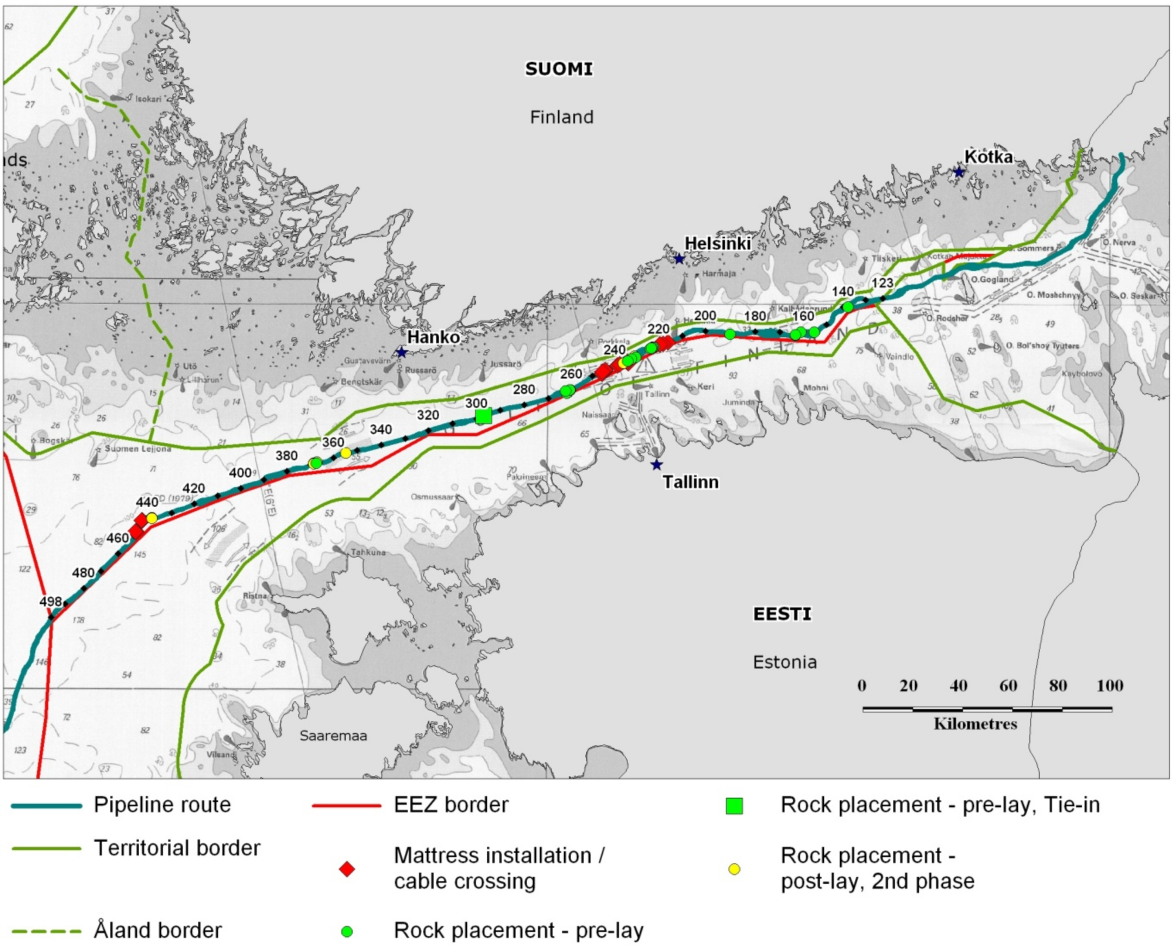

Figure 5.1 Locations of constructed cable mattresses, monitored cable crossings and rock placement during 2010

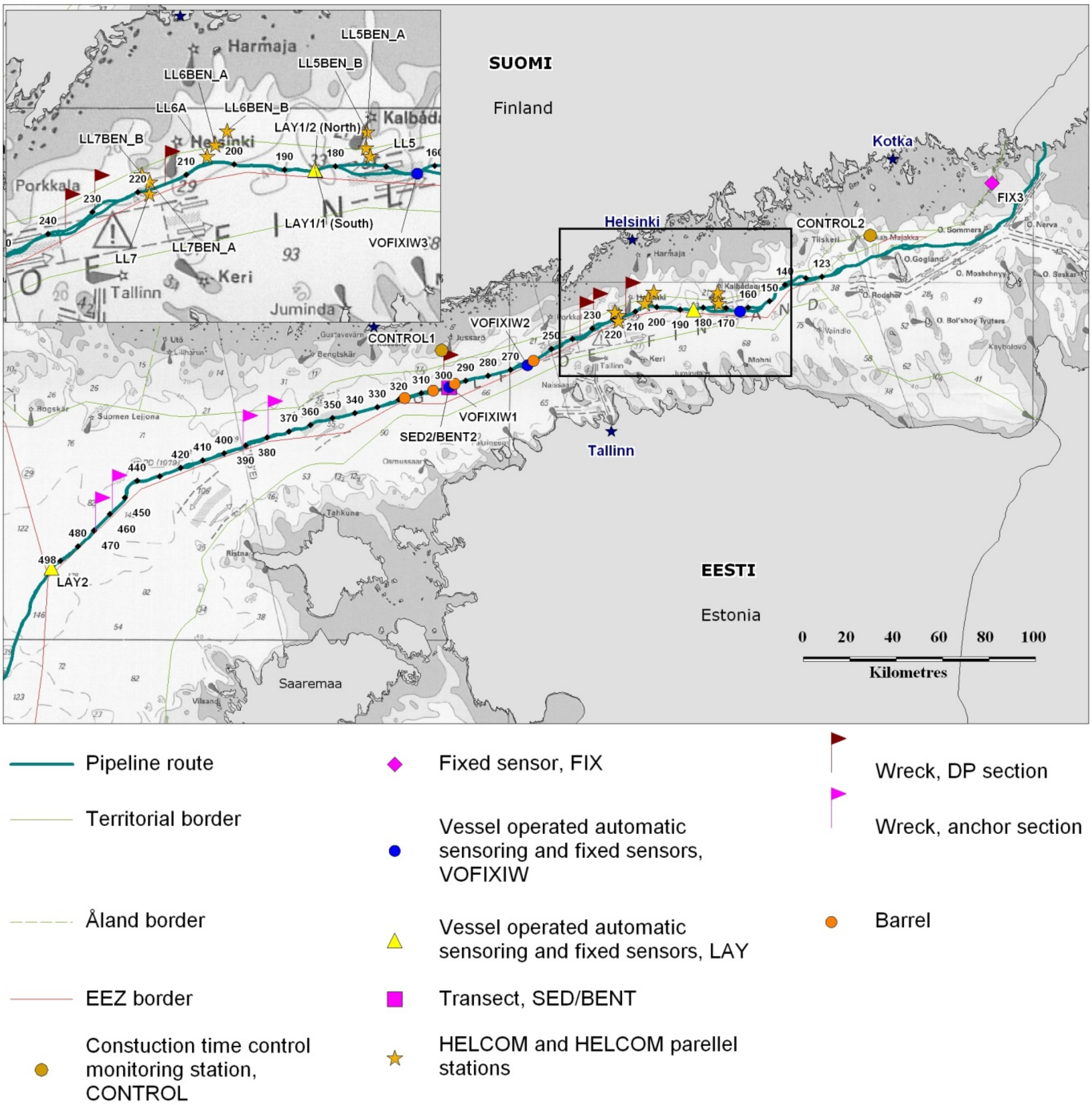

Figure 5.2 Locations of water quality, sediment, benthos and the HELCOM monitoring stations as well as monitored wrecks and barrels related to pipeline construction activities during 2010. Monitoring locations related to munitions clearance are excluded, these are presented in /6, 7/.

5.1 Methods and equipment

Most monitoring methods and equipment used have been the same, regardless of the different construction activities. In this chapter the most commonly used methods and equipment are described. Details of the monitoring methods and any specific methods, used only for certain monitoring activities, are described subsequently in Chapters 5.2-5.8 as relevant.

5.1.1 Seabed morphology, obstacles and pipeline

Monitoring of seabed morphology and obstacles is undertaken in connection with munitions clearance, rock placement, mattress installation and pipelay. The monitoring of all activities is carried out with an ROV instrumented with multibeam echo sounder (MBES), sonar and video cameras (Figure 5.3). The details of the equipment and methods used for the monitoring of

munitions clearance are reported in /6-7/ and of the other relevant construction activities in Chapters 5.3-5.5 of this report.

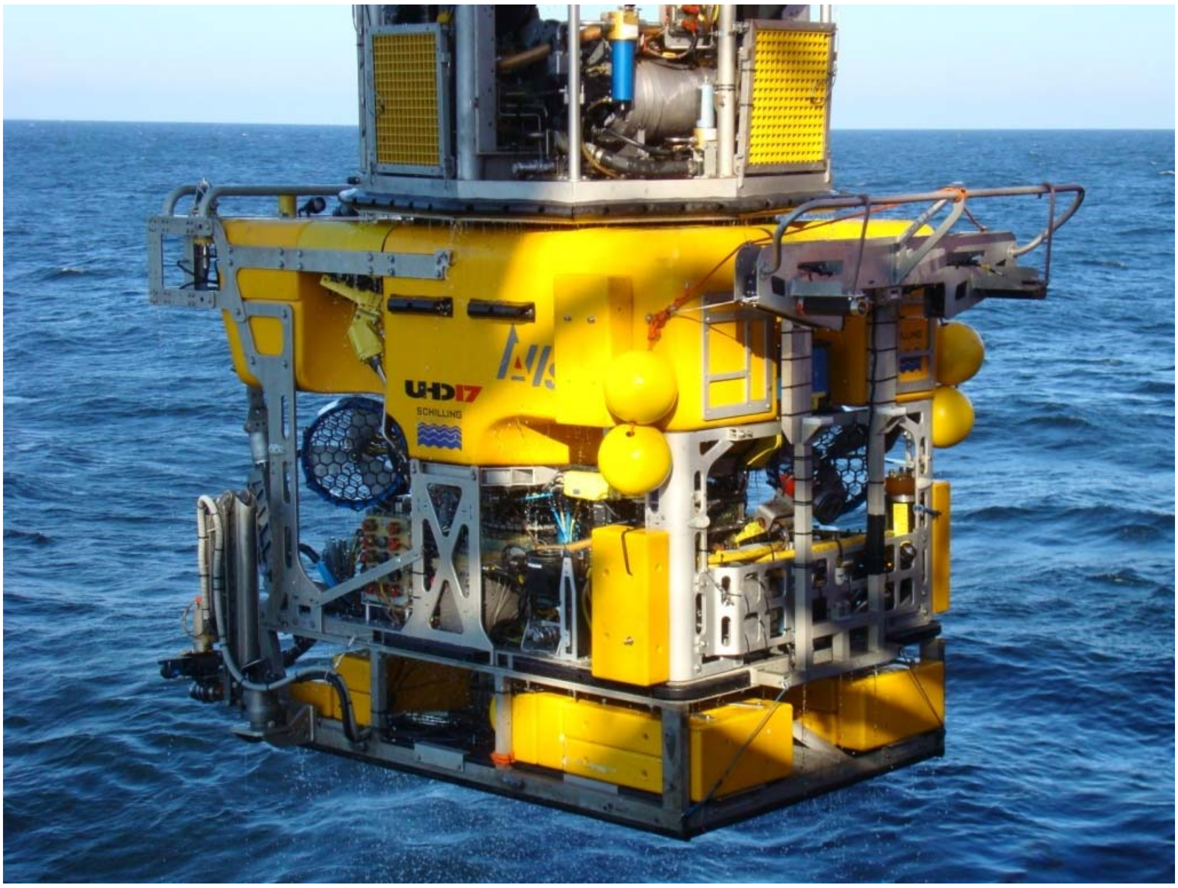

Figure 5.3 A picture of an ROV used in connection with seabed studies

5.1.2 Water quality

Water quality monitoring was performed in connection with munitions clearance, rock placement, pipelay by the anchored and DP lay barge as well as dredging at Russian landfall. Water quality monitoring has been performed with vessel operated monitoring, fixed stations and water sampling.

<u>Vessel operated monitoring</u>
Vessel operated automatic sensoring has been carried out with a multi parameter sonde that measures turbidity, temperature, conductivity and depth /39 – 41/. This automatic self-logging instrument (Figure 5.4) is lowered from a support vessel from sea surface to bottom along pre-planned transect lines. Data is gathered with 20 to 50 cm intervals. According to the monitoring programme /2/, each transect is measured two to three times, depending on the construction activity.

Data from vessel operated automatic sensoring is shown as transect figures presenting how the solid material in a plume behaves with respect to the monitored construction activity. Salinity, turbidity and temperature data are presented as vertical profiles.

Figure 5.4 Self-logging YSI multiparameter sonde used in vessel operated automatic sensoring (left) and a Limnos water sampler (right) /39, 40/

Fixed stations and ADCP
Monitoring at Fixed stations has been performed with self-logging YSI-6600 and YSI-600 series Deep Water multiparameter sondes (Figure 5.4 above). The sensors measure turbidity, temperature, conductivity and oxygen concentration. Sensors are anchored approx. 1-2 m above the seabed for a certain period of time and gather information every 60 minutes. Sensors are anchored to the seabed before construction activity and recovered after the activity is completed. Sensors are equipped with acoustic releasers for recovery of the instruments (Figure 5.5).

An ADCP (Acoustic Doppler Current Profiler) has been attached to fixed stations at some monitoring locations to monitor changes in the current field (current speed and direction) over the entire water column. The ADCP has been placed in close proximity of fixed sensor to the seabed (Figure 5.5) and measure the current field from bottom to surface with a two metre vertical resolution at 60 minute intervals. One measurement is taken every 60 seconds and the averaged value is logged every 60 minutes, which allows the current velocity to be measured with accuracy better than 1 cm/s.

Schematic presentation of fixed sensor and ADCP on the seabed is presented in Figure 5.5 (right).

Figure 5.5 ADCP equipment (RD-Instruments Workhorse Sentinel ADCP) used in current monitoring, (left). Sonardyne acoustic releaser with a distance transponder (middle). Schematic placement of fixed sensor and ADCP (right). /40, 41/

Data from fixed sensoring and the ADCP are presented as time series figures. In addition, the current data has been analysed and shown as distribution figures for current magnitude and direction.

Water sampling and CTD profile
Water samples have been taken to calibrate monitoring equipment and for analysis of nutrients and contaminants. The water samples have been taken both along transect lines and in connection with the installation or service visits and recovery of the fixed stations. Water samples for analyses along the transect lines were gathered at 10 m intervals from surface to bottom. Samples were collected with a 3.5 litres Limnos water sampler (Figure 5.5 above). All water samples were stored in bottles, labelled and kept cold until transportation to the laboratory.

The water samples were analysed for turbidity, suspended solids, conductivity, oxygen concentration, metals (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn), dissolved phosphate phosphorus (PO_4), nitrate-nitrite (NO_3 - NO_2), ammonium (NH_4) as well as total phosphorus (P) and nitrogen (N). Samples were analysed in an accredited laboratory of Kokemäenjoen vesistön vesiensuojeluyhdistys ry. Analyses results have been presented as tables with the sampling locations and the analysed concentrations /39, 40/.

CTD profiles (conductivity, temperature, depth) were recorded by lowering a multi-parameter sonde from the survey vessel through the water column from surface to bottom during installation, service and recovery of fixed sensors.

5.1.3 Sediment

Sediment samples were taken at pre-determined locations in accordance with the monitoring programme /2/. Sampling was performed in connection with munitions clearance and rock placement /41, 43/. Samples were taken along a transect 50, 100, 200, 400, 800, 1,600 and 3,200 metres directly north of the activity. Sediment samples were collected from the uppermost 0 – 2 cm section of surface sediment[6]. In addition deeper samples, 2 – 10 cm, were taken from the two closest locations (50 and 100 m). Samples were taken with a GEMAX type sampler (Figure 5.6, left), which is lowered to the seabed with a hydraulic winch. Samples were sliced into sub-samples, stored in containers, labelled and kept cold until transportation to the laboratory /41, 43/.
The samples were analysed for dioxins/furans, organic tin compounds (TBT, TPhT and their degradation products), metals (As, Cd, Co, Cu, Cr, Hg, Ni, Pb, Zn) and nutrients (Tot-P, PO_4-P, Tot-N, NO_2-N, NO_3-N and NH_4-N) in accordance with approved standards in an accredited laboratory, Eurofins Scientific Finland Oy. Also the grain size distribution/clay content and organic matter content required in normalizing the results were analysed /41/.

Sediment sampling has been performed in accordance to the monitoring programme /2/ once before the activity commenced and once after the activity was completed. Further two sampling campaigns will be performed upon the completion of the first pipeline and the completion of the second pipeline, a total 4 times.

The sediment analysis data from all sampling stations is reported as actual concentrations and as normalized concentrations. These results are presented in tables and in graphs as concentrations in relation to the distance from the activity.

[6] Surface sediment normally covers sediment layer 0-20 cm, but definition can vary depending on the context it is used.

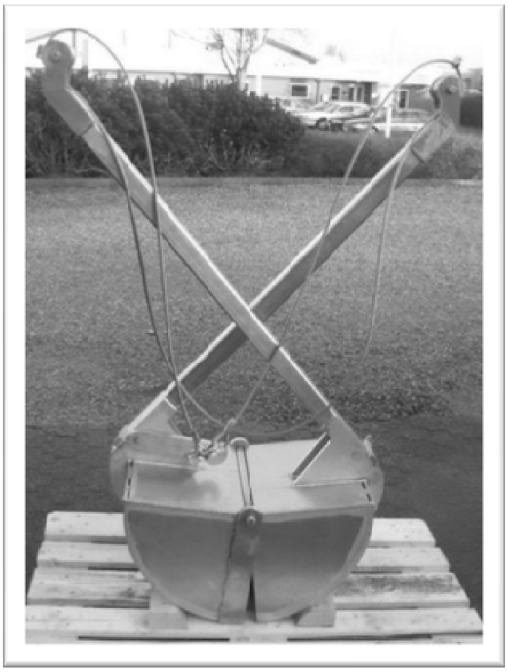

Figure 5.6 GEMAX sediment sampler (left) and Van Veen benthos sampler (right) /41, 43/.

5.1.4 Benthos

Benthos sampling was performed in connection with munitions clearance and rock placement activities. The sampling locations have been identical to the locations for the sediment sampling. In addition oxygen concentration, temperature and salinity measurements were carried out in the water column just above the bottom at each sampling site. Samples were taken along a transect 50, 100, 200, 400, 800, 1,600 and 3,200 metres directly north of the construction activity. /41/

Benthos samples were taken with a Van Veen grab (Figure 5.6, right). Three different replicates were taken from each sampling location and each individual sample was kept separated. Samples were sieved onboard through 1.0 and 0.5 mm sieves, preserved in 70-% methanol and stored in plastic containers for more detailed analyses in the laboratory.

Macrozoobenthos species were indentified and abundances were calculated. The number of individuals and biomasses were calculated per square metre. The total biomasses of the samples were determined as wet weight with a 0.01g accuracy. The lengths of the shells *of Macoma baltica* were measured and accordingly divided into three different groups (<4 mm, 4-10 mm and >10 mm) /41/.

Benthos monitoring was performed according to the monitoring programme /2/ once before the activity commenced and once after the activity was completed. Additional sampling will be carried out after the completion of both the first and second pipeline, once a year for 3 years (in total 5 times).

Benthos sampling has also been performed in connection with the monitoring of HELCOM benthos monitoring stations. This monitoring is presented in more detailed in Chapter 5.6.

5.1.5 Wrecks, barrels and cables

Wrecks, cables and barrels have been monitored prior to and after munitions clearance and pipelay. Monitoring of wrecks and cables was performed with MBES and visual surveys by using an ROV. The monitoring of barrels was carried out through visual inspection with an ROV.

The specific methods used for monitoring any impacts from munitions clearance are reported in /6-7/.

Monitoring of wrecks related to pipelay was performed with two ROVs. One ROV was equipped with MBES to produce 3D images and to serve as a navigation aid for visual survey. The other ROV was equipped with cameras to perform visual survey of the wrecks. Wreck features considered to be significant were subjected to further inspection. The post-lay surveys of wrecks were performed using an ROV equipped with cameras in order to collect still images of the selected wreck features. /44 – 51/

At the cable crossings pipelay was monitored through an ROV based touchdown monitoring (TDM). As-laid survey of the pipeline consisted of MBES and visual surveys by using an ROV /52, 70-72/. As-left surveys of all crossing structures consisted of a general video inspection over the whole crossing structure and MBES survey. In sections where the pipelay was performed by the anchored lay barge *Castoro Sei* also a visual survey 1,000 m either side of the crossing along the cable was performed. The as-left survey was performed by using an ROV /53-54, 87-90, 127-129/.

Pre-lay survey of barrels related to pipelay was performed by using an ROV equipped with video cameras. Barrels were surveyed from every side (360 degree inspection). /86/

5.1.6 Ship traffic

Nord Stream has during the period November 2009 – December 2010 provided 14 notifications for pipelay construction activities to the Border Guard and the Finnish Transport Agency before vessels entered Finnish Waters. The submitted notification documents have been prepared according to information requested by Finnish authorities. In addition Nord Stream has submitted both monthly forecasts and monthly reports to the authorities. The vessels have provided weekly and daily progress reports to the relevant authorities. Several meetings to present construction activities and agree communications procedures were held.

Vessel movements have been monitored by GOFREP. The Finnish Transport Agency has published notices to mariners on project activities.

Safety zones to avoid adverse impacts on commercial shipping were established around all construction activities as munitions clearance, rock placement, mattress installation and pipelay.

5.2 Munitions clearance

During munitions clearance, monitoring of currents, changes in seabed morphology, water quality, sediments and benthos was performed (Figure 5.7). Noise and pressure waves were monitored and their impacts to wrecks, cables and barrels. Furthermore, seabirds, fish and marine mammals were monitored during munitions clearance and mitigation measures were performed. Monitoring during munitions clearance is presented in more detailed in a separate monitoring report and its addendum /6,7/.

Monitoring during munitions clearance is summarized in the following Table 5.3.

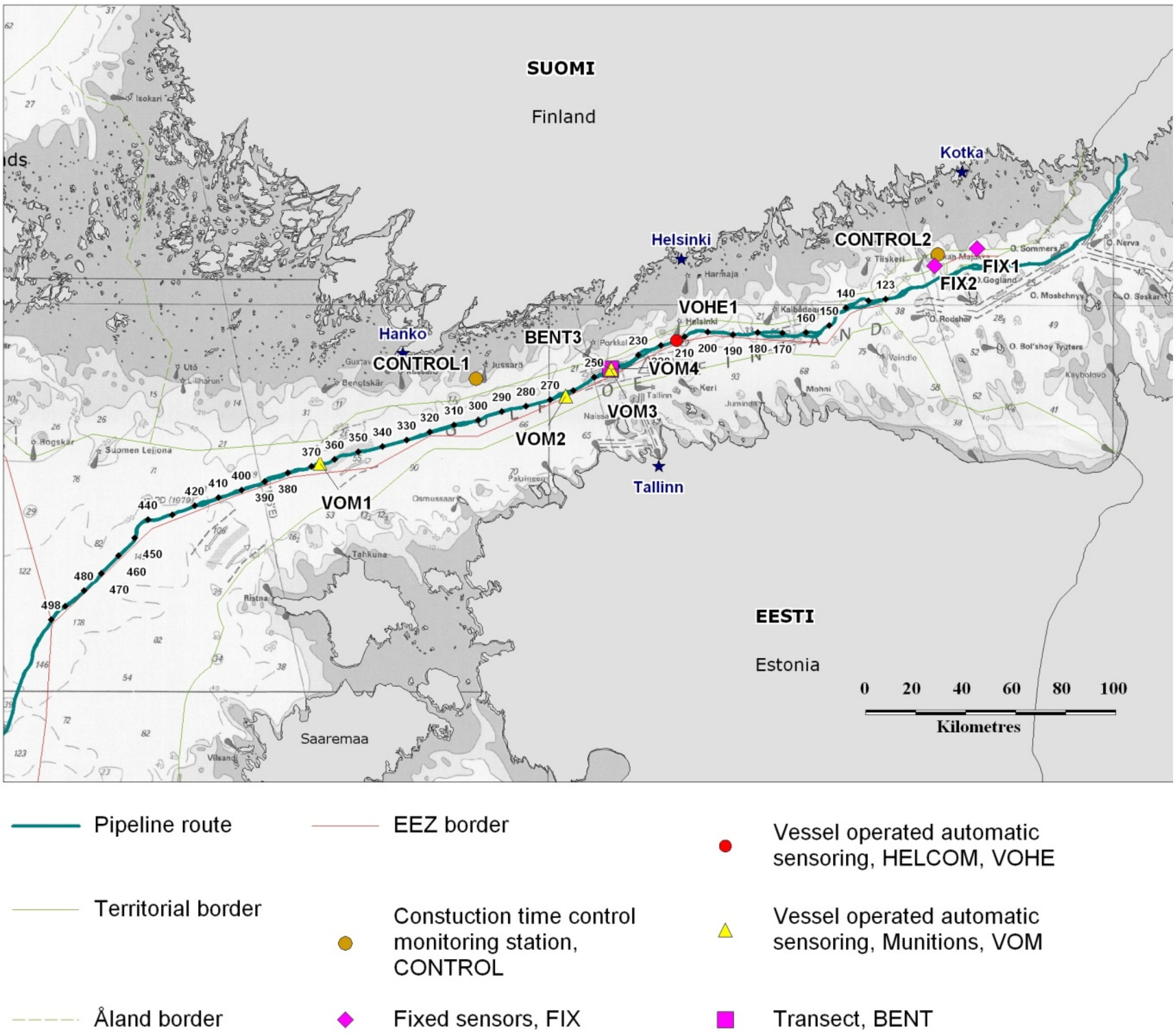

Figure 5.7 Water quality, sediment quality and benthos monitoring during munitions clearance in Finnish EEZ

Table 5.3 Monitoring during munitions clearance in Finnish EEZ

Parameter	Unit	Method	Location	Timing
Crater / depression	m (depth, radius), m^3 (volume)	Multi-beam echo sounder and visual inspection via ROV	All munitions cleared	Prior to and after detonation
Current speed and direction, turbidity, conductivity, temperature and oxygen concentration	m/s (current speed) and degree (direction)	Sensoring from vessel	All munitions cleared	Once prior to the detonation
	m/s (current speed), degree (direction), NTU (turbidity), µs/cm (conductivity), °C (temperature) and mg/l (oxygen)	ADCP with a turbidity sensor and CTD-profile	2 stations close to Natura 2000 area in Tammisaari archipelago and Eastern Gulf of Finland (CONTROL1-2)	Started ca. 2 weeks before the clearance and continues ca. two weeks after the finalization of the pipeline construction, CTD-profile when uploading data

Water samples for metal and nutrient analysis and calibration of sensors	mg/l and FTU (turbidity), mg/l (oxygen), μs/cm (conductivity) and μg/l (total and dissolved P and N, metals)	Water sampling for analysis and calibration	VOM1-4 VOHE1	Directly before and after detonation
			FIX1-2 CONTROL1-2	Every time when data was uploaded
Sediment, nutrients and contaminant dispersion, conductivity, depth and temperature	NTU (turbidity), km (distance and height), h (duration), μs/cm (conductivity), °C (temperature) and m (depth)	Vessel operated automatic sensoring	4 locations based on large charge sizes, seabed of hard clay or mud or close to the Estonian border (VOM1-4)	Once before and two times directly after detonation
		Vessel operated automatic sensoring for HELCOM stations	1 location based on the close proximity to a HELCOM station (VOHE1)	Once before and two times directly after detonation
		Fixed sensoring and CTD-profile	2 locations in the Eastern Gulf of Finland (FIX1-2)	Started ca. 2 weeks before the clearance in Russia and continued ca. two weeks after the clearance, CTD-profile when uploading data
Sediment sampling for analyses of metals, nutrients, dioxins and organic tin compounds and for normalization of the results	mg/kg, (As, Cd, Cr, Co, Cu, Hg, Ni, Pb, Zn, nutrients), ng/kg (dioxins), ug/kg (organic tin compounds), m -% (grain size distribution/clay content,organic matter content)	Sediment sampling with GEMAX-core sampler or similar	VOM1-3 and VOHE1 locations	Once before and once after detonation
Pressure wave	psi (pressure), s (time)	Pressure wave sensor close to the cables or wrecks	7 locations: Noise1-4 in Phase 1 Noise 2-4 in Phase 2	During detonation
		Pressure wave sensor on the PAM buoy	Each detonation site	
Marine mammals and seabirds	Present / absent, number and species, injured (yes / no)	Visual observation by MMO, PAM	All munitions	Prior to and after detonation
Fish shoals	Present / absent	Sonar sweep		Prior to detonation
Mortality of fish	Yes / no, estimated amount and species	Visual observation and collection by nets		After detonation
Benthos, oxygen concentration	Ind./m^2, species/m^2 (abundance), g/m^2 (biomass) and mg/l (oxygen)	Van Veen grab (0.1 m^2)	Benthos sampling transect BENT3	Prior and after detonation

Parameter	Unit	Method	Location	Timing
Cultural heritage sites	Intact / damage	Visual inspection by ROV	All wrecks within 1.0 km from munitions and wrecks S-11-3138 and MB-07-2736 close to munitions F23 and F4	Prior to and after detonation
Cables	Intact / damage		All cables within 1.0 km from munitions	
Barrels	Intact / damage and displacement		Munitions cleared under MP: Until 6 May 2010 all barrels within 1.0 km from munitions; from 7 May 2010 all barrels with environmental risk class 2 or 3 within 1.0 km from munitions; Munitions cleared under WP: all barrels with environmental risk class 2 or 3 within 1.0 km.	

5.3 Rock Placement

During pre-lay rock placement, monitoring of changes in seabed morphology, water quality, sediments and benthos was performed. During post-lay rock placement, seabed morphology was monitored. There were no wrecks, barrels or cables within 50 m of the rock placement sites. The closest distance from a rock placement site to a known wreck, barrel or cable was 0.8 km (barrel). Therefore no monitoring of these potential targets was performed in connection with rock placement.

Pre-lay rock placement was performed at 27 locations in the Finnish EEZ during 2010, including the tie-in at KP 297. Post-lay rock placement was performed at 13 locations. Rock placement locations for 2010 are presented in Figure 3.2.Tables presenting the performed monitoring (Table 5.4), locations (Table 5.7) and timing (Table 5.6) are presented at the end of this Chapter.

5.3.1 Seabed morphology

Seabed morphology was mapped at every rock placement location prior to and after construction of the rock berm. Monitoring was performed with an ROV equipped with MBES, sonar and video cameras (Table 5.4 and Table 5.5). The survey extended laterally at least 10 m beyond the planned rock berm area. If the distance between rock berm locations was less than 200 m, then only one integrated survey to inspect the areas was performed. In addition, prior to rock placement, a gradiometer survey was carried out of the installation corridor of the pipeline (+/- 7.5 m either side of the planned pipeline route). If the area of the planned rock berm extended outside of the installation corridor then the survey was performed in a wider area.

Monitoring was performed as presented in the monitoring programme /2/.

5.3.2 Water quality

In connection with rock placement activities water quality has been monitored with vessel operated automatic sensoring, fixed stations and water sampling at three stations VOFIXIW1, VOFIXIW2 and VOFIXIW3 (Figure 5.9 and Tables 5.4 - 5.6). Methods are described in Chapter 5.1. The monitoring locations were selected on the basis of rock placement volume, seabed sediment type and proximity to the Estonian EEZ.

Vessel operated monitoring was performed along the DPFV's track some 50-200 m away on both sides and it was repeated twice on both sides. Transects were 1,000-1,200 m long. Transect lines continued 400-500 meters in front of and behind the vessel (Figure 5.8). A transect took 30-45 minutes during which time the DPFV had reached the middle section of the monitoring transect.

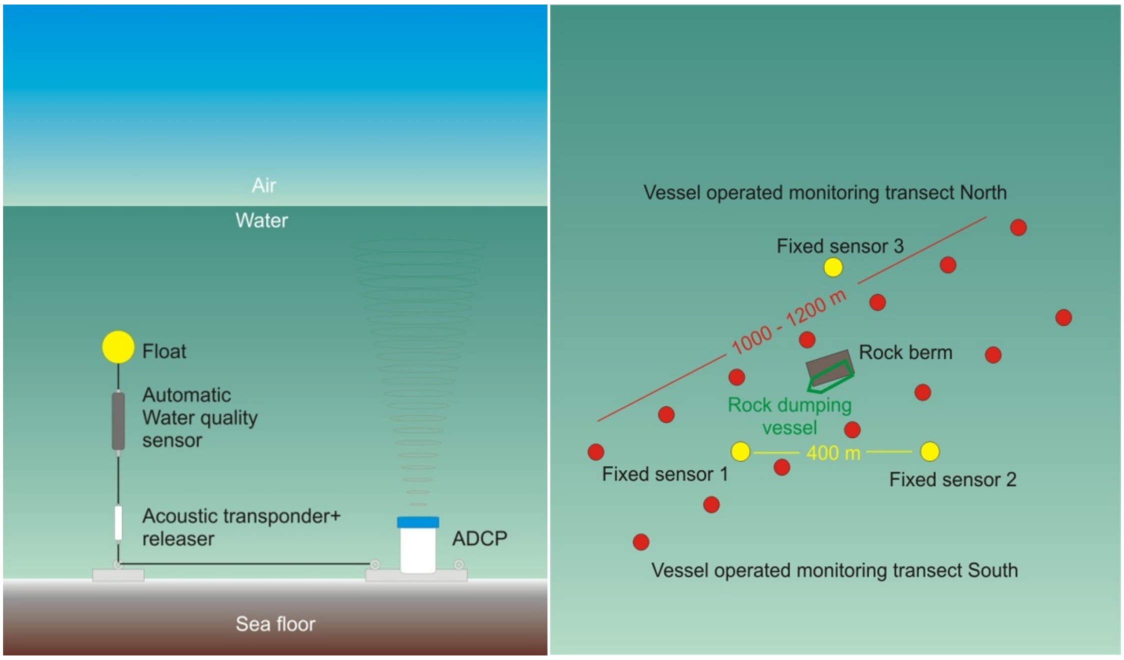

Figure 5.8 Example of a measurement setup for moored fixed stations (left figure, not in scale). A schematic drawing of fixed sensors and orientation of vessel operated monitoring transects at one monitoring site (right, view from above). /41/

Three fixed sensors (FIX, S1-S3) were installed in a triangular form around the rock placement site. The distance between sensors was approximately 400 metres. An ADCP was attached to the southernmost fixed sensor.

Water samples during rock placement were taken on one location, based on the results of the first vessel operated monitoring round, from surface to bottom at 10 m intervals. An additional one water sample from each station was taken and the CTD profile measured during the recovery of the fixed sensors.

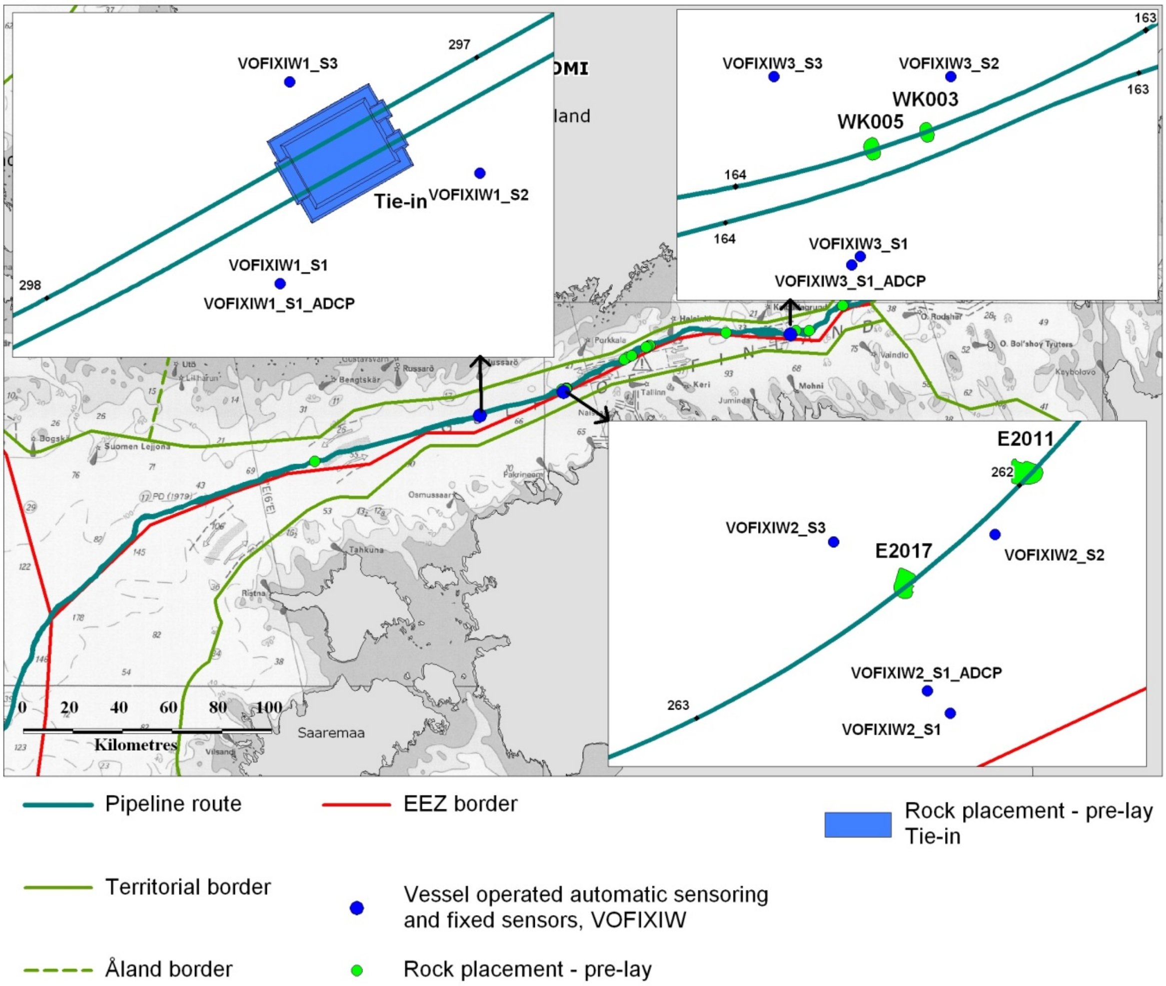

Figure 5.9 Layout of water quality and current monitoring stations VOFIXIW1-3 including fixed sensors (FIX) and ADCP

Monitoring was performed as presented in the monitoring programme /2/ with the following clarifications and modifications /41/:

- Monitoring lines for vessel operated monitoring were 50 m – 200 m on either side of the rock placement vessel. For safety reasons the direction of the lines followed the movement direction of the rock placement vessel. Monitoring was done along these lines, two times during rock placement. According to monitoring programme /2/, the vessel operated monitoring was planned to be performed once before and two times after rock placement.
- Based on the first monitoring results of vessel operated monitoring, water sampling was carried out at one location at each monitoring station. According to monitoring programme /2/, 4 to 6 samples were also planned to be taken according to the sensoring data from the sites that either represent the maximum turbidity concentration or at which elevated turbidity concentrations are no longer observed.
- In addition to the parameters defined in the monitoring programme, metals were also analysed from the water samples taken during recovery of the fixed sensors.

5.3.3 Sediment and benthos monitoring

Contaminants in seabed sediment were monitored in connection with pre-lay rock placement at one location (SED2) and likewise so were benthos species at the same location (BENT2). The SED2/BENT2 stations are at the same location as water quality monitoring station VOFIXIW1

(Figure 5.10). Sediment and benthos sampling was carried out before and after rock placement along a transect line at SED2/BENT2. Sediment samples before and after the activity and benthos samples before the activity were taken at seven different distances from the rock placement site according to the approved monitoring programme /2/. Due to bad weather conditions, it was not possible to perform benthos sampling after the rock placement in BENT2/2 and BENT2/3 sampling locations. Methods are described in more detail in Chapter 5.1.

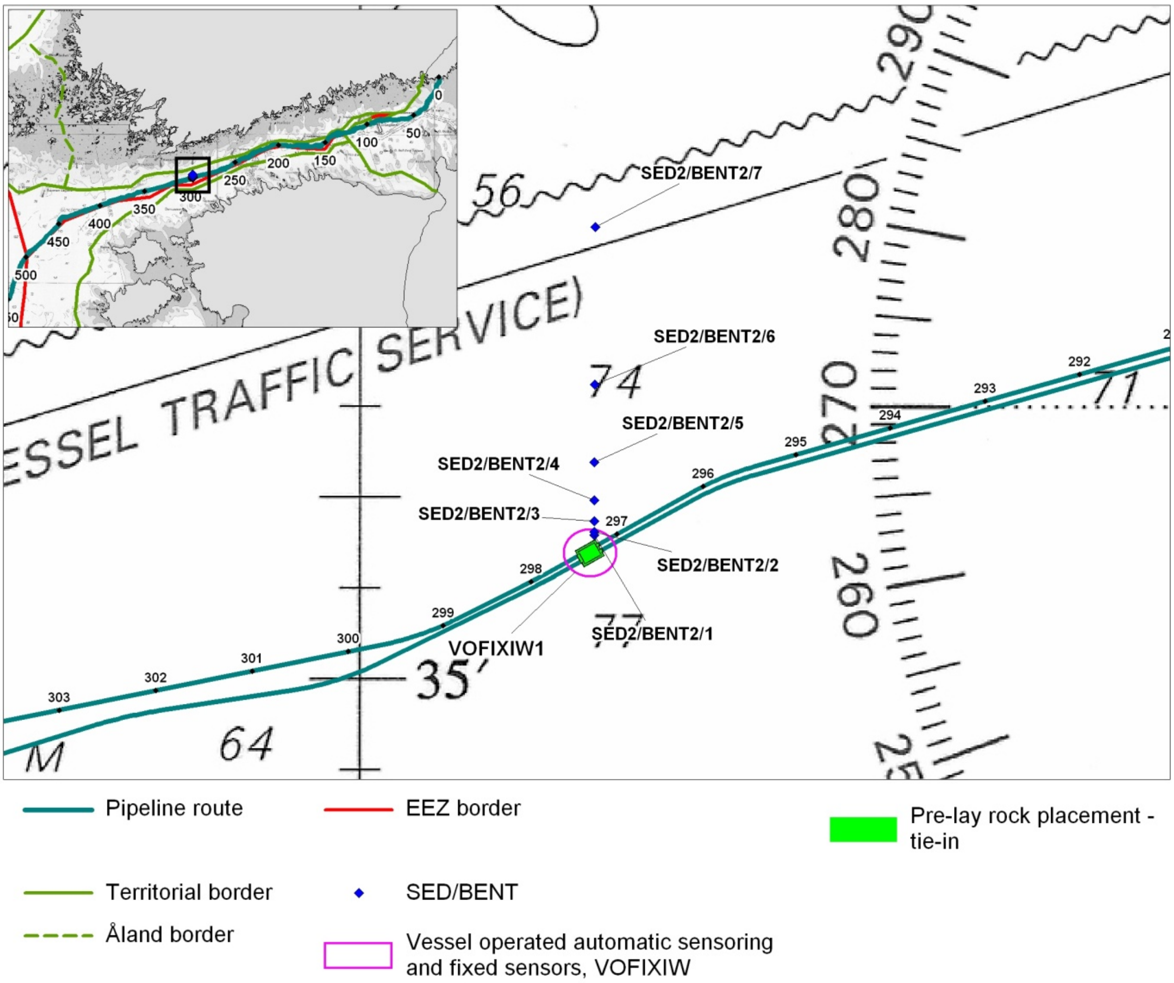

Figure 5.10 Locations of SED2/BENT2 1-7 sampling sites

5.3.4 Summary of monitoring

A summary of the monitoring for rock placement is presented in Tables 5.4, 5.5 and 5.7. Timing of monitoring is presented in Table 5.6.

Table 5.4 Environmental monitoring of rock placement in 2010

Monitoring of rock placement during 2010					
Monitoring target	**Parameter**	**Unit**	**Method**	**Location**	**Timing / frequency**
Seabed morphology	Obstacles and presence of unknown objects	Yes / no, location (coordinates)	Instrumented ROV with multi-beam echo sounder, sonar and video cameras	All rock placement locations	Prior to pre-lay rock placement
	Seabed bathymetry	m (depth)			Prior to rock placement
	Condition of berms	m^3 (volume), *m (height)*			Monitoring berm during placement and after rock placement
Water quality and currents	Suspended sediment, nutrients and contaminant dispersion, conductivity, depth and temperature	NTU (turbidity), km (distance and height), h (duration), µs/cm (conductivity), °C (temperature), and m (depth)	Vessel operated automatic sensoring	VOFIXIW1-3	Twice during rock placement
		m/s (current speed), degrees (direction), NTU (turbidity), µs/cm (conductivity), °C (temperature), and mg/l (oxygen)	ADCP and fixed sensors	VOFIXIW1-3: 1 ADCP and 3 turbidity sensors around rock placement sites	From two weeks before rock placement until approximately two weeks after the rock placement
	Water samples for oxygen, nutrient and metal analysis	mg/l and FTU (turbidity), mg/l (oxygen), µs/cm (conductivity) and µg/l (total and dissolved P and N, metals)	Water sampling for analysis	VOFIXIW1-3	During rock placement
	Water samples and CTD-profile for calibration	mg/l and FTU (turbidity), µg/l (total and dissolved P and N, metals) µs/cm (conductivity), °C (temperature), and m (depth)	Water sampling and CTD-profile for calibration	VOFIXIW1-3	During service/ recovery of fixed sensors
Benthos	Abundance of species and individuals, oxygen concentration	ind./m^2, species/m^2, g/m^2 (biomass) and mg/l (oxygen)	Van Veen grab (0.1 m^2)	Transect BENT2	Once before and once after rock placement.

Monitoring of rock placement during 2010					
Monitoring target	**Parameter**	**Unit**	**Method**	**Location**	**Timing / frequency**
Sediment	Dioxins, nutrients, organic tin compounds, As, Co, Cr, Ni, Zn, Cu, Pb, Cd, Hg, grain size distribution/ clay content and organic matter content	mg/kg, µg/kg, ng/kg, m-%	GEMAX	Transect SED2	Once before and once after rock placement

Table 5.5 Distance from rock placement site to the fixed sensors

Distance between IW and fixed sensors				
Station	**Fixed sensor**	**tie-in, m**	**E2017, m**	**WK003/ WK005, m**
VOFIXIW1	S1	140		
	S2	140		
	S3	80		
VOFIXIW2	S1		310	
	1_ADCP		240	
	S2		220	
	S3		180	
VOFIXIW3	S1			300/220
	1_ADCP			320/240
	S2			120/220
	S3			350/250

Table 5.6 Timing of environmental monitoring of rock placement

Timing of monitoring of rock placement in 2010						
Station	**Rock placed**	**Vessel operated sensoring**	**Fixed sensors and ADCP**	**Water sampling and CTD profile***	**Sediment / Benthos sampling**	**Seabed survey via ROV**
VOFIXIW1 / SED2 / BENT2	7.4.-28.6.2010	27.-28.4.2010	26.3.-2.8.2010	27.4.2010 2.8.2010*	6.4.2010 2.8.2010	
VOFIXIW2	17.-26.5.2010	18.5.2010	30.4.-10.6.2010	18.5.2010 10.6.2010*		
VOFIXIW3	26.-30.5.2010	27.-28.5.2010	6.5.2010-29.6.2010	28.5.2010 29.6.2010*		
All berm locations						Immediately prior to and after rock placement

*CTD profile was taken during recovery of the instruments

Table 5.7 Locations of environmental monitoring of rock placement in 2010

Monitoring of rock placement				
Target	**Station**	**Rock berm / KP**	**Coordinates of sensors/ rock berm Latitude**	**Coordinates of sensors/ rock berm Longitude**
Seabed	-	All rock placement sites*	*	*
Obstacles and rock berms	-	All rock placement sites*	*	*
Water quality	VOFIXIW1 S1 / ADCP	Tie-in / 297.3	59° 35.57'	23° 32.37'
	VOFIXIW1 S2		59° 35.64'	23° 32.80'
	VOFIXIW1 S3		59° 35.74'	23° 32.80'
	VOFIXIW1 (vessel operated)		**	
	VOFIXIW2 S1	E2017 / 262.38 (E2011 / 261.96)***	59° 35.74'	24° 8.37'
	VOFIXIW2 S1 / ADCP		59° 40.53'	24° 8.31'
	VOFIXIW2 S2		59° 40.53'	24° 8.49'
	VOFIXIW2 S3		59° 40.53'	24° 8.06'
	VOFIXIW2 (vessel operated)		**	
	VOFIXIW3 S1	WK005 / 163.68 (WK003 / 163.55) ***	59° 40.53'	25° 45.68'
	VOFIXIW3 S1 / ADCP		59° 53.14'	25° 45.66'
	VOFIXIW3 S2		59° 53.37'	25° 45.90'
	VOFIXIW3 S3		59° 53.37'	25° 45.47'
	VOFIXIW2 (vessel operated)		**	
Sediment and benthos SED2/BENT2	1 / 50 m distance	Tie-in / 297.3	59° 35.76´	23° 32.55´
	2 / 100 m distance		59° 35.78´	23° 32.55´
	3 / 200 m distance		59° 35.84´	23° 32.55´
	4 / 400 m distance		59° 35.95´	23° 32.55´
	5 / 800 m distance		59° 36.16´	23° 32.55´
	6 / 1600 m distance		59° 36.59´	23° 32.55´
	7 / 3200 m distance		59° 37.45´	23° 32.55'

***** For coordinates see Appendix 4.
** Vessel operated automatic sensoring around rock placement vessel
*** At VOFIXIW2 the sensors were installed around the rock berm E2017 and at VOFIXIW3 around the berm WK005

5.4 Mattress installation

During 2010 mattresses were installed at 18 cable crossings (9 per pipeline). All installation locations were monitored prior to, during and after crossing installation as presented in the environmental monitoring programme /2/. Prior to installation the cables were located with an ROV equipped with a cable tracker by using a 50 m long runline along the pipeline route, after which the ROV followed the cable 50 m either side from the crossing point of the cable and route. Furthermore, three or five survey lines were undertaken at 5 m spacing (one or two to the south of the route and one or two to the north, and one along the pipeline centreline). With these inspections the crossing point and the intended position of the mattresses were verified. During the installation, monitoring was performed with ROV and for positioning Ultra Short Baseline (USBL) transponders were used. After the installation an as-built general video inspection (GVI) was made over the whole crossing structure. /14-31/

A summary of the monitoring of the mattress installation is presented in Table 5.8, timing of the mattress installation in Table 3.3 and the locations of mattress installations in Figure 3.9.

Table 5.8 Monitoring of cables during mattress installations

Monitoring of the existing cables and the crossing structures during 2010					
Monitoring target	**Parameter**	**Unit**	**Method**	**Location**	**Timing**
Existing infrastructure (cables)	Position of cable and condition of crossing structures	Coordinates, condition of crossing structures (intact, damage)	Visual inspection and MBES via ROV (plus cable tracker)	18 cable crossings	Prior to, during and after crossing installation

5.5 Pipelay

For pipelay, monitoring of changes in seabed morphology and water quality was performed. Also potential impacts on objects on the seabed such as wrecks, cables and barrels were monitored. Summary of the performed monitoring is presented in Table 5.11 and timing in Table 5.12 in the end of this Chapter 5.5.

5.5.1 Seabed morphology and pipeline

During 2010 the pre-lay surveys were performed for the whole installation corridor of the north-west pipeline KP 123 to KP 498 (Table 5.10) /55-61/. The as-laid survey was performed between KP 123 and KP 270 /62-74/ and between KP 350 and KP 498 /75-81/.

Prior to pipeline installation existing seabed conditions including the seabed bathymetry and obstacles along the pipeline installation corridor were monitored with an ROV instrumented with MBES, sonar and video cameras (Chapter 5.1). The pipeline installation corridor survey extends +/- 7.5 metres either side of the centre line of the planned pipeline route. The condition of the pre-lay rock berms was investigated and compared to the initial design as part of the pre-lay survey. Pipeline touchdown monitoring (TDM) was performed along specific sections to support pipelay with an instrumented ROV. After pipe-laying, as-laid surveys of the pipelines were performed. In the as-laid survey, the MBES was used to survey the pipeline 10 m to either side of the pipe to establish the pipeline on seabed configuration. Adjacent targets were monitored with sonar and video cameras were used for the visual inspection of the as-laid pipeline condition. With the as-laid survey the horizontal and vertical position of the pipeline, condition of the rock berms and magnitude of freespans were documented. Also possible damage to pipeline, coating, anodes or field joints was inspected.

Monitoring was performed according to the approved environmental monitoring programme /2/.

5.5.2 Water quality

Water quality monitoring in connection with pipelay with an anchored and dynamically positioned lay barge was carried out at two stations (LAY2 and LAY1) by means of vessel operated automatic sensoring, fixed sensors and water sampling. Monitoring methods are described in more detailed in Chapter 5.1. Timing of monitoring is presented in Table 5.12.

Anchored lay barge

Water quality monitoring during the pipelay with the anchored lay barge was monitored at one station (LAY2). Vessel operated monitoring was performed along two transects, one parallel and the other perpendicular to the pipeline between KP 491-KP 493 (Figure 5.11 and 5.12). The monitoring activity was interrupted on a number of times upon request of the lay barge due to safety reasons. The interruptions to the monitoring activities caused delays, which meant that both transects were monitored only once. /39/

The LAY2 station also included two fixed sensors with turbidity probe (LAY2 S1 and LAY2 S2). The sensors were located in a line perpendicular to the pipeline route at distances of 50 and 800 m to the North of the pipeline at KP 495 (Table 5.9 and Figure 5.11).

Water sampling was performed during turbidity monitoring from the survey vessel. Altogether 17 water samples were taken for analyses from five different locations (Figure 5.12). During the recovery of the fixed sensors a CTD profile was gathered and an additional two water samples were collected.

Monitoring was performed as presented in the monitoring programme /2/ with the following clarifications and modifications /39/:

- Location of parallel transect was moved, due to safety reasons, behind the lay barge, 50 m aside from the pipeline. In the monitoring programme /2/ the transect was planned to run parallel with the pipeline 800 m offset from the installation corridor to monitor for sediment spreading from anchor operations.
- Location of the perpendicular transect was as presented in the monitoring programme, but the monitored line was +/- 600 metres instead of +/- 800 metres.
- Both vessel operated transects were measured only once instead of two rounds as presented in the monitoring programme.

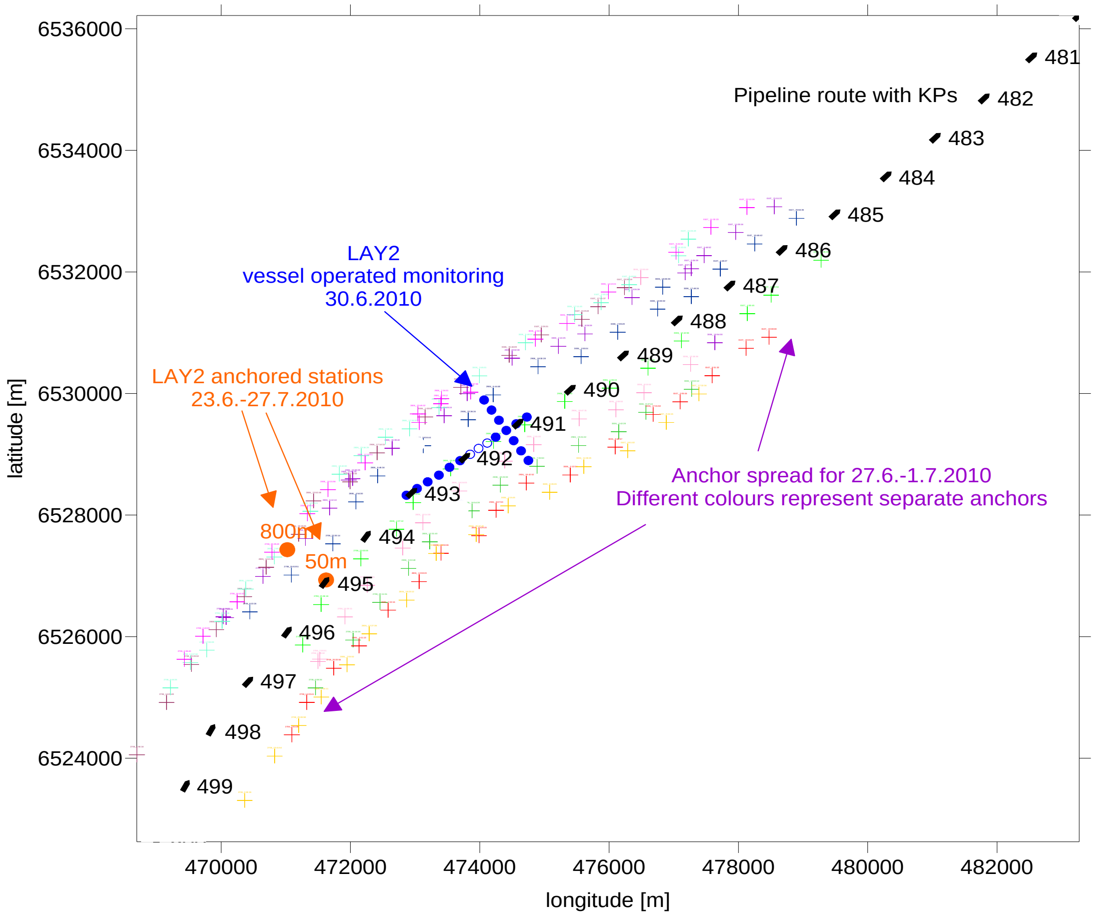

Figure 5.11 Progress of the pipelay and anchor spread on 27.6.-1.7.2010. A schematic drawing of the locations of the fixed monitoring sensors at KP 495 and orientation of the transect lines (blue dots) between KP 491-493 along the pipeline route /39/.

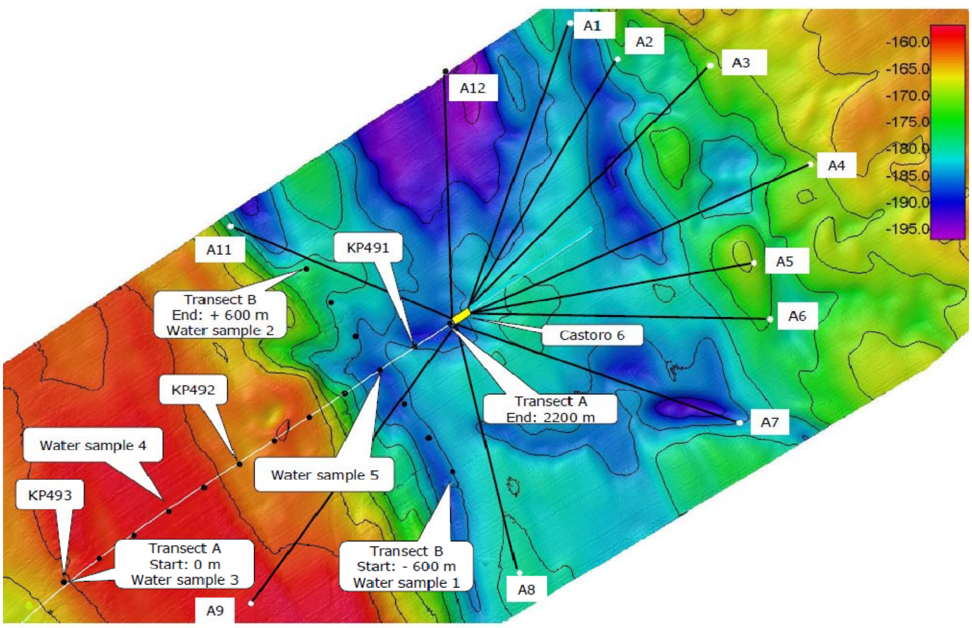

Figure 5.12 Vessel operated transects (black dots), water sampling locations and anchor positions (A1-A12) on a bathymetric map. The shown lay barge position (*Castoro 6* in the middle) and anchor pattern is around the time of the actual vessel operated monitoring /39/.

Table 5.9 Coordinates (in WGS84) of two fixed sensors at the LAY2 monitoring station (S1-S2)

Coordinates of fixed sensors at the LAY2 monitoring station		
Station	**Longitude**	**Latitude**
LAY2 S1	25° 45.47'	58° 52.87'
LAY2 S2	20° 29.84'	58° 53.14'

Dynamically positioned lay barge

The water quality was monitored during pipelay with the DP lay barge at one station (LAY1). The vessel operated monitoring was performed along two transects at approximately KP 179. Transect A was approximately perpendicular to the pipeline and was 1300 m long. Transect B was approximately parallel to the pipeline and 1400 m long (Figure 5.14, Table 5.13). Due to deteriorating weather conditions, the transects were monitored only once. /40/

The station LAY1 comprised also two fixed sensors with a turbidity probe (LAY1 S1 and LAY1 S2). The sensors were located in a line perpendicular to the pipeline route at approximately 50 m distance to the south and to the north from the pipeline at KP 184 (Table 5.10 and Figure 5.13).

Water samples were taken five metres above the seabed at 5 locations, along the transects, (Figure 5.13) during vessel operated monitoring. In addition, two water samples were taken and CTD profile measured during the installation of the fixed sensors. During recovery of the instruments bad weather prevented water sampling and CTD profiling.

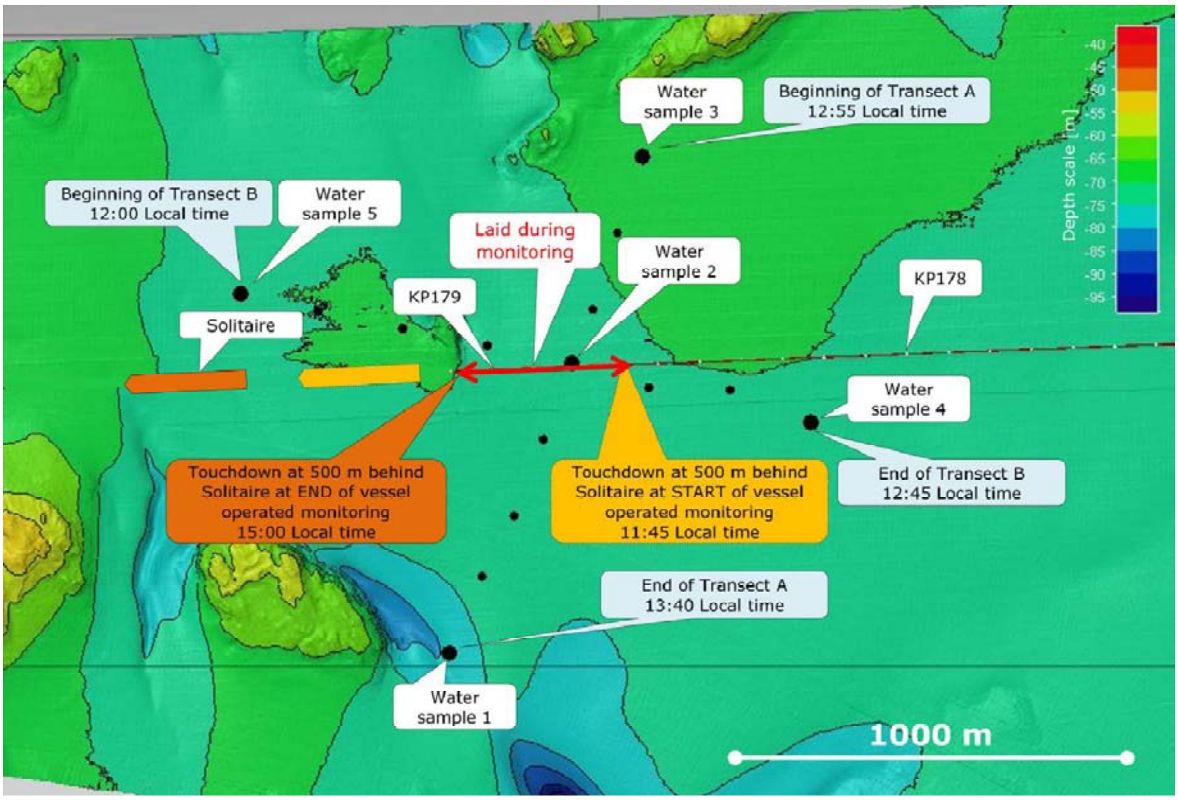

Figure 5.13 A schematic drawing of the orientation of the vessel operated monitoring transects (black dots) as well as water sampling locations at the monitoring station LAY1. Pipelay progress during monitoring is shown as a red arrow. /40/

Table 5.10 Coordinates (in WGS84) of two fixed sensors at the LAY1 monitoring station (S1-S2) /40/

Coordinates of fixed sensors at the LAY1 monitoring station		
Station	**Longitude**	**Latitude**
LAY1 S1	25° 24.399'	59° 53.482'
LAY1 S2	25° 24.372'	59° 53.533'

Monitoring was performed as presented in the monitoring programme /2/ with the following clarifications and modifications /40/:

- Due to deteriorating weather, both vessel operated transects were measured once instead of two times as presented in the monitoring programme.
- During recovery of the fixed sensors, water sampling and CTD profiling was not performed due to bad weather.

5.5.3 Wrecks, barrels and cables

In the anchored lay barge section four wrecks (S-13-31313, S-13-34523, S-15-35565 and S-16-36567) were monitored (Figure 5.14). Pre-lay surveys were conducted between 15th and 17th June 2010 and post-lay surveys on 17th October 2010 /44-51/. Four wrecks (S-07-2736, S-08-2939, S-08-10289 and S-10-3237) are located in the section laid with the dynamically positioned lay barge (Figure 5.14). Pre-lay surveys were performed for these wrecks on 12th September 2010 (S-10-3237) and on 9th and 10th October 2010 /82-85/. Post-lay survey will be carried out in spring 2011. See Chapter 5.1.5 for monitoring methods of wrecks.

In the anchored lay barge section two cable crossings were monitored: crossings for cable EE-S1 at KP 448 and for cable Pangea Seg 3 at KP 442 (Figure 3.9). The first pipeline (north-west) was laid over the mattress arrangements of the crossings on 13th August 2010 (EE-S1) and on 15th August 2010 (Pangea Seg 3). As-laid survey of the pipeline at crossing points was carried out on 9th and 10th September 2010 /52/. As-left surveys of the crossing structures were carried out on 1st, 2nd, and 23rd September 2010 /53-54/.

Seven cables, (FEC-2, EE-SF2, Pangea Seg 3 (at KP 219), Unknown cable (at KP 234), EE-SF3, Estlink and FEC-1) cross with the pipeline in the DP lay barge section (Figure 3.9). The first pipeline (north-west) was laid over the mattress arrangements of the crossings between 28th and 30th November 2010 (FEC-2, EE-SF2 and Pangea Seg 3) and between 5th and 9th December 2010 (Unknown cable, EE-SF3, Estlink and FEC-1). As-laid survey of the pipeline at crossing points was carried out between 14th and 28th December 2010 /70-72/. As-left surveys of the crossing structures were carried out between 28th November and 28th December 2010 /87-90, 127-129/. See Chapter 5.1.5 for monitoring methods of cable crossings.

Four barrels (R-09-23, R-10-3277, R-10-130066 and 11-S-88) located within the installation corridor of the first pipeline (north-west) in the section laid by the DP lay barge were monitored. The pre-lay surveys for these barrels were conducted on 10th and 11th October 2010 /86/. The post-lay surveys were carried out in spring 2011. See Chapter 5.1.5 for pre-lay survey methods of barrels.

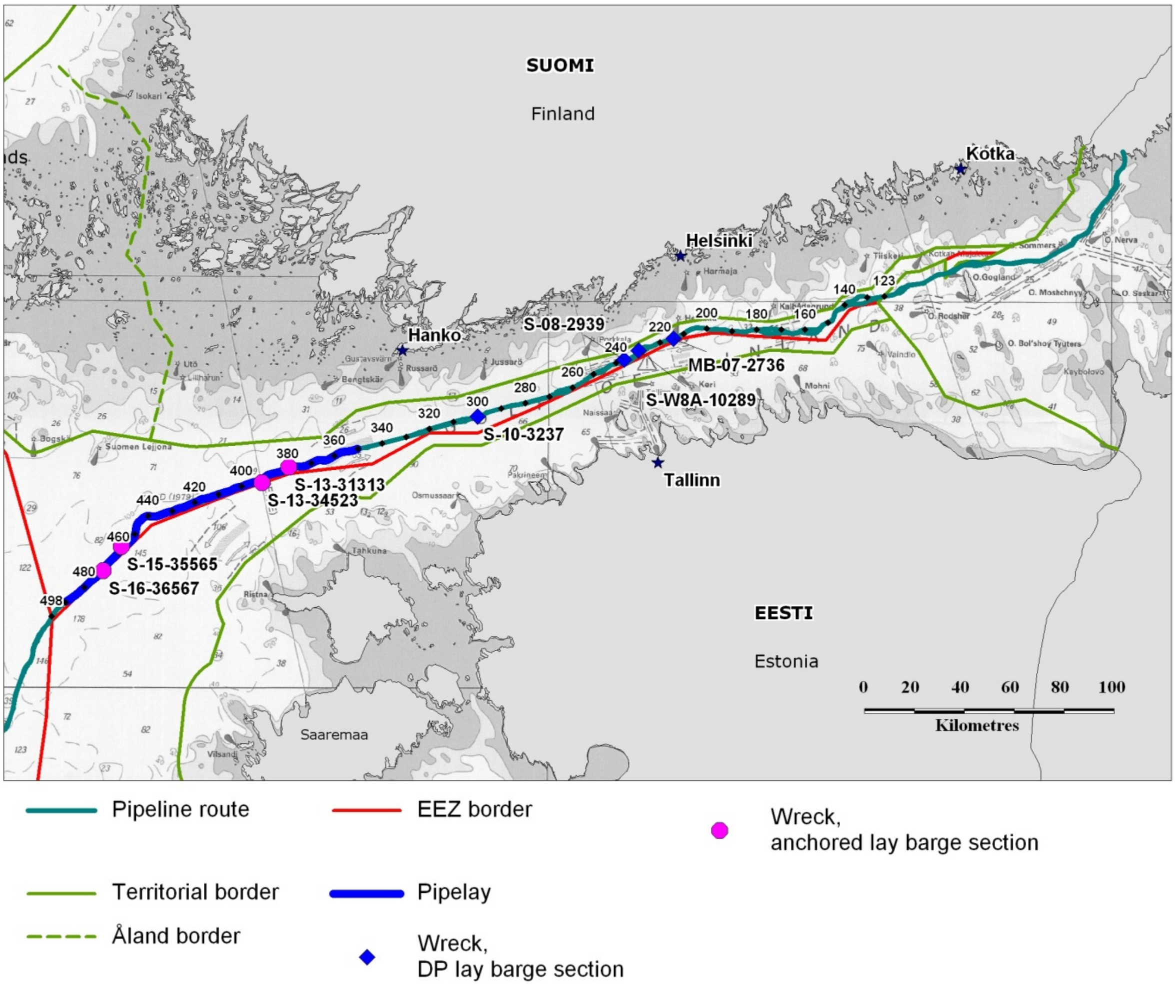

Figure 5.14 All wrecks included in the monitoring in the Finnish EEZ

5.5.4 Summary of the monitoring

Summary of monitoring of pipelay is presented in Table 5.11 and timing of monitoring in Table 5.12.

Table 5.11 Monitoring for pipelay

Monitoring for pipelay during 2010					
Monitoring target	**Parameter**	**Unit**	**Method**	**Location**	**Timing***
Seabed morphology	Obstacles	Yes / no, location (E, N)	ROV instrumented with multi-beam echo sounder, sonar and video cameras	Full length of installation corridor	Prior to pipelay (pre-lay survey)
	Seabed bathymetry	m (depth)			
	Pipe position and condition	m (E, N, depth) intact/damaged		whole pipeline**	After pipelay (as-laid survey)
Water quality	Suspended sediment, nutrients and contaminant dispersion, conductivity, depth and temperature	NTU (turbidity), µs/cm (conductivity), °C (temperature), and mg/l (oxygen)	Fixed sensors	1 sensor ca. 50 metres on both sides of the pipeline (LAY1) 1 sensor outside the pipeline installation corridor and 1 outside the anchor corridor (LAY2)	From1 week before pipelay until 1 week after pipelay.
		NTU (turbidity), km (distance and height), h (duration), µs/cm (conductivity), °C (temperature) and m (depth)	Vessel operated automatic sensoring	LAY1 and LAY2	During pipelay
	Water samples for oxygen, nutrient and metal analysis	mg/l and FTU (turbidity), mg/l (oxygen), µs/cm (conductivity) and µg/l (total and dissolved P and N, metals)	Water sampling for analysis	LAY1 and LAY2	During pipelay
	Water samples and CTD-profile for the calibration	mg/l and FTU (turbidity), µg/l (total and dissolved P and N, metals) µs/cm (conductivity), °C (temperature), and m (depth)	Water sampling and CTD-profile for calibration	LAY1 and LAY2	During service/ recovery of fixed sensors.
Cultural heritage, barrels and existing infrastruc-ture	Presence of new unknown objects	Yes no, location (E,N)	Visual inspection via ROV	Installation corridor	Prior to pipelay

	Position and integrity of cultural heritage	coordinates, Intact / damage	Visual inspection via ROV	8 wrecks	Prior to pipelay
		coordinates, Intact / damage	Visual inspection via ROV	4 wrecks***	Pipeline touchdown and after pipelay
	Position and integrity of barrels	Coordinates, Intact / damage	Visual inspection via ROV	4 barrels ****	Prior to and after pipelay
	Position and condition of cable crossings	coordinates, Intact / damage	Visual inspection via ROV (plus cable tracker)	9 cable crossings	Pre-lay, pipeline touchdown and post-lay

* As planned in the monitoring programme /2/

** As-laid survey in 2010 was performed between KP 123-KP 270 and KP 350-KP 498.

***4 remaining wrecks will be inspected (post-lay survey) in spring 2011

**** Only pre-lay inspection was performed in 2010. Post-lay inspection has been carried out in spring 2011.

Table 5.12 Summary of timing of monitoring for pipelay in 2010

Timing of monitoring for pipelay					
Target	**Vessel operated sensoring**	**Fixed sensors with turbidity sensor**	**Water sampling and CTD profile***	**Pre-lay survey**	**As-laid/ post-lay survey with ROV**
Installation corridor / pipeline				24.7. - 9.8.2010 (KP 123 – KP 350) 14.3. – 28.3.2010 (KP 350 – KP 498)	21.10.2010 – 9.1. 2011 (KP 123 – KP 270) 20.8. – 22.9.2010 (KP 350 – KP 498)
8 wrecks				15.–17.6.2010, 12.9.2010 9.-10.10.2010	17.10.2010**
4 barrels				10.-11.10.2010	
9 cable crossings				24.7. - 9.8.2010 (KP 123 – KP 350) 14.3. – 28.3.2010 (KP 350 – KP 498)	28.11.-28.12.2010 (KP 123 – KP 350) 1.-23.9.2010 (KP 350 – KP 498)
LAY1	13.11.2010	2.11.- 16.12.2010	2.11.2010* 13.11.2010		
LAY2	30.6.- 1.7.2010	23.6.- 27.7.2010	30.6.- 1.7.2010 27.7.2010*		

* CTD profile was taken during installation or recovery of the instruments

**4 wrecks

5.6 HELCOM benthos stations monitoring

Monitoring of HELCOM long term benthos stations and their compensatory stations started before the installation of the first pipeline. In 2011, the monitoring takes place twice a year (early summer and autumn), and after that annually in early summer up to 2015. Three stations are included in the monitoring: LL5, LL6A and LL7 (Table 5.2). The monitoring includes benthos sampling from these stations and two compensatory locations A and B to these stations. The monitoring has been performed according to the approved monitoring programme /2/.

During surveys with *R/V Aranda* between 27th September and 3rd October 2010 echo sounding was performed. The parallel stations were pin-pointed by the GIS approach by creating maps of environmental similarity to the existing stations (Figure 5.15 and Table 5.14) /91/. At the route section close to these HELCOM stations (LL5, LL6A and LL7) pipelay started in November 2010.

Benthos samples prior to pipelay were taken from all monitoring stations and oxygen concentrations were measured from water samples taken 1 m above the seabed. In addition, sediment core samples were taken and temperature and salinity profiles recorded with a CTD profiler.

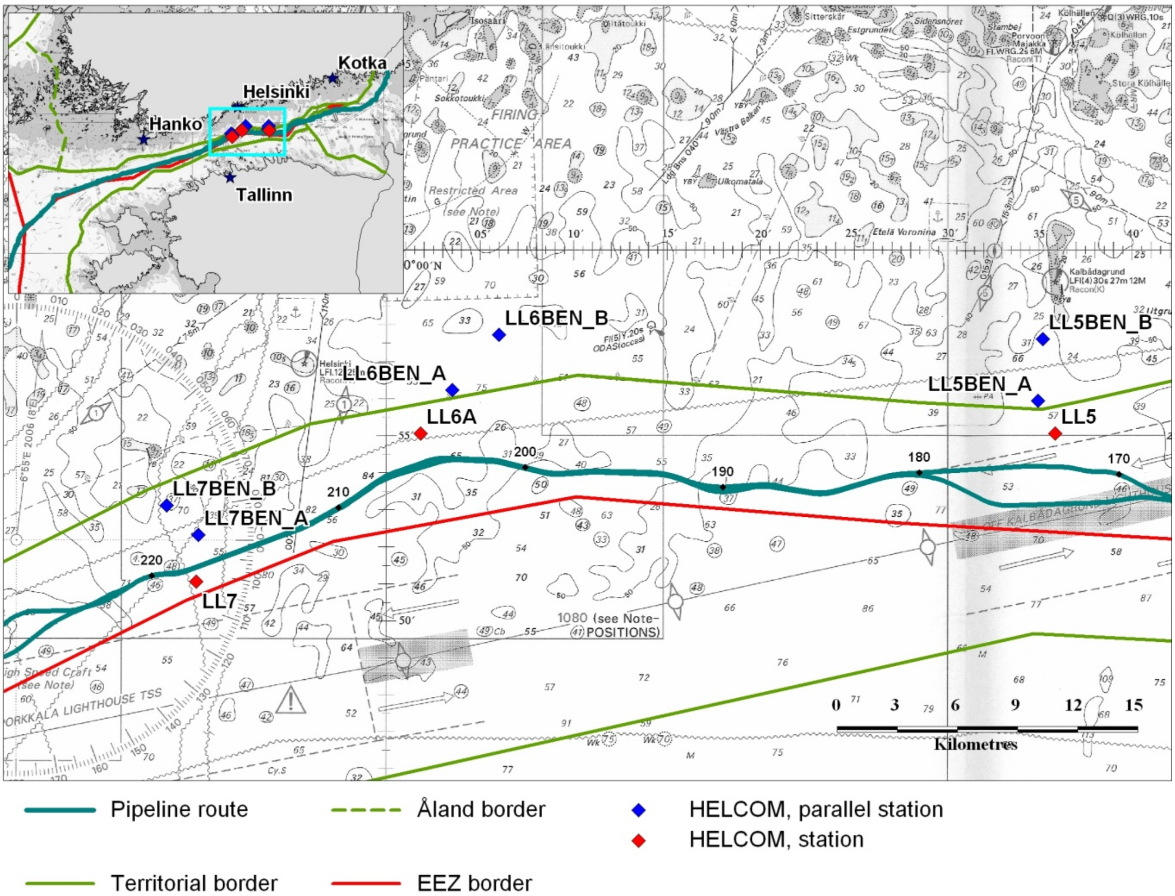

Figure 5.15 Locations of HELCOM benthos monitoring stations LL5, LL6A and LL7 and their selected parallel monitoring stations, A and B.

The benthos samples were taken with a Van Veen grab. Three replicates were taken from LL5, LL6A and LL7 stations (9 samples altogether) and ten samples were taken from each of the parallel A and B stations (Table 5.13). Samples were then sieved onboard with 1 mm and 0.5 mm mesh size (0.5 mm only for three replicates at each station) and species were determined and counted. Samples were stored for further analyses in laboratory.

More detailed description of the methods used for determining the locations for parallel monitoring stations as well as sampling methods can be found in SYKE's monitoring report /91/.

Table 5.13 Monitoring of HELCOM benthos stations

HELCOM benthos station monitoring					
Project activity	**Parameter**	**Unit**	**Method**	**Location**	**Timing / frequency**
Pipelay and operation	Abundance of species and individuals, oxygen concentration	ind./m^2, species/m^2 (abundance), biomass, mg/l (oxygen)	Van Veen grab (ca. 0.1 m^2)	Benthos sampling at HELCOM stations LL7, LL5 and LL6A and their two parallel sites A and B	Once before installation of the first pipeline. In 2011 twice a year (early summer and fall), and after that annually in early summer up to 2015

Table 5.14 Location of parallel HELCOM stations and sampling prior to pipelay /91/

HELCOM benthos station monitoring prior to pipelay					
Station	**Depth m**	**Longitude**	**Latitude**	**No of van Veen grabs**	**Distance from pipeline**
LL5	69			3	1.6 km (north)
LL5BEN_A	69			10	3.3 km (north)
LL5BEN_B	70			10	6.4 km (north)
LL6A	24			3	1.4 km (north)
LL6ABEN_A	43			10	3.4 km (north)
LL6ABEN_B	49			10	6.3 km (north)
LL7	43			3	0.6 km (south)
LL7BEN_A	54			10	1.5 km (north)
LL7BEN_B	17			10	3.4 km (north)

5.7 Long term water quality and current monitoring

Long term water quality and current monitoring is being carried out at two monitoring stations, CONTROL1 and CONTROL2 (Figure 5.7, Table 5.15) /42/. Monitoring is performed with ADCP, turbidity sensor, water sampling and CTD profile (Chapter 5.1).

CONTROL1 is situated in the western part of the Gulf of Finland at a depth of 43 m and CONTROL2 is situated in the eastern part of the Gulf of Finland at a depth of 47 m. Both stations are situated close to Natura 2000 areas.

Table 5.15 Coordinates (in WGS84) of the long term water quality and current monitoring stations CONTROL1-2 /42/

Coordinates of long term water quality and current monitoring stations		
Station	**Longitude**	**Latitude**
CONTROL1		
CONTROL2		

Monitoring equipment was installed in November 2009, two weeks prior to the commencement of the first munitions clearance phase. Water quality and currents will be monitored throughout the construction period. Long term water quality monitoring and timing of performed monitoring are presented in Table 5.16 and Table 5.17).

Table 5.16 Long term water quality monitoring /2/ and /42/

Long term monitoring during 2009 and 2010					
Monitoring target	**Parameter**	**Unit**	**Method**	**Location**	**Timing / frequency**
Water quality	Current speed and direction, turbidity, conductivity, temperature and oxygen concentration	m/s (current speed), degrees (direction), NTU (turbidity), µs/cm (conductivity, °C (temperature) and mg/l (oxygen)	ADCP with a turbidity sensor and CTD profile	2 stations: one in Eastern Gulf of Finland (CONTROL2), and one close to Natura 2000 area in Tammisaari archipelago (CONTROL1)	Throughout the whole construction period. CTD-profile when uploading data
	Water samples for calibration of sensors and nutrient and metal analysis	mg/l and FTU (turbidity), mg/l (oxygen), µs/cm (conductivity) and µg/l (total and dissolved P and N, metals)	Water sampling for calibration and analysis	CONTROL1 and 2	From two weeks before until two weeks after the construction works when uploading data

Table 5.17 Timing of long term monitoring and data downloading /42/

Timing of long term monitoring		
Station	**ADCP with turbidity sensor**	**Water sampling and CTD profile**
CONTROL1	4.11.2009→2.12.2010	26.4.2010 1.7.2010 1.9.2010 2.12.2010
CONTROL2	3.11.2009→16.12.2010	5.5.2010 29.6.2010 16.10.2010 16.12.2010

Monitoring at CONTROL1 and CONTROL2 stations was performed according to approved monitoring programme /2/ with the following modifications or changes:

- Metal analyses were added to the water samples taken during service/ recovery of turbidity sensors.

5.8 Transboundary monitoring Russia - Finland

Impacts of the dredging activities at the Russian landfall area on the water quality in the Finnish waters have been monitored at one station, FIX 3 (Figure 5.16, Table 5.18) /42/. Monitoring was performed with a fixed multi-parameter sonde that measures turbidity, temperature, conductivity and oxygen concentration. In addition water samples were taken for calibration purposes and a CTD profile was recorded during the service visit and recovery of the equipment (Chapter 5.1).

Table 5.18 Coordinates (in WGS84) of the transboundary monitoring station FIX3 /42/

Coordinates of FIX3 monitoring station		
Station	**Longitude**	**Latitude**
FIX3	27° 40.76'	59° 43.97'

Monitoring at FIX3 station started on 5th May 2010 and continued until 2nd September 2010 (Table 5.20). The monitored parameters and monitoring methods are presented in Table 5.19.

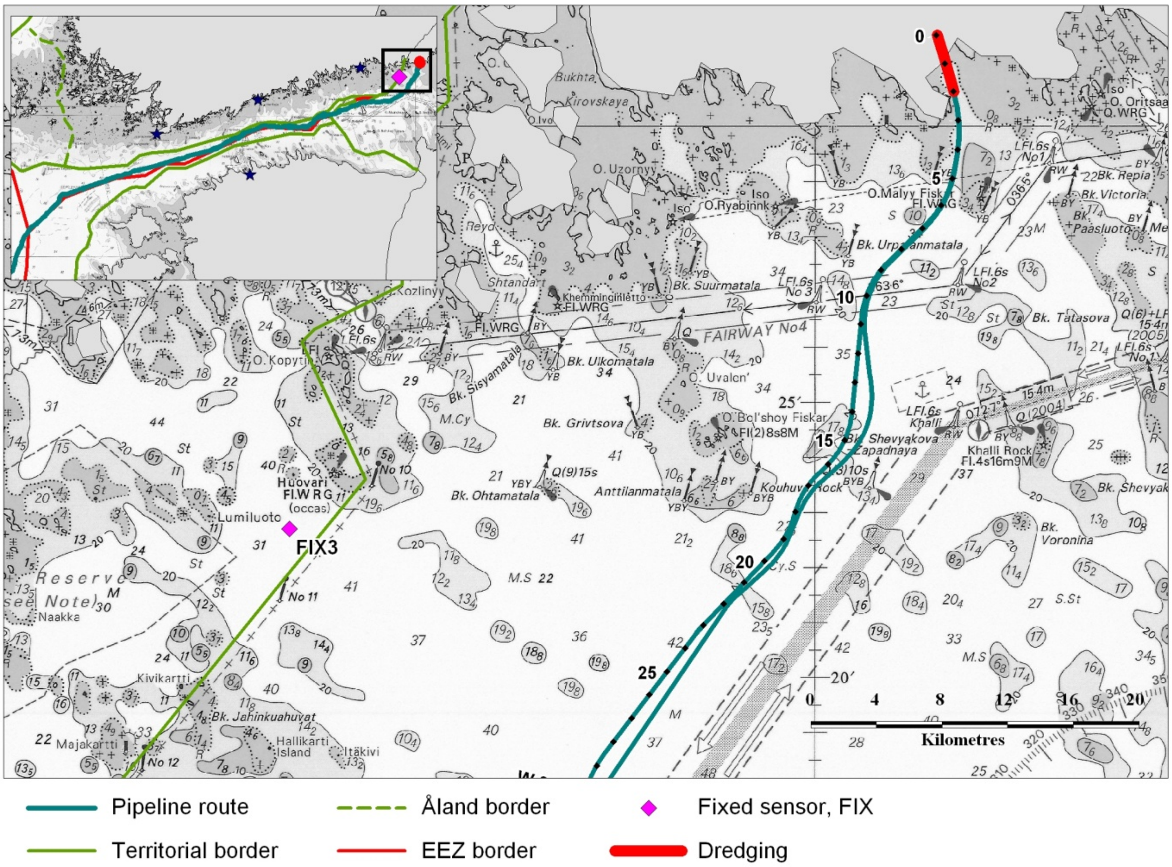

Figure 5.16 Monitoring station FIX3 and the dredged pipeline stretch close to the Russian landfall

Table 5.19 Monitoring of transboundary effects from dredging activities in Russia during 2010 /2/ and /42/

Monitoring of dredging in Russia during 2010					
Monitoring target	**Parameter**	**Unit**	**Method**	**Location**	**Timing / frequency**
Water quality	Suspended sediment, conductivity, temperature and oxygen concentration	NTU (turbidity), µs/cm (conductivity), °C (temperature) and mg/l (oxygen)	Fixed sensoring and CTD-profile	1 station in the Eastern Gulf of Finland (FIX3)	Starts ca. 2 weeks before the dredging and continues ca. two weeks after the dredging, CTD-profile when downloading data
	Water samples for calibration of sensors and nutrient analysis	mg/l and FTU (turbidity), mg/l (oxygen), µs/cm (conductivity) and µg/l (total and dissolved P and N, metals)	Water sampling for calibration and analysis	FIX3	When downloading data

Table 5.20 Timing of transboundary monitoring and data downloading /42/

Timing of transboundary monitoring		
Station	**Turbidity sensor**	**Water sampling and CTD profile**
FIX3	5.5.2010→2.9.2010	30.6.2010 2.9.2010

6. MONITORING RESULTS

This chapter describes the results of the environmental monitoring of the pipeline construction activities during 2010. The meaning and significance of the results are also discussed. Monitoring results of munitions clearance, which started in the end of 2009, are presented in detail separately in the final monitoring report on munitions clearance /6/ and its addendum /7/.

6.1 Munitions clearance

6.1.1 Seabed morphology

The primary impacts on the seabed are the craters being created by the munitions clearance. The seabed has been measured before and after the clearance activity. Typical images of all impacts on the seabed are included in /6/ and /7/.

The dimensions of the craters have been measured and the following observations were made:

- The actual measured crater diameter was smaller than the predicted crater diameter
- The actual measured crater volume was 10 % of the assumed volume
- The shape of the crater was less 'cone-like' than was assumed, but resembled more a depression with more or less even bottom and less deep than assumed
- The shape of the crater varied significantly, most likely due to typical soil conditions, but probably also due to typical type of charges and clearance technique
- In many cases the resulting 'crater' consists of an uplift of the seabed at the actual location of the detonation, most likely due to the result of dissipation of porewater pressure within the soft silty/clayey sediments caused by the blast wave and heat from the explosion

6.1.2 Water quality and currents

The most common sediment type at the sites of the detonations was very soft or soft clay. The following observations were made during monitoring:

- Elevated turbidity was recorded mainly in the water layer 10 meters above the seabed
- The highest turbidity values just above the bottom were 5-6 NTU and on the top of that layer 1-3 NTU
- Average concentration of suspended solid matter calculated for all water samples taken was 2.4 mg/l and average turbidity value was 0.7 FNU[7]
- For all measurements the concentration of suspended solids in water was nowhere higher than 10 mg/l for a maximum of 18 hours
- The extent of the turbidity plumes, if any, extended 200-300 meters around the detonation point
- Metal or nutrient concentrations did not increase from the background values in the vertical sampling profiles

As per the approved monitoring programme for munitions clearance, currents were considered to be strong either when the bottom close current speed (5 meters from the seabed) or the average current speed throughout the water column exceeds 0.3 m/s within the sector of 120 – 210 degrees (flow direction). Average currents were much lower than 0.2 m/s and the bottom currents even lower, except for a few days when they were higher than the surface currents, but still lower than 0.3 m/s /6,7/.

[7] FNU = a turbidity unit equivalent to NTU

6.1.3 Sediment quality

Sediment quality monitoring has been performed prior to and after detonation of four munitions.

The following observations were made during monitoring:

- The concentrations of metals and dioxins and furans were low
- The concentrations of TBT were relatively high (at some locations)
- There was no systematic change in the number of the samples that were below or above the threshold values[8] in the samples taken before or after clearance

No statistically significant correlation could be found for concentration changes when plotted against the measured distance from munitions. Considering this and the low turbidity levels monitored after the detonations, it is unlikely that these recorded changes are related to munitions clearance activities.

6.1.4 Benthos

Benthos samples taken prior to and after the detonation along the transect at the station BENT3 showed that the nearest locations from the activity were almost lifeless during sampling (Figure 5.7). The species abundances in the samples before the detonations varied between 3-1057 individuals/m^2 and afterwards between 0-774 individuals/m^2 /43/. Abundances were highest on the location farthest away (3200 m) from munitions clearance.

During sampling after the clearance the oxygen conditions were poor on the bottoms studied.

6.1.5 Underwater noise

The peak pressures have been measured to check the validity of the predictions made.
By far the most measurements showed lower peaks than predicted. In only 4 observations the actual peak pressure was higher than the predicted.

6.1.6 Fish, seabirds and marine mammals

Prior detonation a workboat searched the area with a fish finder and in none of the clearances a fish shoal was detected. Prior to each detonation a small fish scarer charge was fired to frighten fish away. The detonations killed fish that happened to swim in the vicinity of the detonation site and that were not sufficiently scared away. Baltic herring was the only species that was recovered in large numbers after the detonations.

Various bird species have been observed being eating dead fish on the sea surface after the detonations.

Prior to all detonations, marine mammals were observed in the clearance area visually by two marine mammal observers and acoustically by the passive acoustic monitor. Before one detonation, one seal was observed in the area. Prior to each detonation, seal scrammers were applied to scare away any marine mammals in the area. During both munitions clearance campaigns no impacts on marine mammals have been reported and there have not been any reported injured animals.

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[8] Level 1= normalised concentration below or at Level 1 is considered to be uncontaminated and harmless to the water environment.
Level 2= normalised concentration above Level 2 is considered to be contaminated.

6.1.7 Wrecks, barrels and cables

During the munitions survey a number of cables and cultural heritage sites were found, mainly wrecks, which could be impacted by the munitions clearance activities. However, based on post–activity monitoring results no damage to the objects was noticed.

During the munitions survey a large number of barrels were found that could be impacted by the munitions clearance. Of many barrels the content was unknown and the ability of the barrel to withstand the pressure wave condition was questionable. The visual inspection confirmed that none of the barrels had moved or been damaged as the result of the clearance induced pressure wave. Two barrels were damaged during the visual inspections. In both cases the barrel was damaged by the operation of the ROV. One of the barrels was in such a bad condition that the original content, if any, must have been released before the damage. The other barrel was assessed as an environmental risk class 3 barrel, i.e. observed to be intact. However, the images of the damaged barrel showed the barrel was filled with sediment suggesting that the original risk class 3 assessment was fortunately conservative and that it in reality was most likely of a lower risk class.

6.1.8 Helcom long term monitoring stations

The nearest munition from the HELCOM long term monitoring stations had a charge of 150 kg and was located 4.6 km from the HELCOM station LL7 (Figure 5.15). Water quality was monitored prior to and after the detonation of this munition at the station VOHE1. The monitoring results show that the area with maximum concentration higher than 3 mg/l was approximately 0.1 km^2. The length of the maximum concentration contour was about 1 km to the southwest direction and insignificant in the southeast direction, being the direction towards the HELCOM station.

6.1.9 Munitions clearance in Russia

In total 48 munitions have been cleared in Russian waters in the periods 4th December 2009 – 13th December 2009 (32 munitions), 15th May 2010 – 19th May 2010 (11 munitions) and 10th – 12th July 2010 (5 munitions). In July 2010 five munitions with small charge weights identified in the control survey prior to pipelay were cleared /6/. During the period 3rd November 2009 and 30th June 2010 water quality measurements were performed. The turbidity of the water in the Finnish waters, near the border, has been continuously measured by two fixed monitoring stations at FIX1 and FIX2 (see Chapter 5).

The turbidity peaks that were measured on 29th December 2009 and 15th January 2010 were not caused by munitions clearance but were due to high wind velocities causing waves and turbulence that increased turbidity in sea water. The clearance activities in December 2009 stopped on 19th December 2009. Neither did the clearance activities in May 2010 cause measurable turbidity increase at the monitoring stations.

The monitoring results confirm that there has been no measurable impact of the munitions clearance activities in Russian waters on relevant water quality parameters at the monitored locations. Based on these observations it is justified to state that the Russian munitions clearance activities, related to pipeline construction, had no measurable impacts on the Finnish waters. This confirms the results of the impact assessment.

6.2 Rock placement

For rock placement monitoring of seabed morphology, water quality, sediment quality and benthos was performed.

6.2.1 Seabed morphology

The collected monitoring data provided necessary information to determine the size and height of constructed rock berms and their footprint on seabed by comparing the terrain models developed from the bathymetric data gathered prior, and subsequent to rock placement. Difference between the design and as-built height for the pre-lay berms was obtained by comparing the highest point of the designed rock berm to the highest point of the constructed one. A table presenting pre-lay rock placement location, depth, designed and actual amounts of rock material placed, as-built berm heights and footprint of the berm is presented in Appendix 4. Post-lay rock placement locations and the amount of rock material placed are also presented in Appendix 4.

The amount of pre-lay rock placement in 2010 was 219,398 m^3 in 27 rock berms. The total footprint of the berms is 90,117 m^2 (Table 6.1).

The amount of post-lay rock placement in 2010 was 21,966 m^3 in 13 rock berms. The design height and as-built footprint of the post-lay rock berms, where relevant, will be determined after the post-lay rock placement is finished. Some post-lay rock placement will be performed on top of the existing rock berms not increasing the berm footprint. For this reason the footprint of post-lay rock berms will be determined for only new rock placement sites. The overall footprint of pre-lay and post-lay rock berms will be determined after the post-lay activity is finished and compared to the designed.

Table 6.1 Amount of pre-lay and post-lay rock placement in 2010

Rock placement in 2010				
	Pre-lay		**Post-lay**	
	m^3	**footprint m^2**	**m^3**	**footprintm^2**
26 rock berms	96,988	43,529*		
13 rock berms			21,966	**
Tie-in	122,410	46,588		
total	219,398	90,117	21,966	**

*Excluding berm E2012 which is not finished

**Will be reported after the post-lay rock placement activity is finished

6.2.2 Water quality

Water quality data during rock placement was gathered by vessel operated monitoring of transects, fixed sensors and water sampling at three stations VOFIXIW1-3 (Figure 5.8 and Tables 5.4-5.6). Methods are described in Chapter 5.1. The current roses in this chapter present the observed currents averaged over the lowest 10 m water column above the seabed. Water depth at the stations varied between 60-79 m.

Monitoring results of the stations are presented in Appendix 5.

When reading the water quality results measured in connection with the different construction activities, it is worth noting that the value of 10 NTU is considered to be the lowest limit at which turbidity is visible to the human eye (see Figure 6.1).

Figure 6.1 A series of water samples of different turbidity shown in NTU unit

<u>Turbidity increase during the activity</u>
In the next chapters elevated turbidity in sea water refers to monitored turbidity value >5 NTU. This measured value includes the average background turbidity (2 NTU) and turbidity increase because of the activity (>3 NTU). Turbidity value 3 NTU corresponds to suspended solids value ≥10 mg SS/l (parameter used in modelling), when a conservative conversion factor 3.4 was used to make these two parameters comparable (see Chapter 7.2.3).

6.2.2.1 Station VOFIXIW1 (KP 297, tie-in site)

Rock placement at the tie-in site has been performed in 12 events over a 32 day long period in April and May 2010. Small remedial placements were performed over 2 days in June 2010. The duration of single events varied from 7 to 21 hours. Rock material was placed on the seabed between 7th April and 28th June 2010 (Table 5.7).

<u>Currents</u>
Observed currents are averaged values, over one hour, in the lowermost 10 m of the water column above the seabed. The values are based on recordings for each 2 metres within the lowest layer.

According to recordings at the tie-in site, the prevailing bottom close currents were heading towards east and northeast (Figure 6.2). During the period 5th April – 22nd May 2010 when the main part of rock placement was performed, the median value of the current speed was 5.0 cm/s.

<u>Transects and fixed sensors</u>
Four vessel operated monitoring transects were performed during the monitoring of the rock placement event between 27th -28th April 2010, two transects south of the rock placement vessel and two on the north side. In total 11,150 m^3 of rock material was placed on the seabed in two events during this period. During the rock placement event the average current was directed towards northeast with a speed of 5 cm/s. Direction varied between north and southeast with speeds up to 14 cm/s /94/.

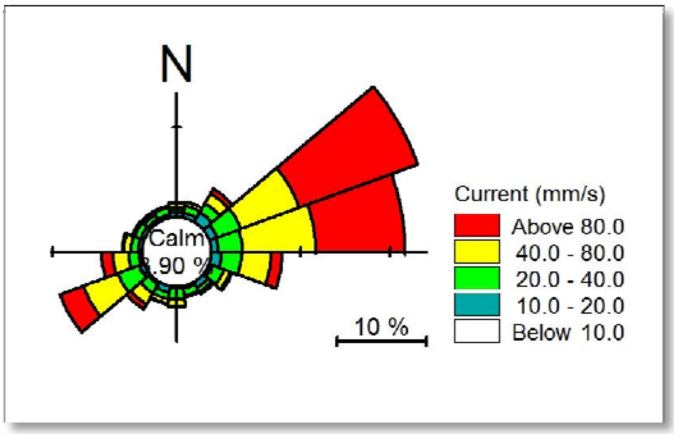


Figure 6.2 Current rose for the observed current direction and speed, averaged over the lowermost 10 m of the water column, at VOFIXIW1 (tie-in site) during rock placement. Time-period 5th April 2010 – 22nd May 2010. /94/

During the events turbidity recordings varied at the three fixed monitoring sites (S1-S3) around the tie-in site as presented in Table 6.2 and Table 6.3.

The measured background turbidity was evaluated to be around 1-3 NTU in April. From the 5th May 2010 the background value increased to a level around 5 NTU because of an advective inflow of a dense, highly turbid water mass. /94/

Table 6.2 Bottom close current and turbidity recordings during rock placement at VOFIXIW1 on 27th April 2010 /94/

Rock placement at VOFIXIW1on 27th April 2010					
Turbidity monitoring site (Figure 5.9)	**Distance to edge of the berm, tie-in m**	**Direction of the site from rock placement**	**Rock material placed m^3**	**Average current speed and direction**	**Maximum measured turbidity NTU**
S1	140	South-west	4,879	4.3 cm/s 74° (E-NE)	1-2
S2	140	East			27
S3	80	North-west			11

Table 6.3 Bottom close current and turbidity recordings during rock placement at VOFIXIW1 on 28th April 2010 /94/

Rock placement at VOFIXIW1on 28th April 2010					
Turbidity monitoring site (Figure 5.9)	**Distance to edge of the berm, tie-in m**	**Direction of the site from rock placement**	**Rock material placed m^3**	**Average current speed and direction**	**Maximum measured turbidity NTU**
S1	140	South-west	6,271	6.8 cm/s 74° (E-NE)	1-2
S2	140	East			8
S3	80	North-west			28

In the transect monitoring, the turbidity plume in the lowermost 10 m water layer above the seabed was recorded in three of the four transects (Figure 6.3). Signs of turbidity were seen in the northern transect during both rounds and only just registered in the southern transect (part of the plume) during the second round. Elevated turbidity was recorded in the layer 70-80 m below the water surface /94/.

During the first round, in the northern transect, the maximum turbidity recorded was 8.4 NTU. The average turbidity in the lowermost 10 m of water layer was 2.7 NTU. The length of the plume with an elevated turbidity (>5 NTU) was approximately 500 metres in the direction of the transect. In the southern transect no signs of turbidity were recorded (Figure 6.3).

During the second round the sediment plume was detected on both sides of the rock placement vessel (Figure 6.3). In the northern transect the maximum turbidity recorded was 21.8 NTU. The average turbidity in the lowermost 10 m of water layer was 2.5 NTU. The length of the plume in the direction of the transect was approximately in the order of 600 metres. In the southern transect maximum and average values were 10.9 NTU and 2.4 NTU, respectively. In this case the length of the plume could not be assessed because the plume was only seen in the northern end of the transect and it was anticipated that the plume would extend beyond the transect. /94/

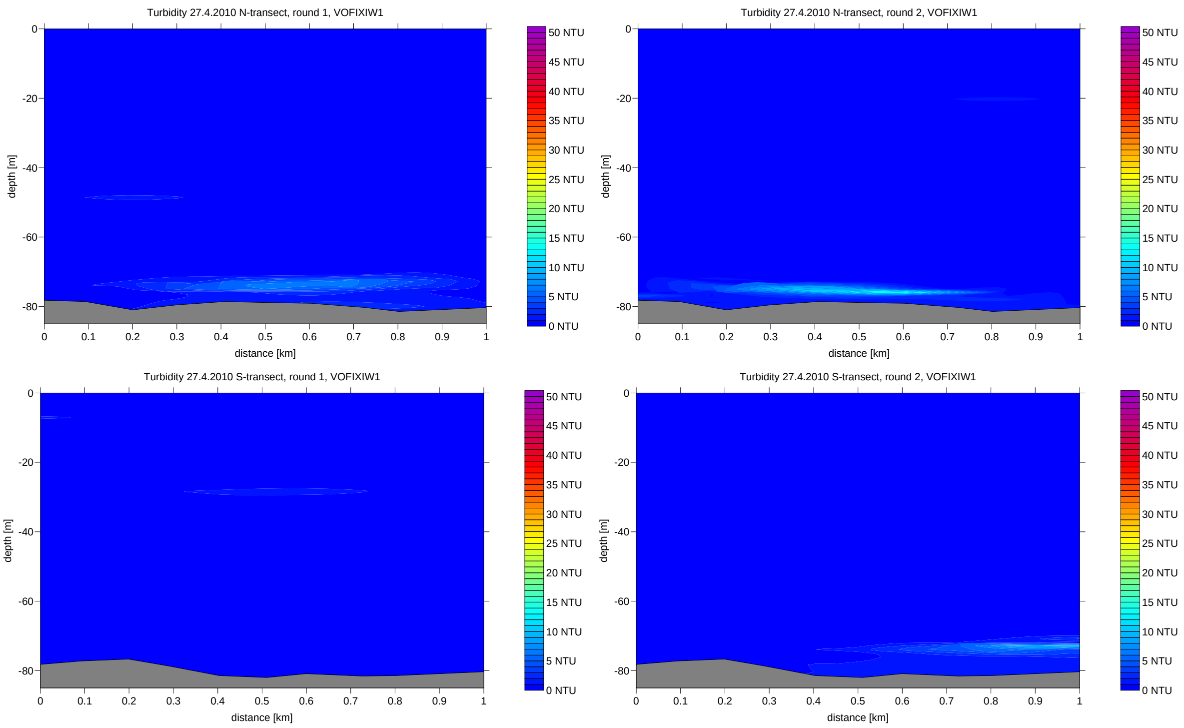


Figure 6.3 Vessel operated turbidity monitoring along the northern and southern transect at VOFIXIW1 on 27th – 28th April 2010. Northern transect= upper images; Southern transect= lower images. First round= left; second round= right /41/.

The highest turbidity values recorded by the fixed sensors during the period 5th April and 22nd May 2010, when the main part of rock placement was performed, are presented in Table 6.4.

The duration of single turbidity peaks over 5 NTU were normally 1-6 hours. An exception was the sensor S3, northwest from the activity, where turbidity peaks relating to two of the rock placement events lasted approximately 12 hours. The total time-period when turbidity in sea water near the bottom was over 5 NTU lasted between 0.6-2.5 days, depending on the sensor. /94/

Table 6.4 Maximum turbidity recordings by the fixed sensors at VOFIXIW1 during 5th April – 22nd May 2010 /94/

Turbidity at fixed sensors on 5th April – 22nd May 2010				
Fixed sensor (Figure 5.9)	**Date of maximum turbidity**	**Rock material placed on the date of max. turbidity m³**	**Average current speed and direction during the max. turbidity**	**Maximum measured turbidity NTU**
S1	18.4.2010	10,400	5 cm/s 242° (W-SW)	54
S2	27.4.2010	4,900	5,2 cm/s 71° (E-NE)	27
S3	12.4.2010	11,200	2.9 cm/s 56° (NE)	45

Figure 6.4 shows graphically how the turbidity peaks near the seabed behaved after the rock placement events. Most of the peaks appeared in April 2010**.**

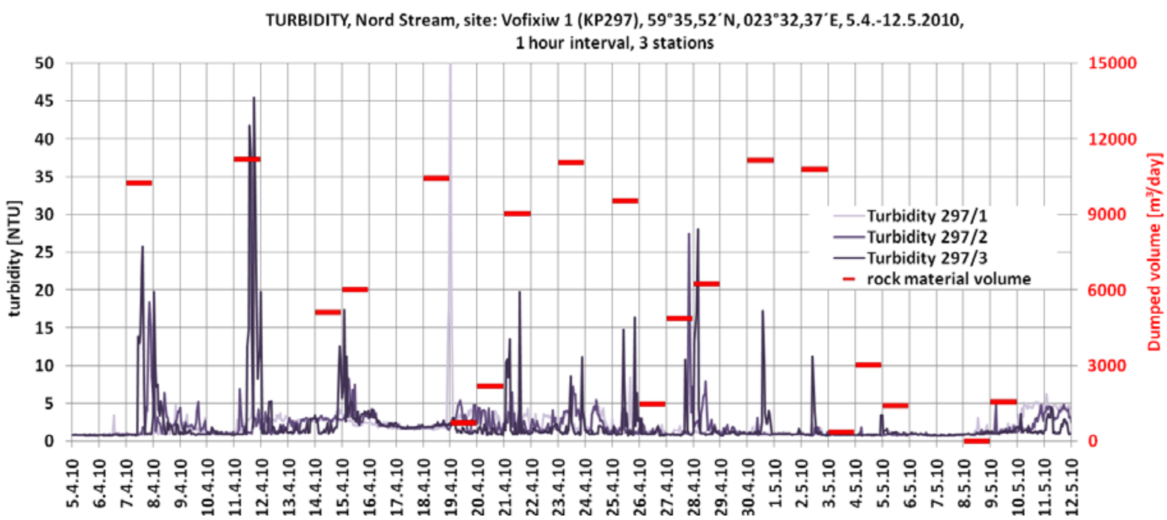


Figure 6.4 Turbidity (NTU) recorded by fixed sensors, near the seabed (left y-axis), together with daily volumes of placed rock material (right y-axis) at VOFIXIW1 during 26.3.2010 – 2.8.2010 /41/

In Figure 6.5 turbidity data from the long-term CONTROL 1 station 15.6 km north of the tie-in site, is plotted in the same chart with the monitored turbidity data from VOFIXIW1 during rock placement. Although the depths of the locations differ, the figure shows increased turbidity levels at both stations between the 12th and 16th June 2010. This might be due to hydrographic or meteorological forcing.

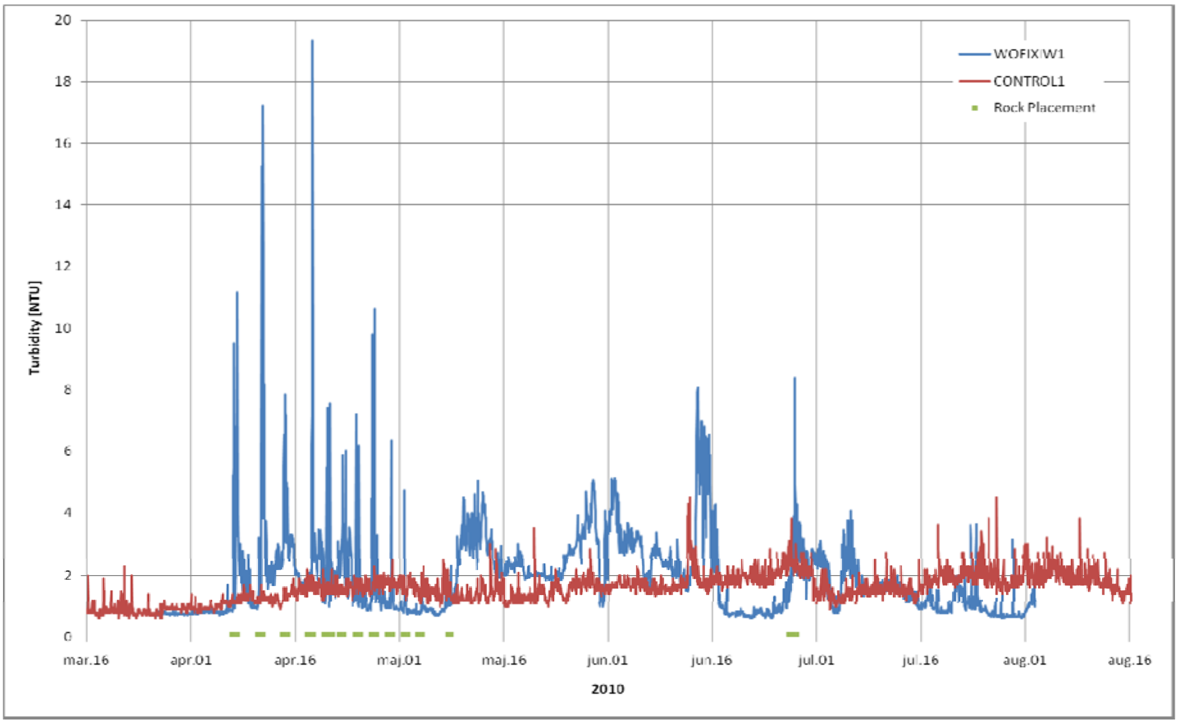


Figure 6.5 Time series of measured turbidity at CONTROL1 and VOFIXIW1. Rock placement events are indicated with the green markers on the x-axis /95/.

<u>Water samples</u>
During the vessel operated monitoring of the southern transect, water samples were taken approximately 300 m to the south of the activity.

During sampling (27th April 2010) the turbidity value (7.7 FNU) was only slightly elevated from the background value (1-3 NTU) one metre above the seabed. The oxygen concentration was 5.8 mg O_2/l and the concentration of total phosphorus was 69 µg P/l, respectively. The average nutrient level in the rest of the water column, from the surface to 70 m, was 26 µg P/l and 300 µg N/l. Metal concentrations in sea water were generally below the detection limit or below 1 µg/l. The highest values measured near the seabed were about 1-3 µg/l for zinc, lead and arsenic. /41/

6.2.2.2 Station VOFIXIW2 (KP 262)
Rock placement at VOFIXIW2 has been performed on two locations during the period 17th – 26th May 2010 (Table 5.7). During the period rock material was placed in events up to duration of 11 hours.

<u>Currents</u>
Observed currents are averaged values, over one hour, in the lowermost 10 m water column above the seabed. The values are based on recordings for each 2 metres within the lowest layer.

During rock placement at the site, dominating bottom close currents were more evenly distributed between all directions than at the tie-in site. However, the larger proportion of the currents had southwesterly and northeasterly directions (Figure 6.6). During the entire monitoring period 30th April -10th June 2010 the median current speed value was 3.9 cm/s.

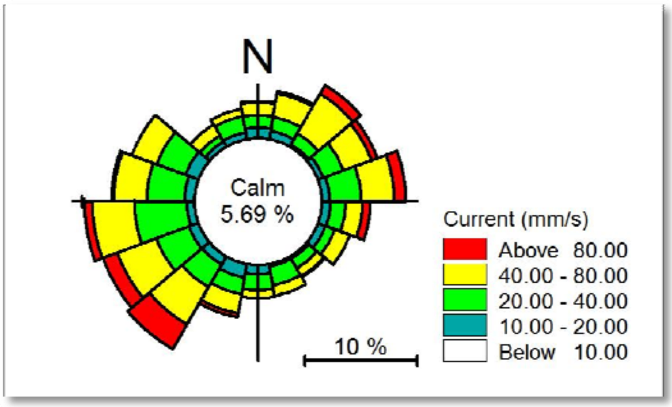


Figure 6.6 Current rose for the observed current directions and speed, averaged over the lowermost 10 m water column, at the site VOFIXIW2 during rock placement. Time-period 30th April 2010 – 10th June 2010 /94/.

Transects and fixed sensors

Four transects were monitored by a vessel during the rock placement event on 18th May 2010, two transects east of the rock placement vessel and two on the west side. A total of 3,800 m^3 of rock material was placed on the seabed on the day in question. The average current during the rock placement period was directed towards the west with a speed of 2 cm/s. The direction varied from west to northeast with speeds up to 5 cm/s. /94.

Turbidity recordings at the three fixed monitoring sites (S1-S3) are presented in Table 6.5. The measured background turbidity was around 1 NTU.

Table 6.5 Bottom close current and turbidity recordings during rock placement at VOFIXIW2 /94/

Rock placement at VOFIXIW2 on 18th May 2010					
Turbidity monitoring site (Figure 5.9)	**Distance to edge of the berm, E2017 m**	**Direction of the site from rock placement**	**Rock material placed at the site m^3**	**Average current speed and direction**	**Maximum measured turbidity NTU**
S1	310	South	3,791	2.0 cm/s 263° (W)	2
S2	220	North-east			4
S3	180	North-west			3

During the transect monitoring a turbidity plume in the lowermost 5 m water layer above the seabed was recorded in one of the four transects (Figure 6.7). Minor increased turbidity values (around 10 NTU) were recorded in a small section just above the seabed at the deepest point of the western transect during the second round. The water depth was 55-60 m. The length of the plume in the direction of the transect was evaluated to be of the order of 200 m, 2-3 m above the seabed /94/.

In the eastern transect no signs of turbidity were recorded (Figure 6.7).

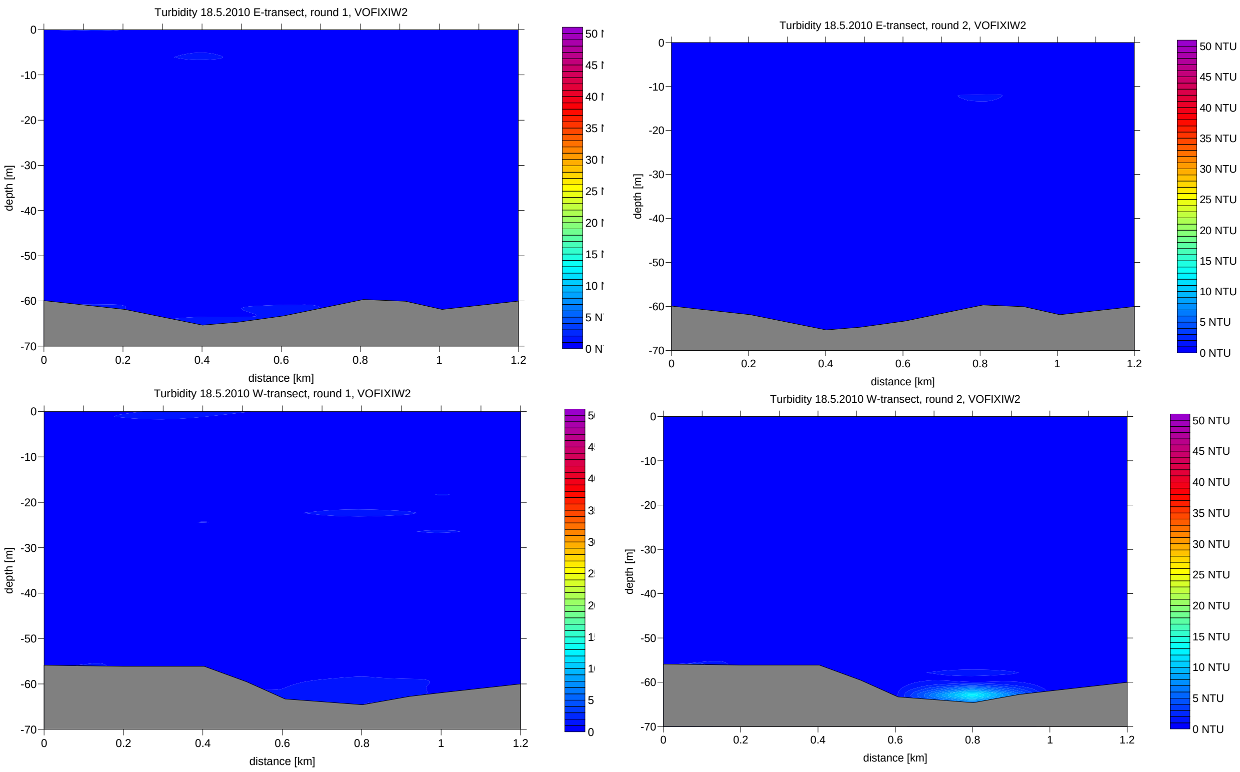


Figure 6.7 Vessel operated turbidity monitoring along the eastern and western transect at VOFIXIW2 on 18th May 2010. Eastern transect= upper images; Western transect= lower images. First round= left; second round= right /41/.

Table 6.6 Maximum turbidity recordings by the fixed sensors at VOFIXIW2 during 30th April – 10nd June 2010 /94/

Turbidity at fixed sensors on 30th April – 10th June 2010				
Fixed sensor (Figure 5.9)	**Date of maximum turbidity**	**Rock material placed on the date of max. turbidity m^3**	**Average current speed and direction during the max. turbidity**	**Maximum measured turbidity NTU**
S1	25.5.2010	3,400	3.8 cm/s 236° (SW)	4
S2	22.5.2010	1,000	4.0 cm/s 237° (SW)	14
S3	24.5.2010	1,800	2.2 cm/s 14° (N-NE)	8

The duration of single turbidity peaks over 5 NTU, where recorded, was 1-2 hours. The total time-period when turbidity near the bottom was over 5 NTU lasted between 1-6 hours (S2 and S3) or was zero (S1) /94/.

Figure 6.8 shows graphically the occurrence and magnitude of the turbidity peaks near the bottom, during the rock placement events.

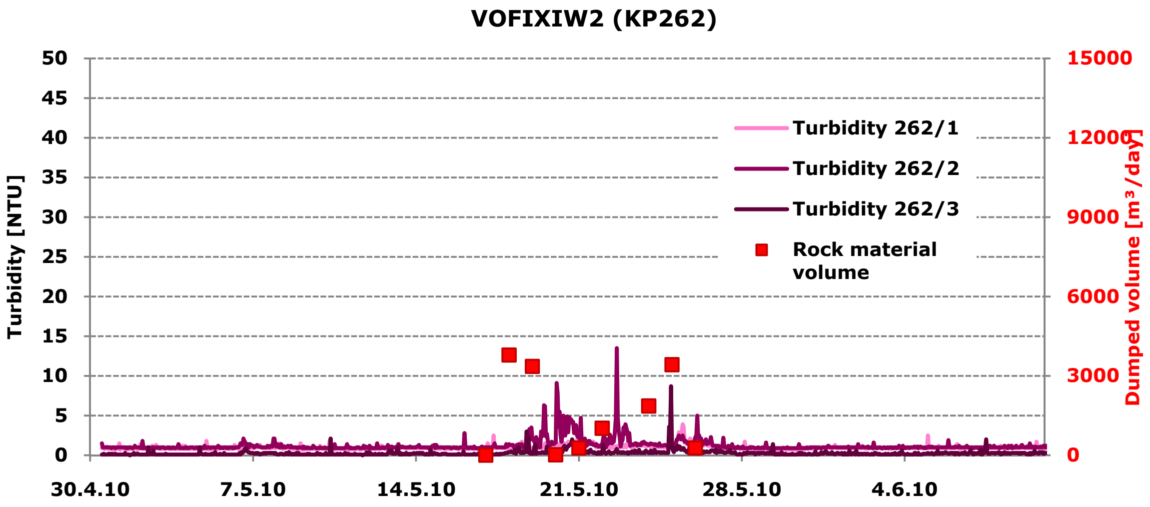


Figure 6.8 Fixed sensors. Turbidity (NTU) near the seabed (left y-axis) together with daily volumes of placed rock material (right y-axis) at VOFIXIW2 during 30.4.2010 – 10.6.2010 /41/.

Water samples

During vessel operated monitoring of the western transect, water samples were taken approximately 300 m to the north of the activity, about 0.8 km from the Estonian EEZ.

During sampling (18^{th} May 2010) the turbidity value (0.73 FNU) was at a background level one metre above the seabed. Oxygen concentration was 8.1 mg O_2/l and the concentration of total phosphorus was 47 µg P/l, respectively. The average nutrient level in the rest of the water column, from surface to 50 metres, was 24 µg P/l and 300 µg N/l. Metal concentrations in sea water were at a background level.

6.2.2.3 Station VOFIXIW3 (KP 163)

Rock placement at VOFIXIW3 has been performed at two locations during the period 26^{th} – 30^{th} May 2010 (Table 5.7). Rock material was placed in events that lasted up to duration of 11 hours.

Currents

Observed currents are averaged values, over one hour, in the lowermost 10 m water column above the seabed. The values are based on recordings for each 2 metres within the lowest layer.

During rock placement at the site the dominating bottom close currents had eastern and south-westerly directions (Figure 6.9). During the entire monitoring period 6^{th} May – 29^{th} June 2010 the median value of the current speed was 3.5 cm/s.

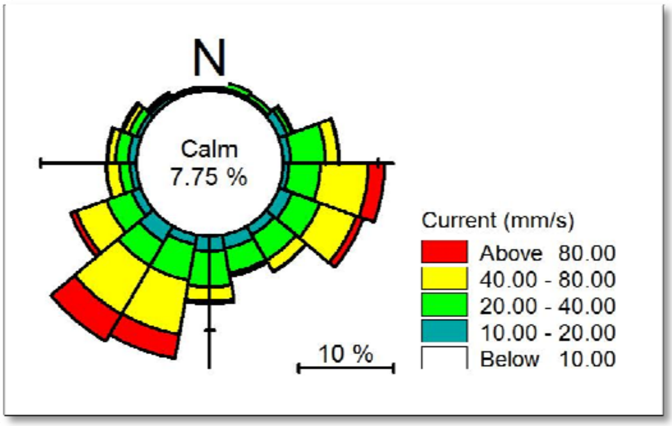


Figure 6.9 Current rose for the observed current direction and speed, averaged over the lowermost 10 m water column, at the site VOFIXIW3 during rock placement. Time-period 6th May 2010 – 29th June 2010 /94/.

Transects and fixed sensors
Four transects were monitored by a vessel during the rock placement event on 28th May 2010, two transects south of the rock placement vessel and two on the north side. During the day a total of 4,400 m^3 of rock material was placed on the seabed. The current direction varied between east and southwest with the average speed of 2.4 cm/s /94/.

Turbidity recordings at the three fixed monitoring sites (S1-S3) are presented in Table 6.7. The measured background turbidity was evaluated to be around 1NTU.

Table 6.7 Bottom close current and turbidity recordings during rock placement at VOFIXIW3 /94/

Rock placement at VOFIXIW3 on 28th May 2010					
Turbidity monitoring site (Figure 5.9)	**Distance to edge of the berm, WK003/WK005 m**	**Direction of the site from rock placement**	**Rock material placed at the site m^3**	**Average current speed and direction**	**Maximum measured turbidity NTU**
S1	300/220	South-east	4,401	2.4 cm/s 161° (SSE)	7
S2	120/220	North-east			9
S3	350/250	North-west			6

Turbidity levels were generally low during vessel operated monitoring. Elevated turbidity was recorded in part of in the northern transect, near the seabed (Figure 6.10). Total depth was approximately 60 metres.
The highest turbidity values were around 7 NTU, while average values were within a background level /41/.

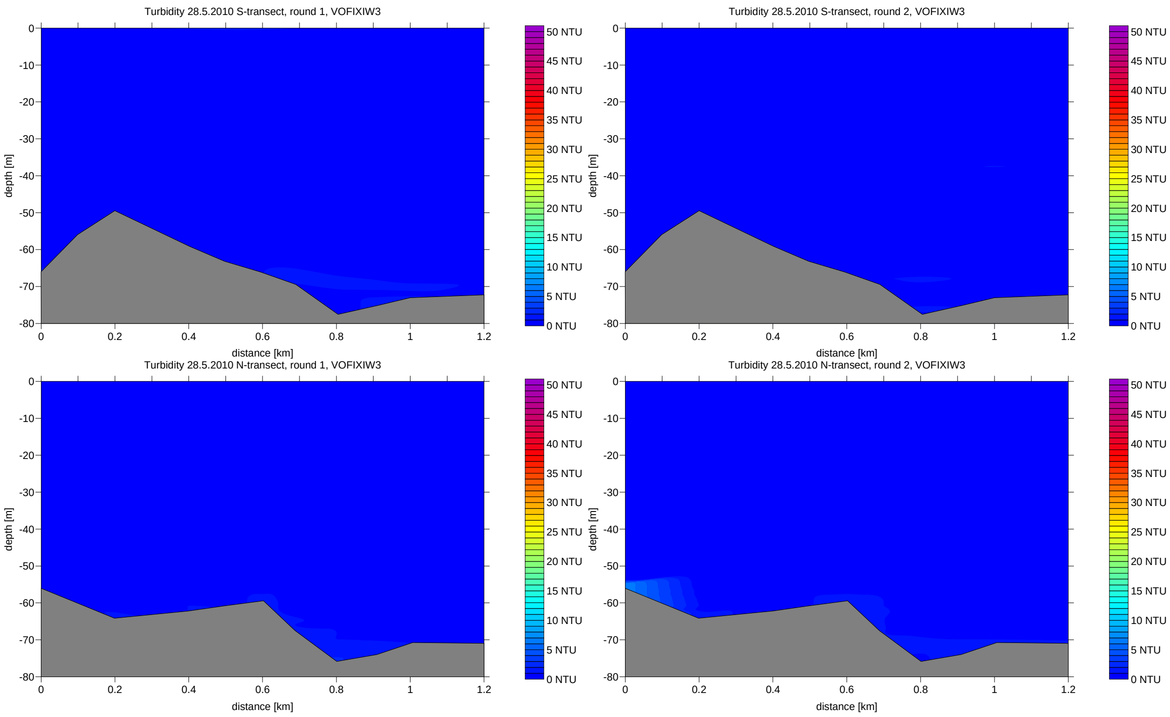


Figure 6.10 Vessel operated turbidity monitoring along the southern and northern transect at VOFIXIW3 on 28th May 2010. Southern transect= upper images; Northern transect= lower images. First round= left; second round= right /41/.

The highest turbidity values recorded by the fixed sensors were measured during transects monitoring and presented in Table 6.7. The whole duration of elevated turbidity in sea water, values over 5 NTU, lasted a maximum of one hour /94/.

Figure 6.11 shows graphically the occurrence and magnitude of turbidity peaks near the seabed, during the rock placement events in May 2010.

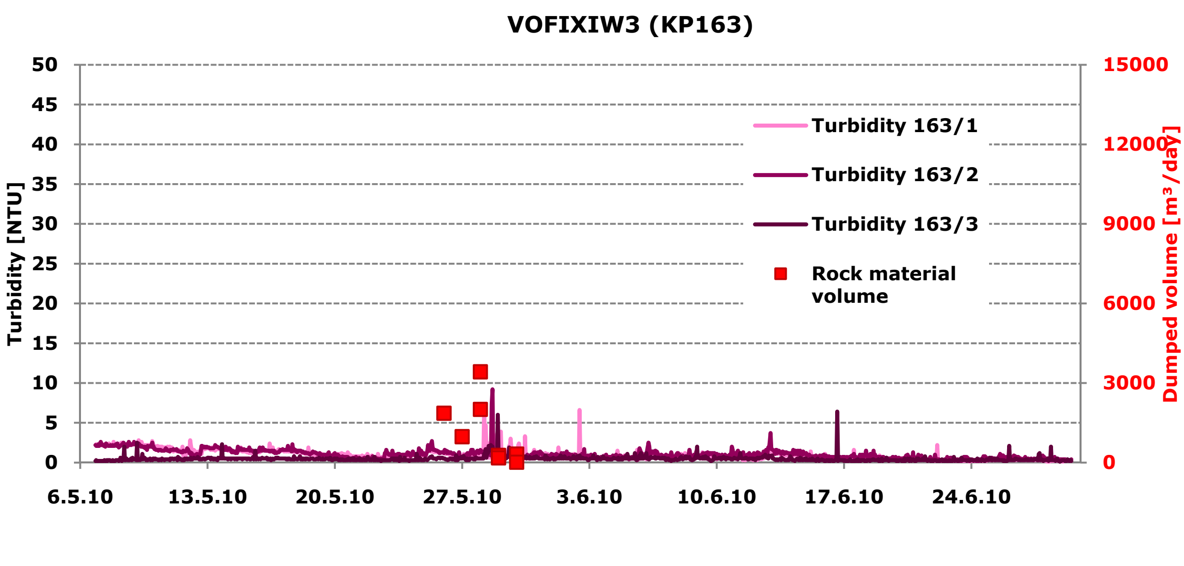


Figure 6.11 Fixed sensors. Turbidity (NTU) near the seabed (left y-axis) together with daily volumes of placed rock material (right y-axis) at VOFIXIW3 during 6.5.-29.6.2010 /41/.

Water samples
During vessel operated monitoring of the northern transect, water samples were taken approximately 100 m to the north of the activity, 2.4 km from the Estonian EEZ.

During sampling (28th May 2010) the turbidity value (3.9 FNU) indicated very slight turbidity increase near the seabed. Oxygen concentration was 2.6 mg O_2/l and the concentration of total phosphorus was 110 µg P/l, respectively. Average nutrient level in the rest of the water column, from surface to 50 metres, was 38 µg P/l and 350 µg N/. Metal concentrations in sea water were generally low, near or below the detection limit.

6.2.3 Sediment quality

Sediment sampling was carried out before and after rock placement along a transect line at SED2 related to the VOFIXIW1 station at the tie-in site. Sediment samples were taken from seven different locations along the transect line towards north from the rock placement location at the tie-in site (Figure 5.10, Tables 5.4-5.5). The furthest locations (3,200 m from the rock placement site) served as control stations.

6.2.3.1 General properties

The average concentration of dry matter was higher in the deeper sediment than in the surface sediment (Table 6.8). Also the percentage of dry matter was higher in both layers after the activity was finished. This difference can be explained by natural variation of sediment's physical composition. The percentage of organic matter was generally low and the value decreased below the uppermost surface layer. Concentration of clay in the sediments was quite high, on average >50 %, ranging from 42 to 81%. Highest values were measured in samples taken after the rock placement activity at a distance of 100 m from the tie-in area. At the same location the content of organic matter was zero.

Table 6.8 The average physical composition of the surface sediment along the transect SED2 /41/

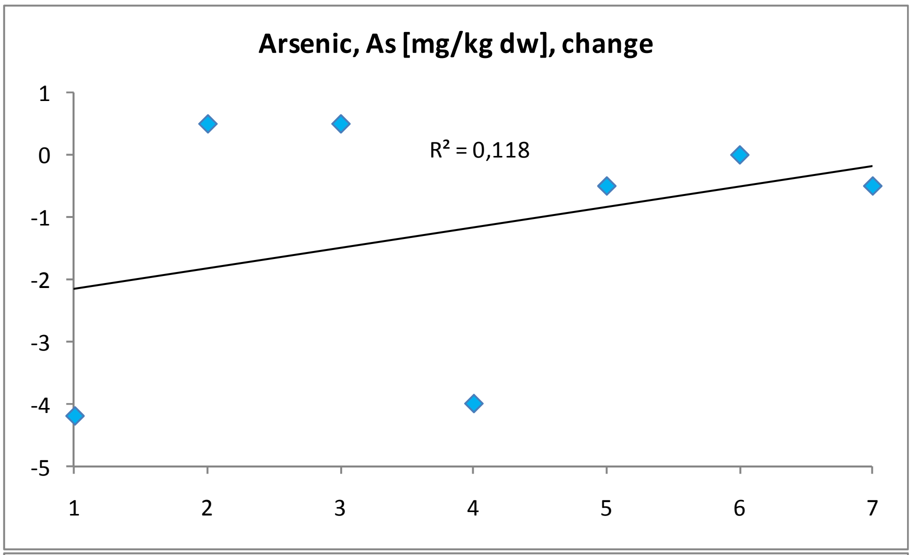
Sediment quality	0–2 cm (locations 1-7)		2-10 cm (locations 1-2)	
	pre*	post**	pre	post
Dry matter concentration %	14.7	19.8	24.7	39.2
Organic matter content % dw	9.4	8.8	4.2	4.1
Clay particles (<0.002 mm) % dw	52 (pre/post)		63 (pre/post)	

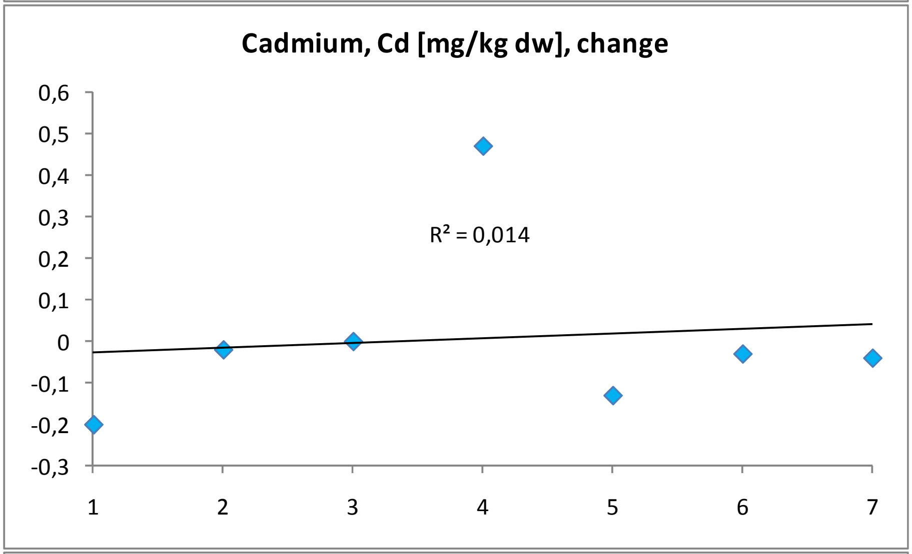
* Pre refers to sampling prior to rock placement.
** Post refers to sampling after rock placement.

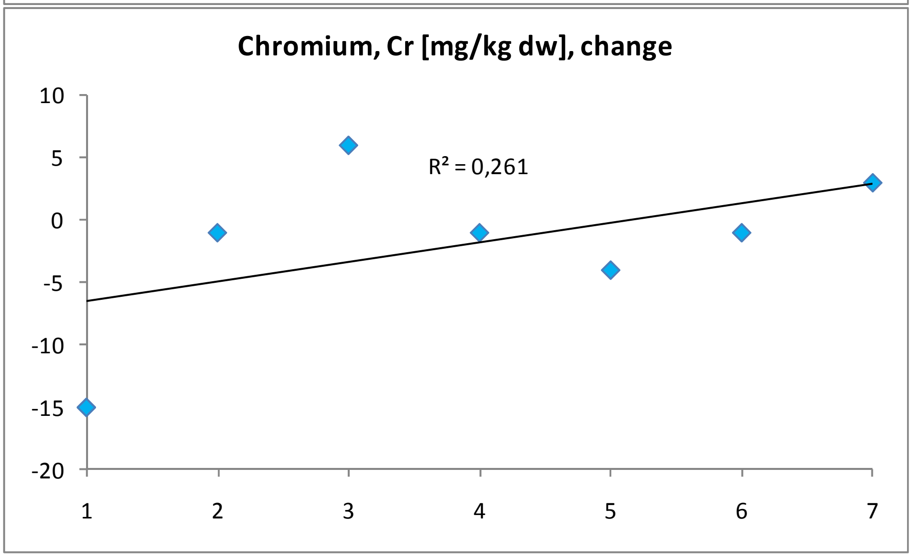
6.2.3.2 Arsenic and heavy metals

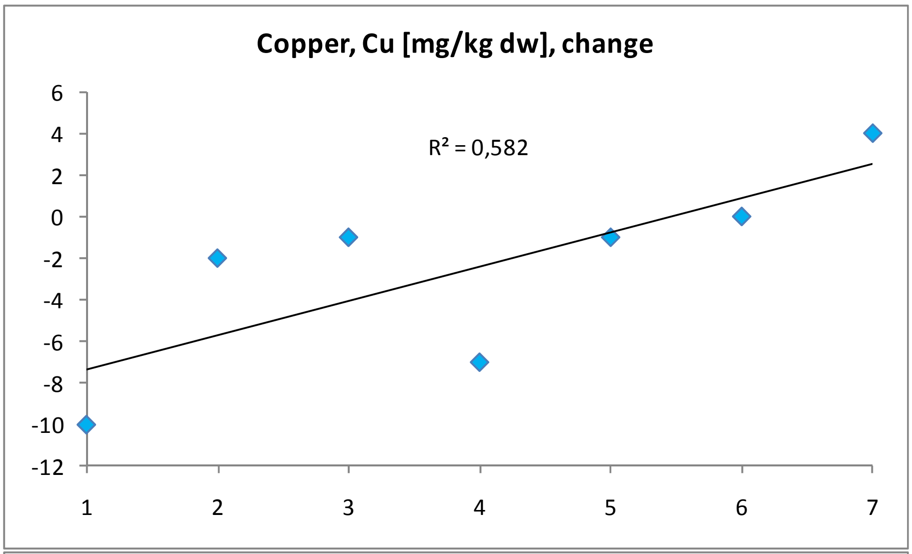
The analysed concentrations of arsenic and heavy metals are presented in Appendix 5, Table 6.9 and Figure 6.12). The concentrations were generally low. The only exception was a single elevated value of copper (220 mg/kg dw), that was detected from a sample taken before the rock placement started, in location SED2/2B (distance 100 m, depth 2-10 cm).

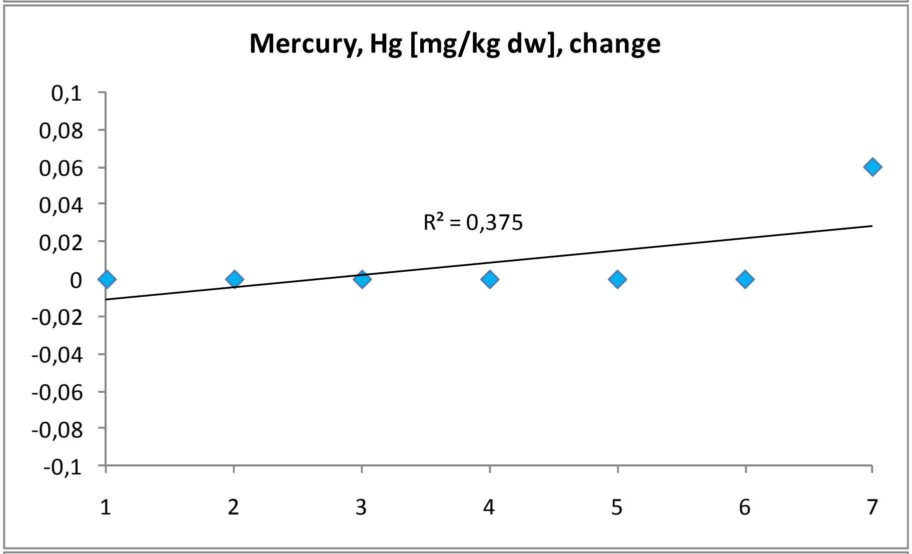
The graphs of the change in analysed arsenic and heavy metal concentrations, dry matter content and residual on ignition in surface sediment (0-2 cm) before and after the rock berm construction plotted against sampling location where 1 to 7 represent distances 50, 100, 200, 400, 800, 1600 and 3200 m, from the berm are presented in Figure 6.12.

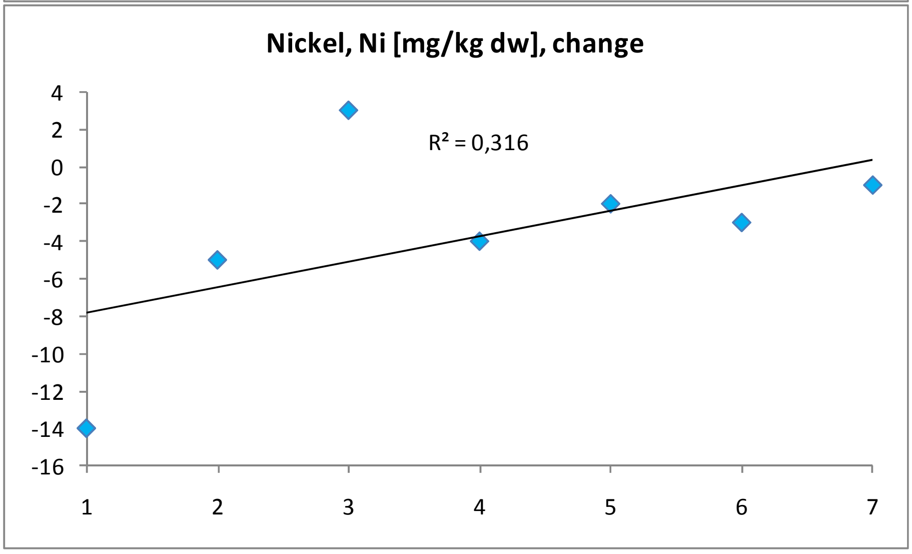

Arsenic, As [mg/kg dw], change
R² = 0,118
1
0
-1
-2
-3
-4
-5
1 2 3 4 5 6 7

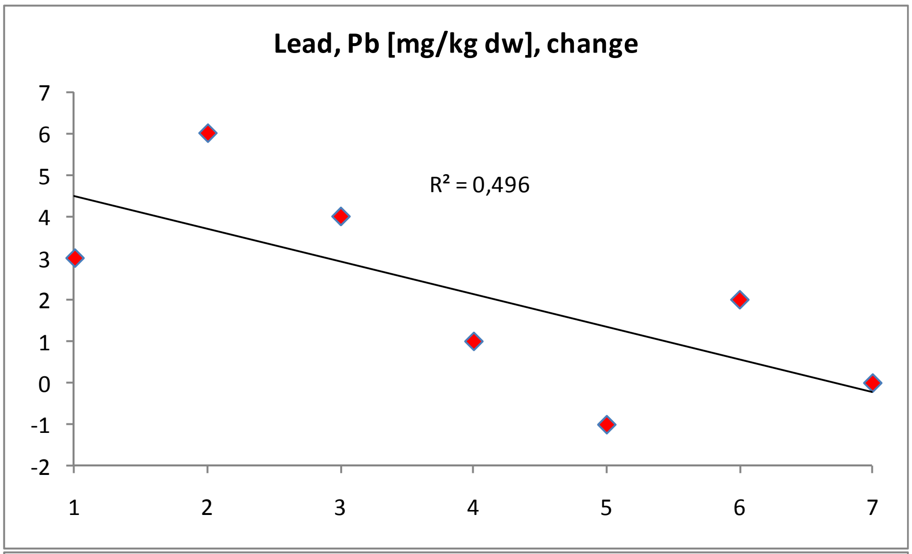

Cadmium, Cd [mg/kg dw], change
R² = 0,014
0,6
0,5
0,4
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
1 2 3 4 5 6 7

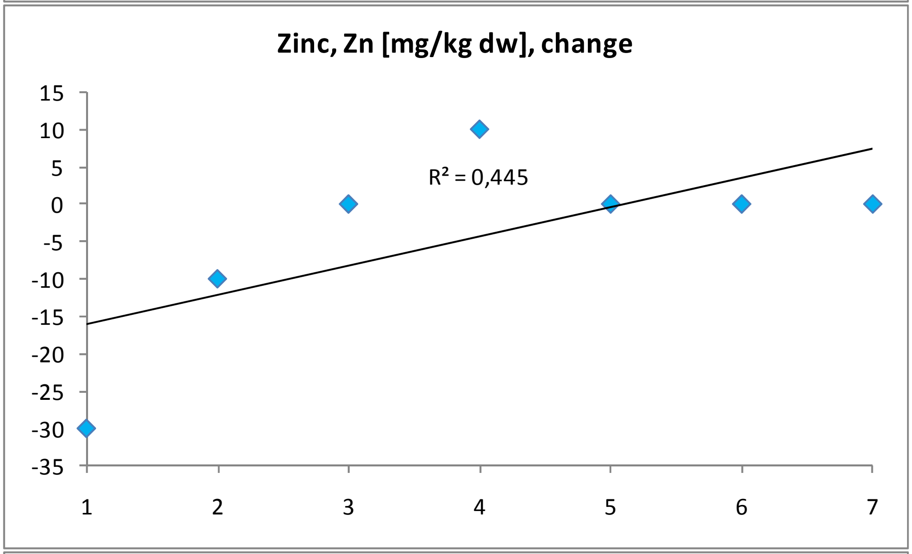

Chromium, Cr [mg/kg dw], change
R² = 0,261
10
5
0
-5
-10
-15
-20
1 2 3 4 5 6 7

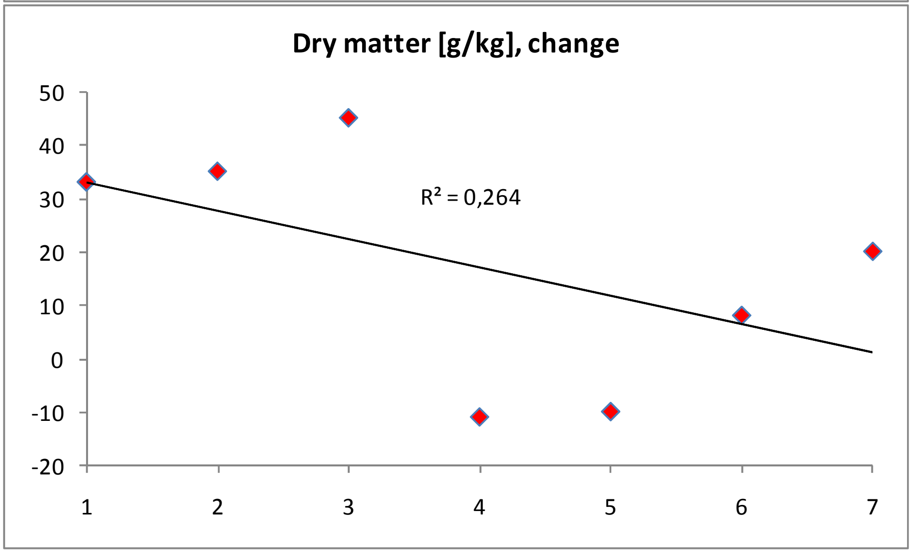

Copper, Cu [mg/kg dw], change
R² = 0,582
6
4
2
0
-2
-4
-6
-8
-10
-12
1 2 3 4 5 6 7


Mercury, Hg [mg/kg dw], change
R² = 0,375
0,1
0,08
0,06
0,04
0,02
0
-0,02
-0,04
-0,06
-0,08
-0,1
1 2 3 4 5 6 7


Nickel, Ni [mg/kg dw], change
R² = 0,316
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
1 2 3 4 5 6 7


Lead, Pb [mg/kg dw], change
R² = 0,496
7
6
5
4
3
2
1
0
-1
-2
1
2
3
4
5
6
7


Zinc, Zn [mg/kg dw], change
R² = 0,445
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
1
2
3
4
5
6
7


Dry matter [g/kg], change
R² = 0,264
50
40
30
20
10
0
-10
-20
1
2
3
4
5
6
7

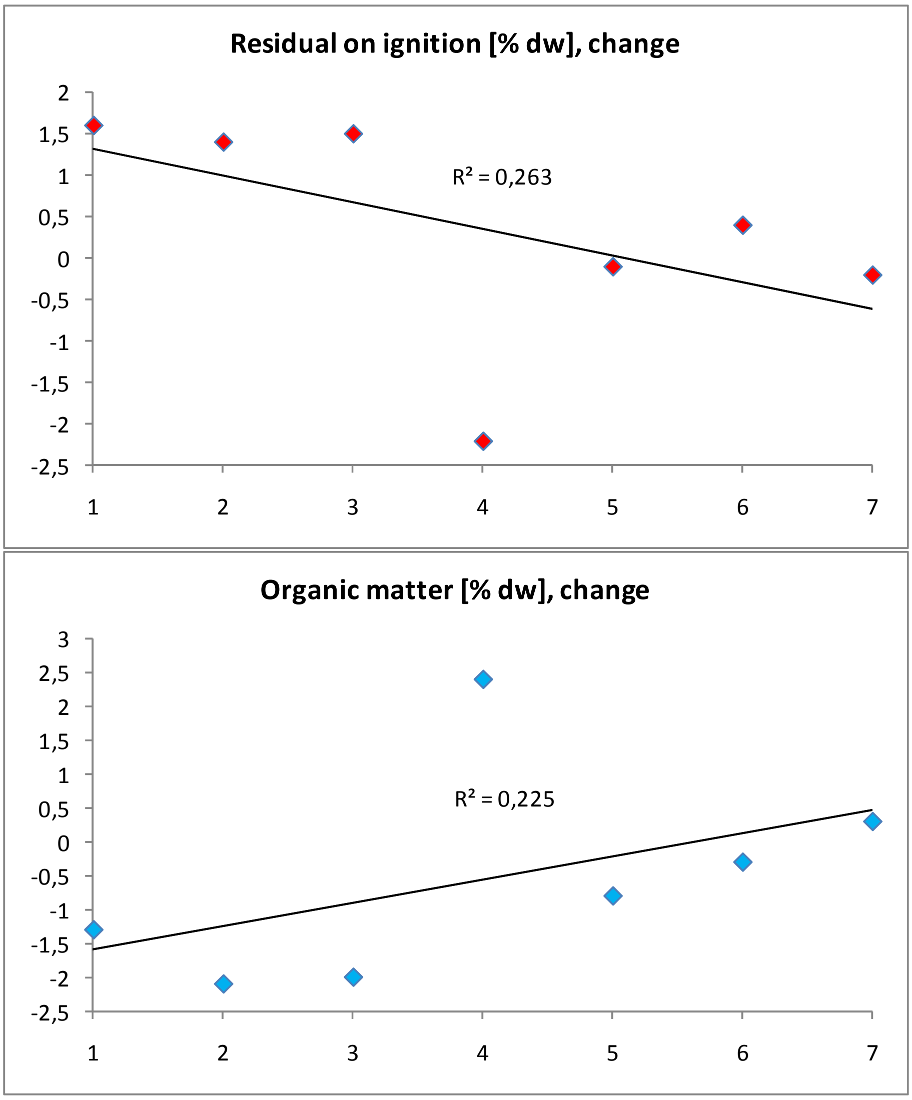


Figure 6.12 Change of metal concentrations (without normalisation), dry matter content, residual on ignition and organic matter content in pre and post activity sampling near the tie-in site /41/. The X-axis refers to the sampling location's number along the transect (1 = 50 m, 7 = 3,200 m; Table 5.5).

The graphs indicate that the concentrations of arsenic and nearly all heavy metals as well as the organic matter content in the surface sediment tend to decrease after rock berm construction. The decrease was most distinct at the sampling locations closest to the berm. However, the only statistically significant decrease was for copper (R^2 = 0.58, when the limit for the statistical significance is 0.56). Concentrations of lead showed an exception, as values indicated slight increase between pre and post samples. However, this trend was not statistically significant and the general level of lead was low. Dry matter concentration and residual on ignition close to the rock berm showed slight increases in post sampling.

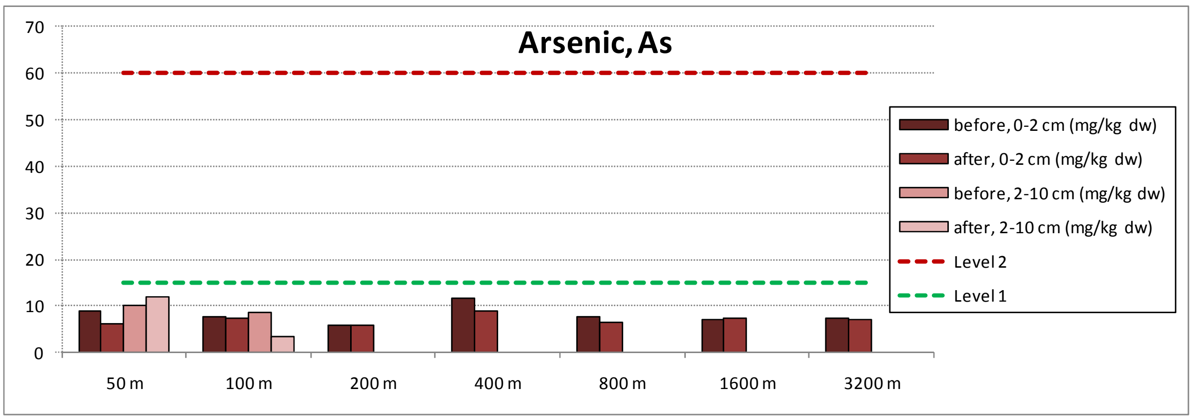
An example of the relation between the monitored metal concentrations to modelling input concentrations used in the assessment of the environmental impacts /96/ is presented in Table 6.9. The sampling locations at distances of 50 m and 3,200 m from the rock berm are used as reference.

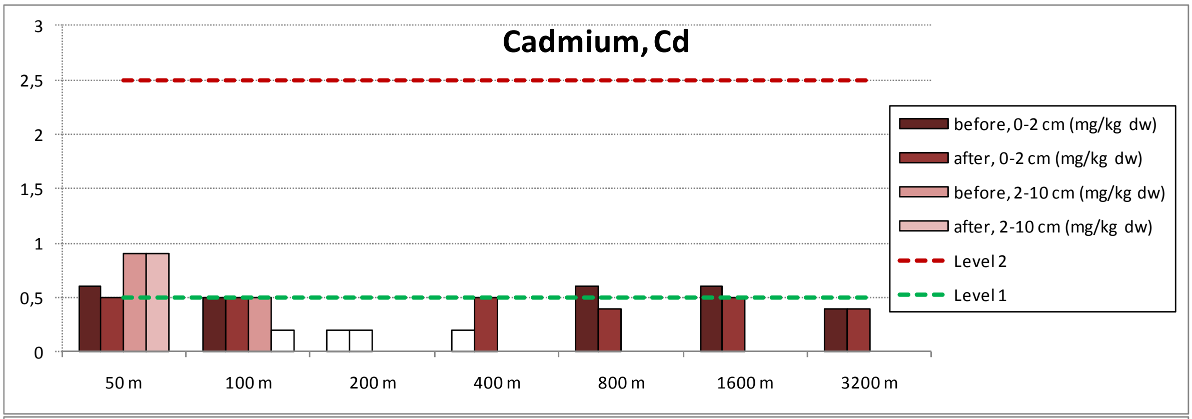
Table 6.9 Relation of monitored metal concentrations at distances of 50 m and 3,200 m from the rock berm to modelling input concentrations (90th% fractiles) /96/. Samples from 0-2 cm sediment layer, values without normalisation.

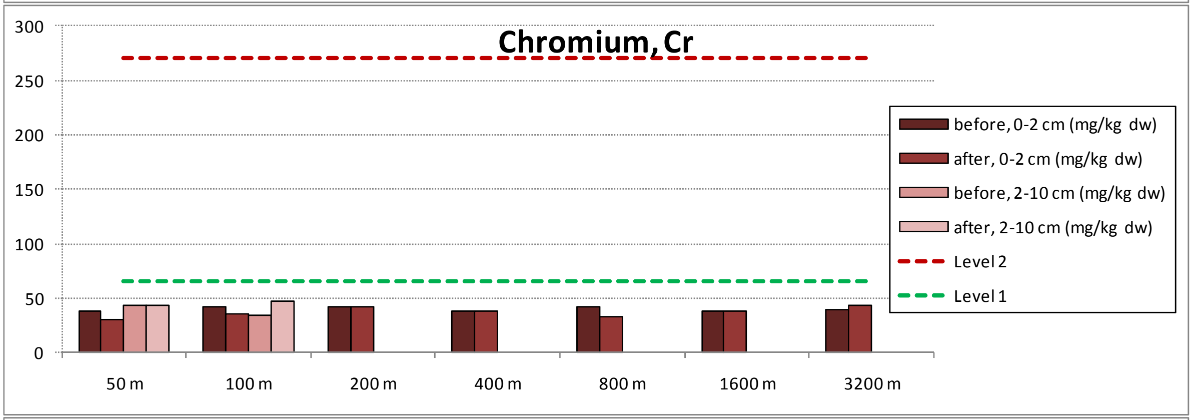
Substance	Monitored concentrations			Modelling input conc.
	Sampling phase	Distance, metres		
		50	3,200	
Arsenic, mg/kg dw	pre	12	10	15.5
	post	7.8	9.5	
Cadmium, mg/kg dw	pre	0.76	0.50	1.76
	post	0.56	0.46	
Chromium, mg/kg dw	pre	57	61	58.5
	post	42	64	
Copper, mg/kg dw	pre	39	33	96.6
	post	29	37	
Mercury, mg/kg dw	pre	<0.10	<0.10	0.066
	post	<0.10	0.11	
Nickel, mg/kg dw	pre	44	43	55
	post	30	42	
Lead, mg/kg dw	pre	26	28	38.7
	post	29	28	
Zinc, mg/kg dw	pre	160	150	360
	post	130	150	

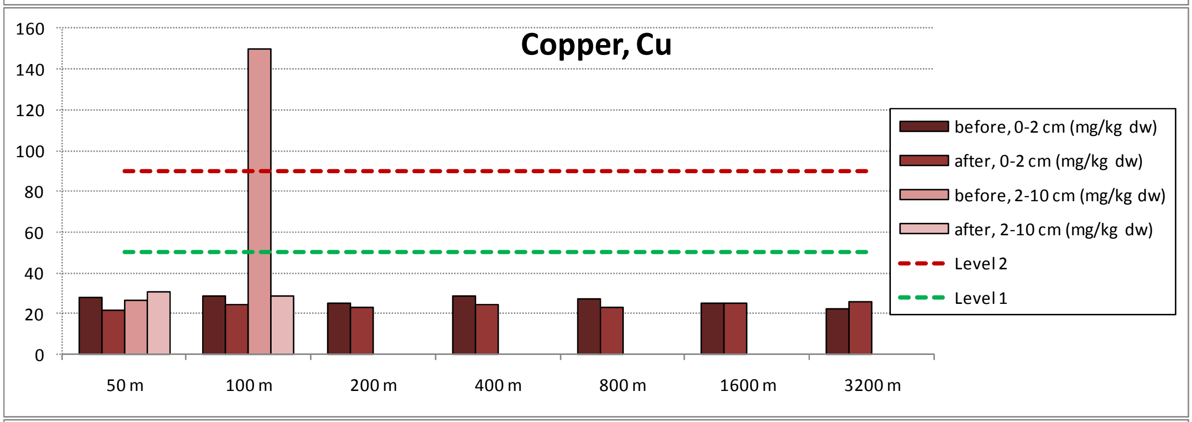
Table 6.9 indicates that the input concentrations used in modelling the spreading of the potential contaminants are in the main clearly higher than the monitored concentrations. For chromium and mercury the monitored and the modelling input values are at the same level.

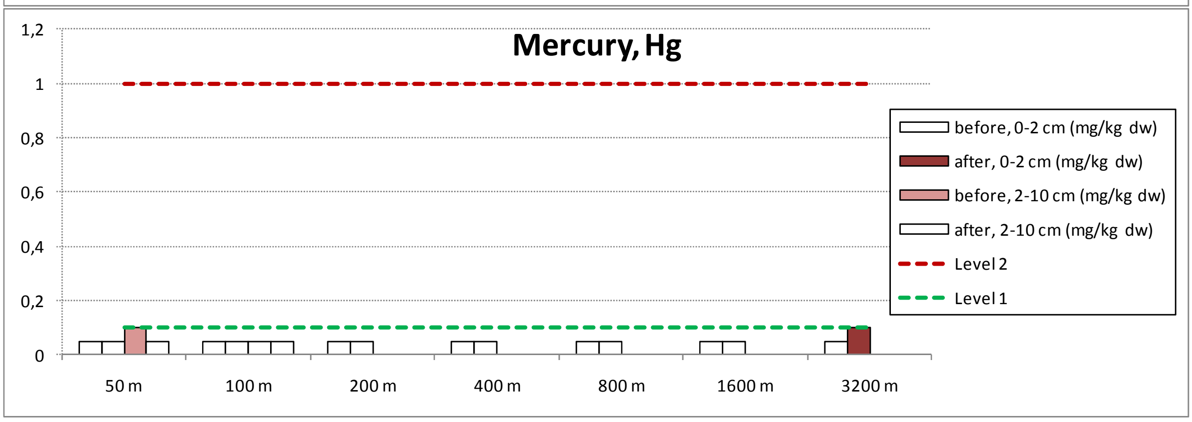
The normalised concentrations of arsenic and heavy metals are presented in histograms in Figure 6.13. The histograms indicate also the Level 1 and Level 2 threshold values of the Finnish quality criteria developed for the instructions for dredging and depositing dredged materials /97/. The numerical values are presented in Appendix 5.




Cadmium, Cd
3
2,5
2
1,5
1
0,5
0
50 m
100 m
200 m
400 m
800 m
1600 m
3200 m
before, 0-2 cm (mg/kg dw)
after, 0-2 cm (mg/kg dw)
before, 2-10 cm (mg/kg dw)
after, 2-10 cm (mg/kg dw)
Level 2
Level 1


Chromium, Cr
300
250
200
150
100
50
0
50 m
100 m
200 m
400 m
800 m
1600 m
3200 m
before, 0-2 cm (mg/kg dw)
after, 0-2 cm (mg/kg dw)
before, 2-10 cm (mg/kg dw)
after, 2-10 cm (mg/kg dw)
Level 2
Level 1


Copper, Cu
160
140
120
100
80
60
40
20
0
50 m
100 m
200 m
400 m
800 m
1600 m
3200 m
before, 0-2 cm (mg/kg dw)
after, 0-2 cm (mg/kg dw)
before, 2-10 cm (mg/kg dw)
after, 2-10 cm (mg/kg dw)
Level 2
Level 1


Mercury, Hg
1,2
1
0,8
0,6
0,4
0,2
0
50 m
100 m
200 m
400 m
800 m
1600 m
3200 m
before, 0-2 cm (mg/kg dw)
after, 0-2 cm (mg/kg dw)
before, 2-10 cm (mg/kg dw)
after, 2-10 cm (mg/kg dw)
Level 2
Level 1

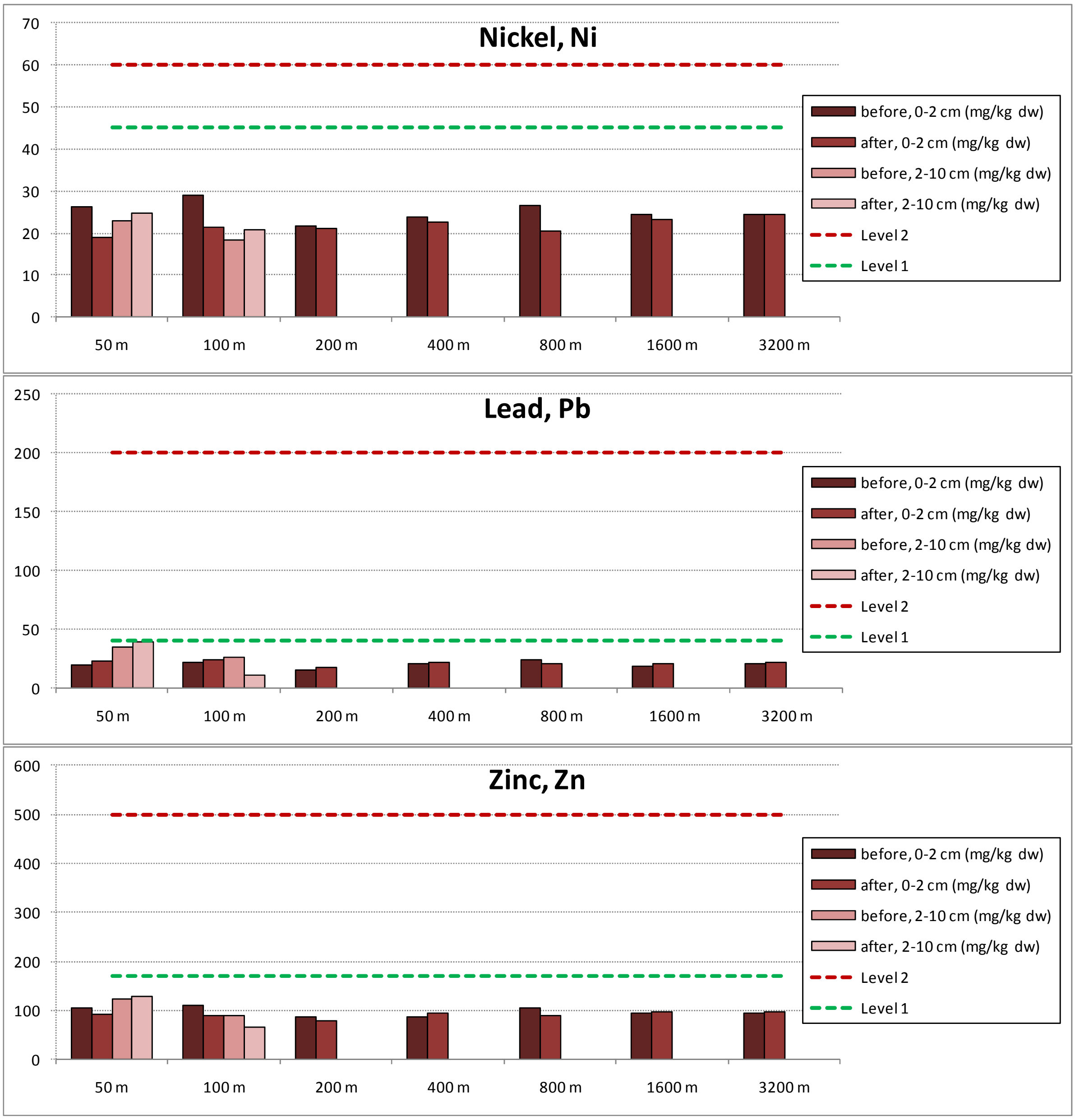


Figure 6.13 Normalised concentrations of arsenic and analysed heavy metals in surface sediment along the transect SED2 before and after rock placement. The white bars indicate concentrations below detection limit; presented values are detection limit divided by 2.

The normalised concentrations of arsenic and most heavy metals did not exceed the Level 1 threshold values. The elevated single copper concentration of sample SED2/2B was 150 mg/kg dw, exceeding Level 2 (90 mg/kg dw). Cadmium showed slightly elevated concentrations of 0.6-0.9 mg/kg dw (Level 1 being 0.5 mg/kg dw) in some sampling locations. However, all the normalised cadmium concentrations were low compared to Level 2 (2.5 mg/kg dw).

6.2.3.3 Dioxins and furans

The analysed concentrations of dioxins/furans are presented in Appendix 5, Table 6.10 and Figure 6.14. The analysed concentration level was generally low and the WHO-TEQ and I-TEQ concentrations of dioxins/furans were practically identical. However, the concentrations analysed from sample SED2/1B (distance 50 m, depth 2-10 cm) were 2-3-fold higher compared to the general level.

The graph of the change of analysed concentrations of dioxins/furans in surface sediment (0-2 cm) before and after the rock berm construction plotted against distance from the berm, are presented in Figure 6.14.

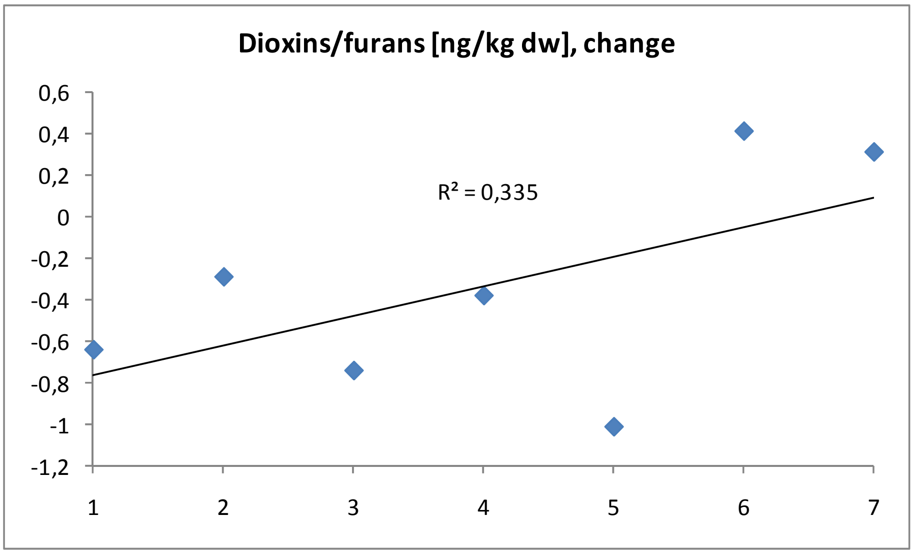


Figure 6.14 Change of concentrations of dioxins/furans (without normalisation) in pre and post activity sampling near the tie-in site /41/. The X-axis refers to the sampling location's number along the transect SED2 (Table 5.5).

There was a decreasing tendency in the concentration of dioxins/furans in the surface sediment close to the rock berm after the rock placement work. However, the tendency did not fulfil the requirements of the statistical significance.

An example of the relation between the monitored concentrations of dioxins/furans to modelling input concentrations used in the assessment of the environmental impacts /98/ is presented in Table 6.10. The sampling locations at distances of 50 m and 3,200 m from the rock berm are used as reference.

Table 6.10 Relation of monitored concentrations of dioxins/furans at distances of 50 m and 3,200 m from the rock berm to modelling input concentrations (90^{th}% fractiles) /98/. Samples from 0-2 cm sediment layer, values without normalisation.

Substance	Monitored conc.			Modelling input conc.
	Sampling phase	Distance, metres		
		50	3200	
Dioxins/furans, ng WHO-TEQ/kg dw	pre	7.10	7.11	17.9
	post	6.46	7.42	

The concentration of dioxins/furans used as modelling input value can be considered to be conservative.

The normalised WHO-TEQ concentrations of dioxins/furans are presented in Figure 6.15 with the Level 1 and Level 2 threshold value lines /97/. The numerical values are presented in Appendix 5.

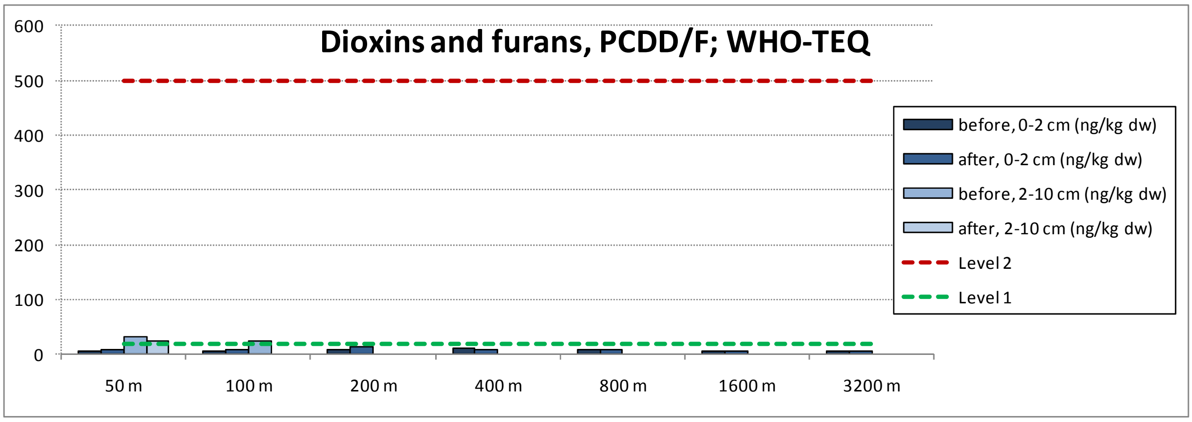


Figure 6.15 Normalised concentrations of dioxins/furans in surface sediment along the transect SED2 before and after rock placement

Normalised concentrations of dioxins/furans were mainly below or very close to the Level 1 threshold value. Normalised concentrations of the pre sample from the SED2/1B location were highest, being on the level of 30-32 ng/kg dw WHO-TEQ/I-TEQ. All the concentrations were low compared to Level 2 (500 ng/kg dw).

6.2.3.4 Organotin compounds

The analysed concentrations of organotin compounds are presented in Appendix 5, Table 6.11 and Figure 6.16. Analysed tributyltin (TBT) concentrations were relatively high both in pre and post samples, showing random concentration peaks along the monitored transect. However, concentrations of the other organotin compounds were low or moderately low.

The graph of the change of analysed TBT concentrations in surface sediment (0 - 2 cm) before and after rock berm construction plotted against distance from the berm are presented in Figure 6.16.

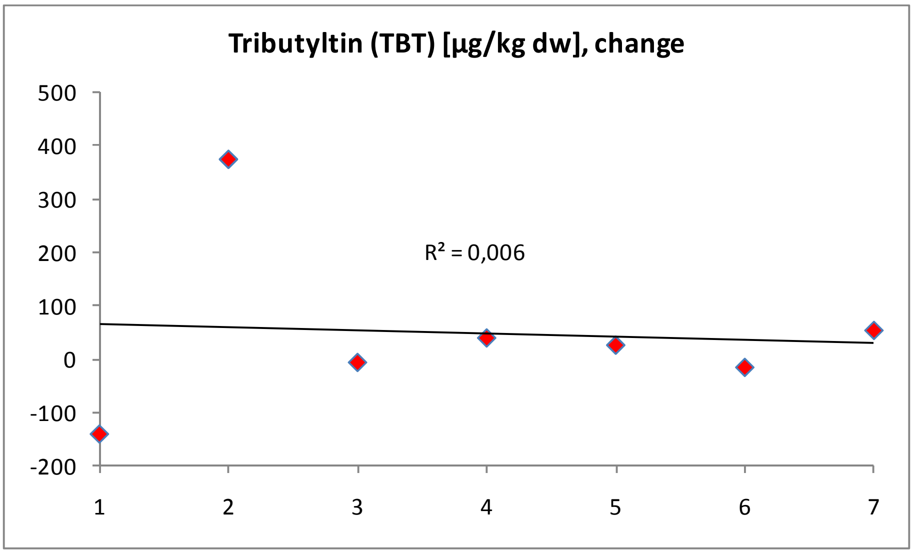


Figure 6.16 Change of tributyltin (TBT) concentrations (without normalisation) in pre and post activity sampling near the tie-in site /41/. The X-axis refers to the sampling location's number along the transect SED2 (Table 5.5).

Generally the TBT concentration did not show any tendency along the distance from the rock berm. However, close to the berm the concentrations showed wide variation, which probably indicate both the heterogeneity of the seafloor and the random existence and behaviour of TBT.

An example of the relation between the monitored TBT concentrations to modelling input concentrations used in the assessment of the environmental impacts /96/ is presented in Table 6.11. The sampling locations at distances of 50 m and 3,200 m from the rock berm are used as reference.

Table 6.11 Relation of monitored TBT concentrations at distances of 50 m and 3,200 m from the rock berm to modelling input concentrations (90th% fractiles) /96/. Samples from 0-2 cm sediment layer, values without normalisation.

Substance	Monitored conc.			Modelling input conc.
	Sampling phase	Distance, metres		
		50	3200	
TBT, µg/kg dw	pre	266	39.7	70.4
	post	124	92.5	

For TBT the modelling input value can be considered to be mainly lower than the monitored concentrations.

The normalised concentrations of TBT are presented in Figure 6.17 with the Level 1 and 2 threshold value lines /97/. The numerical values are presented in Appendix 5.

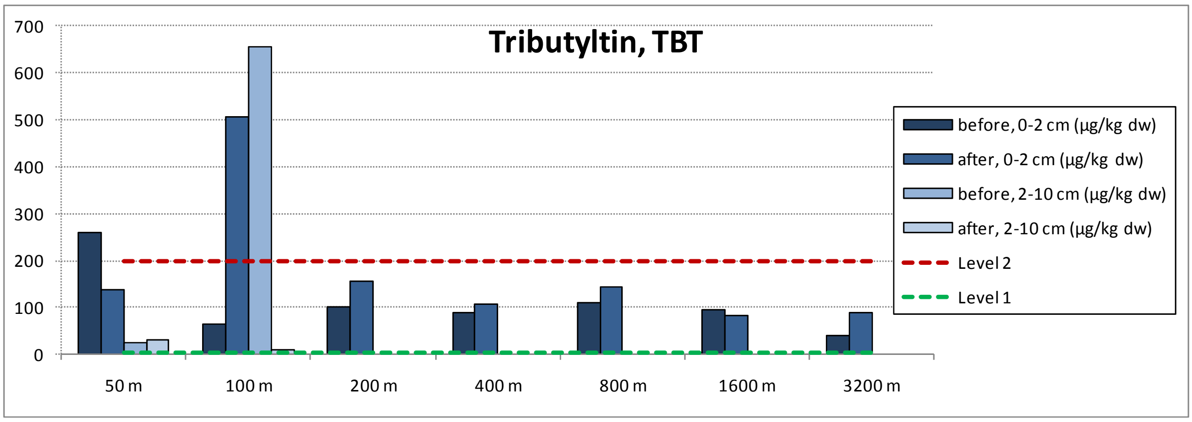


Figure 6.17 Normalised concentrations of tributyltin (TBT) in surface sediment along the transect SED2 before and after rock placement.

Normalised TBT concentrations were all categorised above Level 1 (3 µg/kg dw) and in three samples the concentrations exceeded Level 2 (200 µg/kg dw). The concentration was highest at sampling location 100 m (nr 2) from the rock berm in the pre sample. In general the pre and post concentrations of TBT were highest at sampling locations 50 m (nr 1) and 100 m (nr 2) from the rock berm.

6.2.3.5 Advanced statistical analyses

In the following the main results of the advanced statistical analyses concerning sediment samples taken before and after the rock placement activity in 2010 are presented. The purpose of the analyses was to examine if the analysed concentrations of the monitored critical

parameters vary between the pre and post activity monitoring. The data analysed includes the results from the transect SED2 in 2010. The relevant results from the baseline monitoring in 2009 /99/ have been used in analysis and as comparison where applicable. The 2009 results from the sampling points nearest to the tie-in site have been used. The data used in the analysis represents the 0 - 2 cm sediment layer for the 2009 survey and the sediment layers of 0 - 2 cm and 2 - 10 cm for the 2010 surveys /100/.

Arsenic and heavy metals

A comparison of median values for the pre (in 2009 and in 2010) and post sediment samples (in 2010) is shown in Figure 6.18. The median value for the post monitoring samples after the rock placement is divided by the median value from the pre samples. If value is greater than 1 this indicates an increase in the median value.

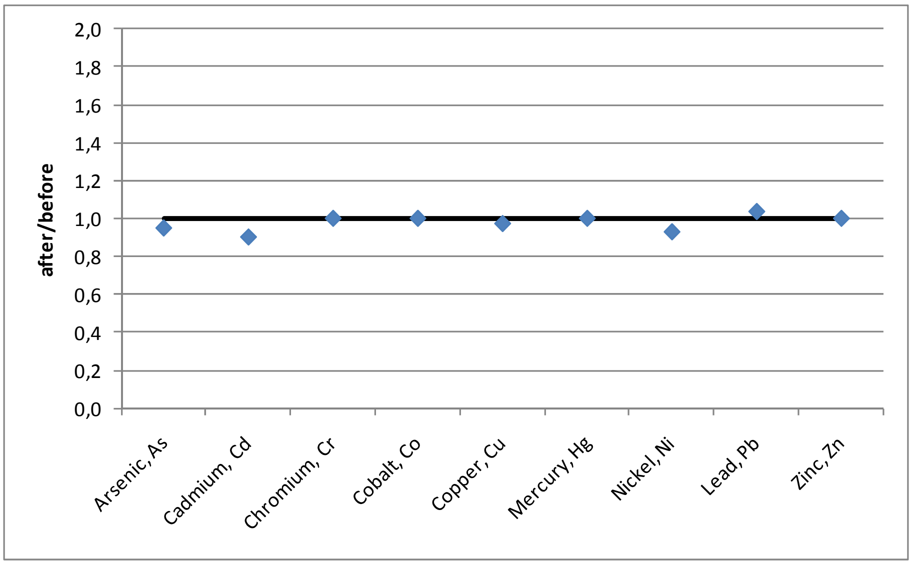
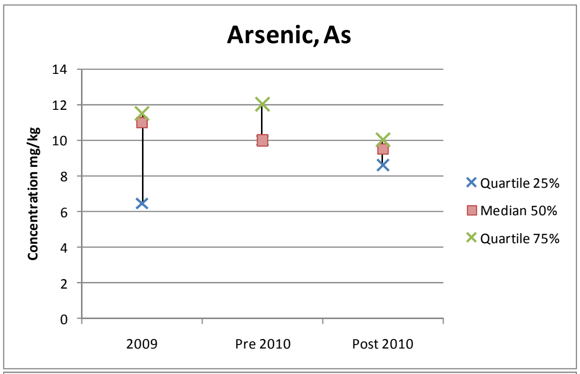
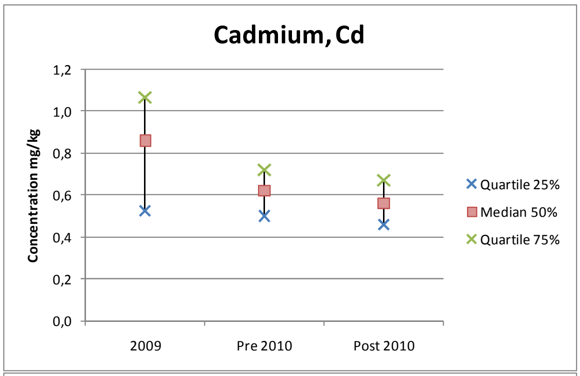


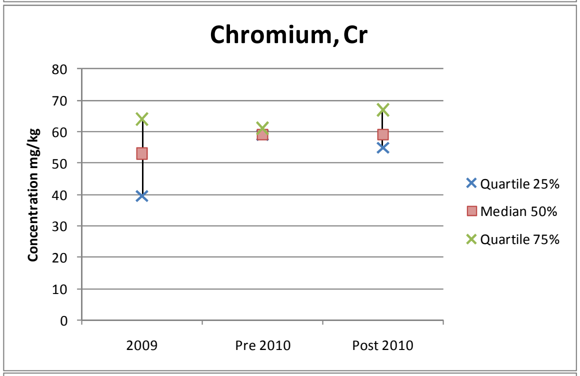
Figure 6.18 Comparison of pre and post activity median values (post/pre) /100/

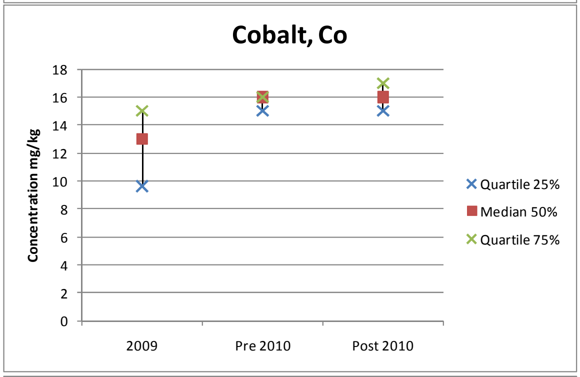
For arsenic and heavy metals the median value in the post works sampling was only greater for lead.

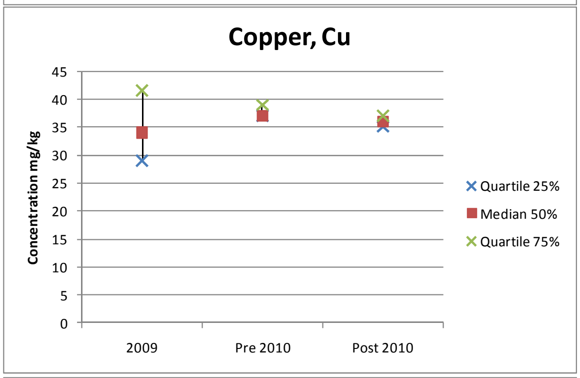
The boxplots illustrating the differences between the arsenic and heavy metal concentrations for the three sampling periods (2009 /99/, "Pre 2010" and "Post 2010") are presented in Figure 6.19. The boxplots indicate the median and the 25 % and 75 % quartiles.

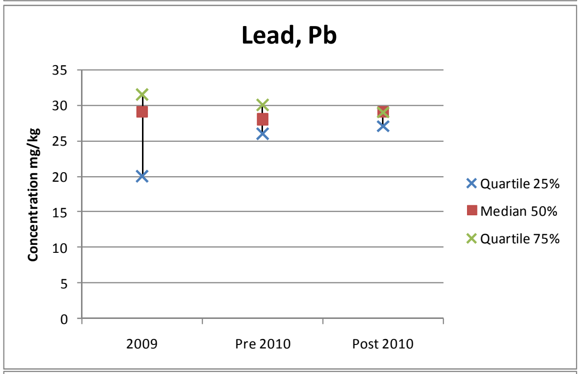

Arsenic, As
Concentration mg/kg
14
12
10
8
6
4
2
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%

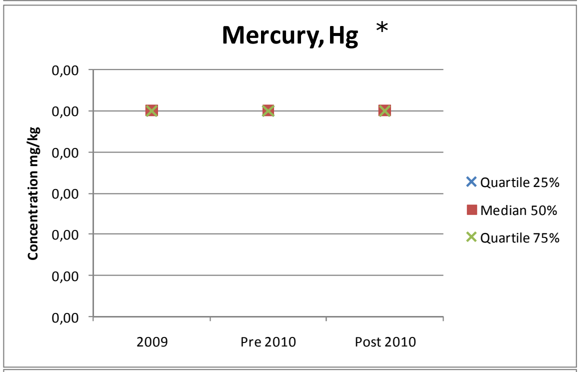

Cadmium, Cd
Concentration mg/kg
1,2
1,0
0,8
0,6
0,4
0,2
0,0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%

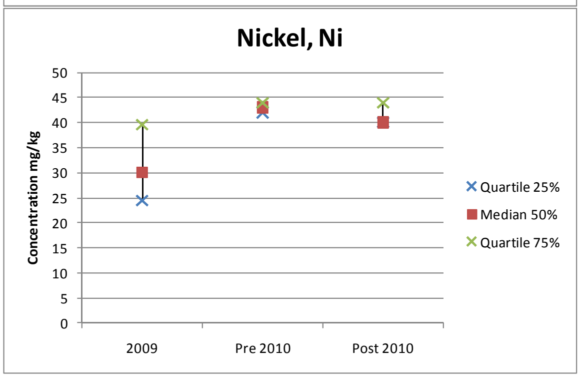

Chromium, Cr
Concentration mg/kg
80
70
60
50
40
30
20
10
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%

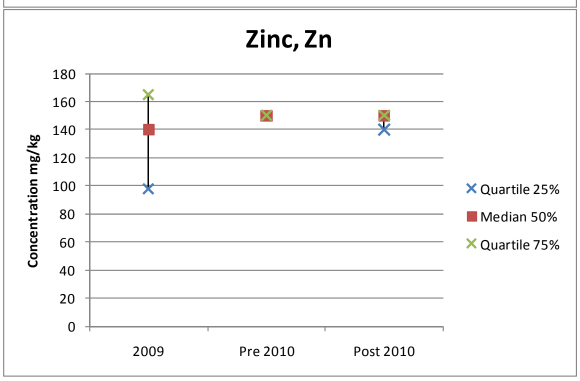

Cobalt, Co
Concentration mg/kg
18
16
14
12
10
8
6
4
2
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%


Copper, Cu
Concentration mg/kg
45
40
35
30
25
20
15
10
5
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%


Lead, Pb
Concentration mg/kg
35
30
25
20
15
10
5
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%


Mercury, Hg *
Concentration mg/kg
0,00
0,00
0,00
0,00
0,00
0,00
0,00
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%

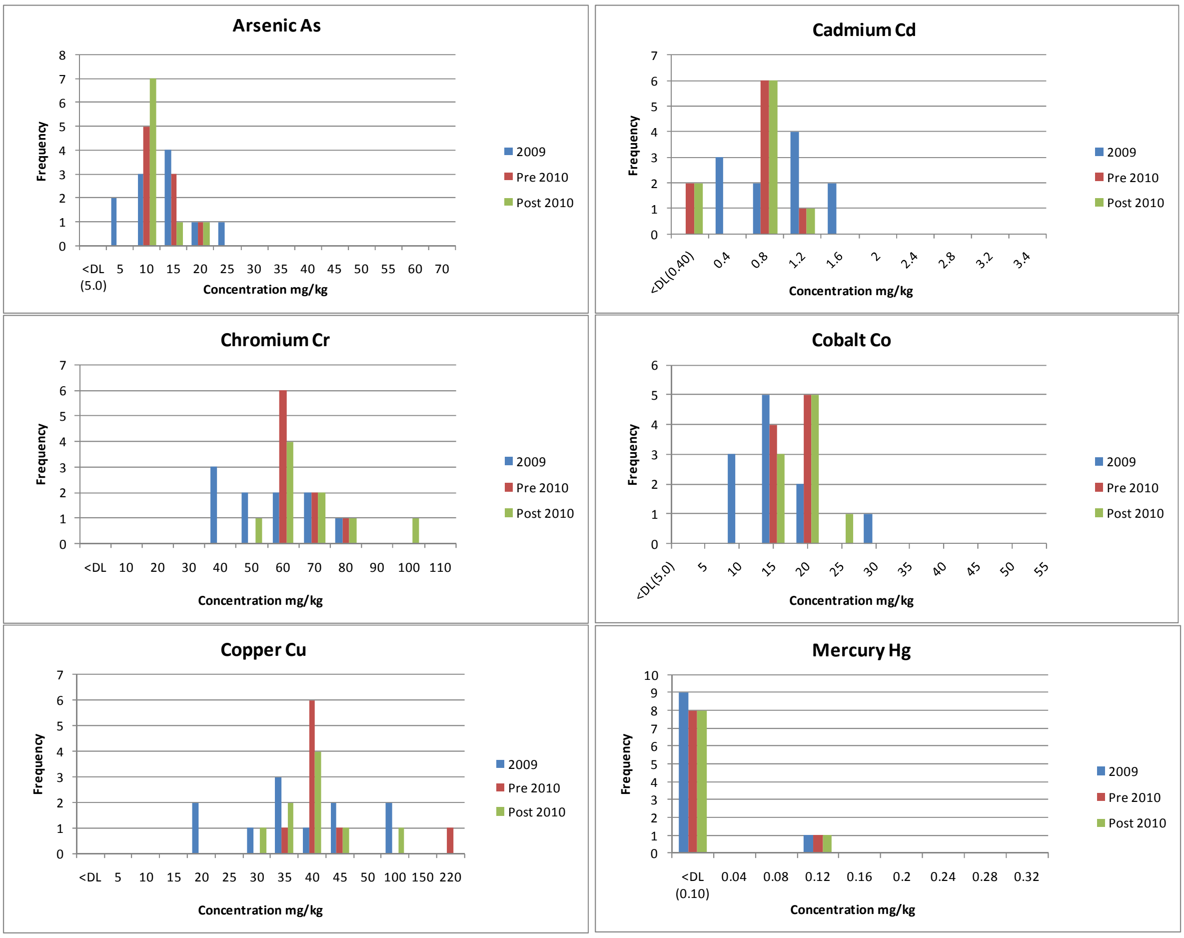

Nickel, Ni
Concentration mg/kg
50
45
40
35
30
25
20
15
10
5
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%


Zinc, Zn
Concentration mg/kg
180
160
140
120
100
80
60
40
20
0
2009
Pre 2010
Post 2010
Quartile 25%
Median 50%
Quartile 75%

*The analyses results of Hg from the three sampling rounds (2009, before rock placement 2010 and after rock placement 2010) were below the detection limit, except for one water sample. Due to this, the 25%-quartile, median and 75%-quartile are below the detection limit (0.1 mg/kg).

Figure 6.19 The boxplots for arsenic and heavy metals /100/
Only lead showed an increase in median concentration from pre the samples to the post samples taken after rock placement works, which match the Figure 6.18. However, the data from 2009 /99/ showed an even greater median, which suggests that the rock placement activity had no effect on lead concentration.

The bar charts for metals are presented in Figure 6.20. The blue bars show the results from the survey in 2009 /99/, the red bars from the pre samples in 2010 and the green bars from the post samples in 2010.



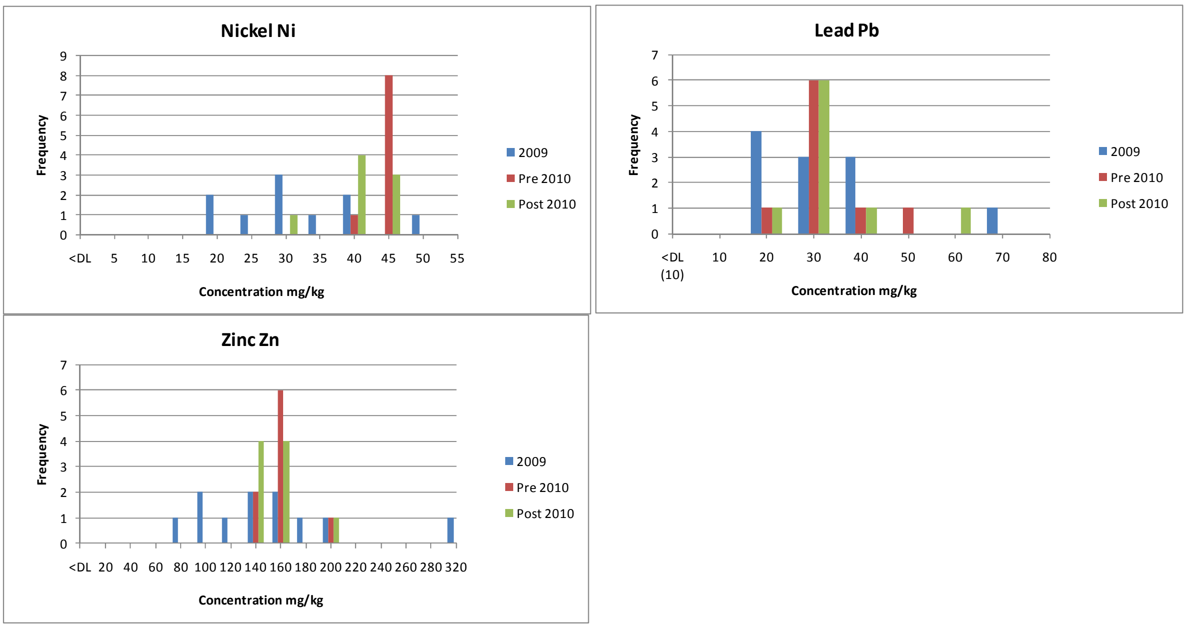


Figure 6.20 The bar charts for arsenic and heavy metals /100/

For arsenic there was no indication of a greater concentration as a result of the rock placement. For cadmium a number of the samples in the 2009 survey data showed higher values than those recorded in 2010. For chromium one sample in 2010 dataset had a higher value, which does not indicate a general trend. For cobalt and copper, samples taken during the 2009 survey and during the pre sampling 2010 had higher concentrations than the post works samples.

Most mercury samples for all three sampling sets had values below the detection limit. Only one value was above the detection limit of 0.1 mg/kg dw in 2009, pre 2010 and post 2010 sample sets.

Nickel showed no increasing level as a result of the rock placement. Samples in 2009 had greater value than those measured in both pre and post 2010 sample sets.

Lead and zinc levels in pre and post samples in 2010 were nearly identical. There was no indication of a greater concentration of the two compounds as a result of the rock placement compared to the 2009 environmental survey.

The data had large variability and most contaminants did not follow the normal distribution. The graph for chromium was the only one showing some tendency towards a normal distribution. Based on this it was not possible to use the F-test. The nonparametric Wilcoxon rank sum test was used instead to compare independent samples of two populations (before and after samples). The tested hypotheses were:

H_0: There is no difference in the concentrations in pre and post samples 2010 ($\mu1=\mu2$)
H_a: Contaminant concentrations are significantly higher in post samples 2010 ($\mu1<\mu2$)

The results of the Wilcoxon rank sum test were as follows:

Arsenic and heavy metals	Z	$Z_{critical}$	Decision
Arsenic, As	1.325	-1.645	Do Not Reject H_0
Cadmium, Cd	0.397	-1.645	Do Not Reject H_0
Chromium, Cr	0.265	-1.645	Do Not Reject H_0
Cobalt, Co	-0.530	-1.645	Do Not Reject H_0
Copper, Cu	1.280	-1.645	Do Not Reject H_0
Mercury, Hg	-0.044	-1.645	Do Not Reject H_0
Nickel, Ni	0.795	-1.645	Do Not Reject H_0
Lead, Pb	-0.309	-1.645	Do Not Reject H_0
Zinc, Zn	0.971	-1.645	Do Not Reject H_0

For arsenic and heavy metals it could be concluded on a 95 % confidence level that the pre and post activity sampling data populations are not significantly different as the H_0 hypothesis was not rejected /100/.

Dioxins and furans
A comparison of summary statistics based on WHO-TEQ concentrations of data from 2010 and the relevant data from 2009 /99/ showed that the median value for dioxin/furan samples was lower in the 2010 samples (including both pre and and post samples) compared to the 2009 samples /100/.

The boxplot showing the differences between the dioxin/furan concentrations for the three sampling sets (2009 /99/, "Pre 2010" and "Post 2010") is presented in Figure 6.21. The boxplot indicates the median and the 25 % and 75 % quartiles.

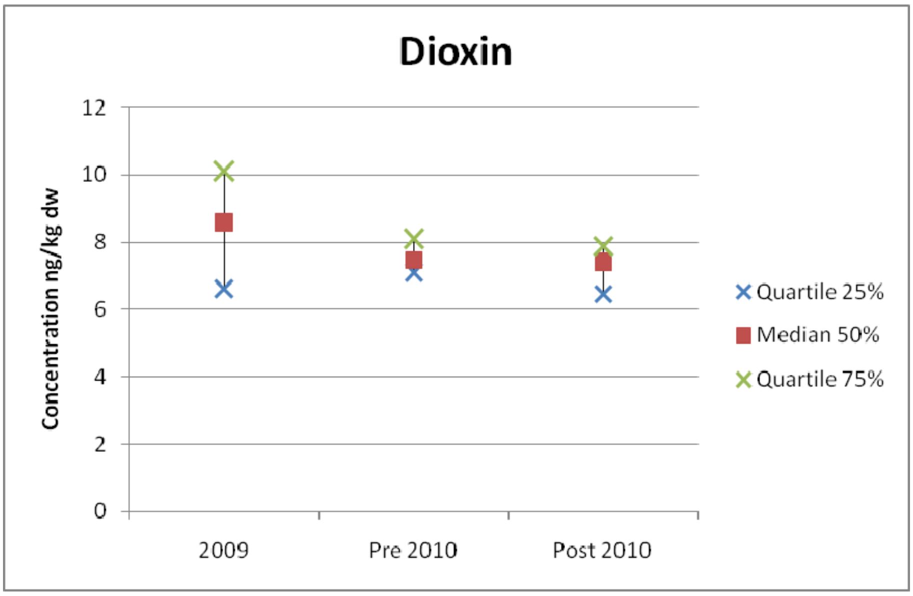


Figure 6.21 The boxplot for dioxins/furans /100/

Figure 6.21 shows that there was no increase in dioxins/furans concentrations from the pre sampling 2010 to the post sampling 2010. Data from 2009 had a higher median value compared to 2010.

The bar charts for dioxins/furans are presented in Figure 6.22. The green bars show the results from the survey in 2009 /99/, the blue bars from the pre samples in 2010 and the red bars from the post samples in 2010.

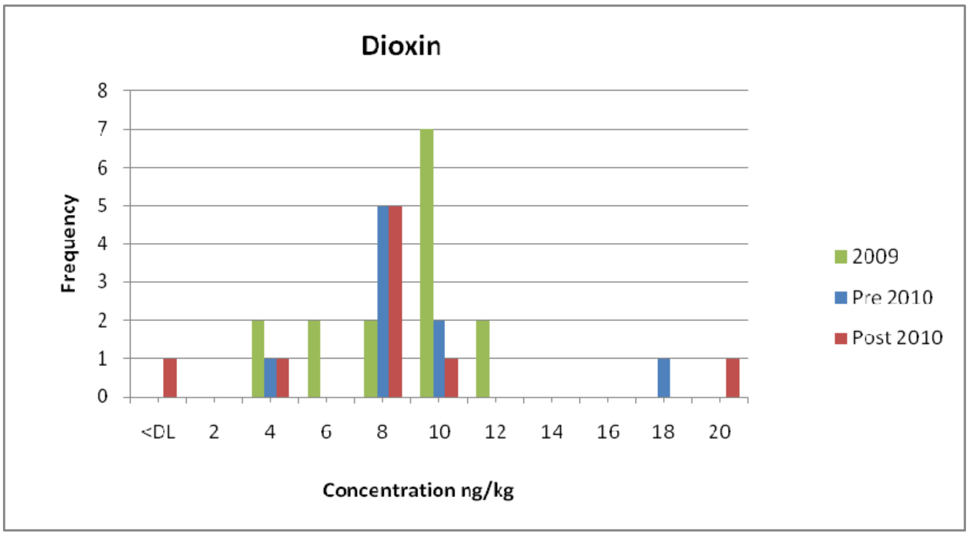


Figure 6.22 The bar chart for dioxins/furans /100/

Figure 6.22 shows that more samples had higher concentrations of 10-12 ng/kg dw in the 2009 sampling compared to the both 2010 samplings. However the pre and post samples from the same sampling location and sediment depth (SED2 1B, 2-10 cm) in 2010 showed significantly higher values of 18-20 ng/kg dw, but this indicates a random higher concentration and is not related to the rock placement activities.

The 2009 and the pre sample 2010 data did not follow the normal distribution and the F-test could not be used. The nonparametric Wilcoxon rank sum test was used instead to compare independent samples of two populations (before and after samples). The tested hypotheses were:

H_0: There is no difference in the concentrations in pre and post samples 2010 ($\mu_1=\mu_2$)
H_a: Contaminant concentrations are significantly higher in post samples 2010 ($\mu_1<\mu_2$)

The result of the Wilcoxon rank sum test was as follows:

Dioxins/furans	Z	$Z_{critical}$	Decision
PCDD/F, WHO-TEQ	0.221	-1.645	Do Not Reject H_0

For dioxins/furans the H_0 hypothesis was not rejected and therefore on a 95 % confidence level the pre and post activity sampling data populations are not significantly different /100/.

Organotin compounds
The 2009 survey did not include organotin analyses, so here only the results from the 2010 surveys are presented.

A comparison of summary statistics for organotin compounds monobutyltin (MBT), dibutyltin (DBT) and tributyltin (TBT) showed that in the 2010 results the median and maximum values were higher after rock placement for all three compounds /100/.

In the following only the results concerning TBT are presented, because the concentrations of MBT and DBT depend to high extent on the existence of TBT (MBT and DBT are degradation products of TBT) and because TBT is far more toxic than the other two compounds.

The boxplot showing the differences between the TBT concentrations for the pre and post sampling sets in 2010 ("Pre 2010" and "Post 2010") is presented in Figure 6.23.

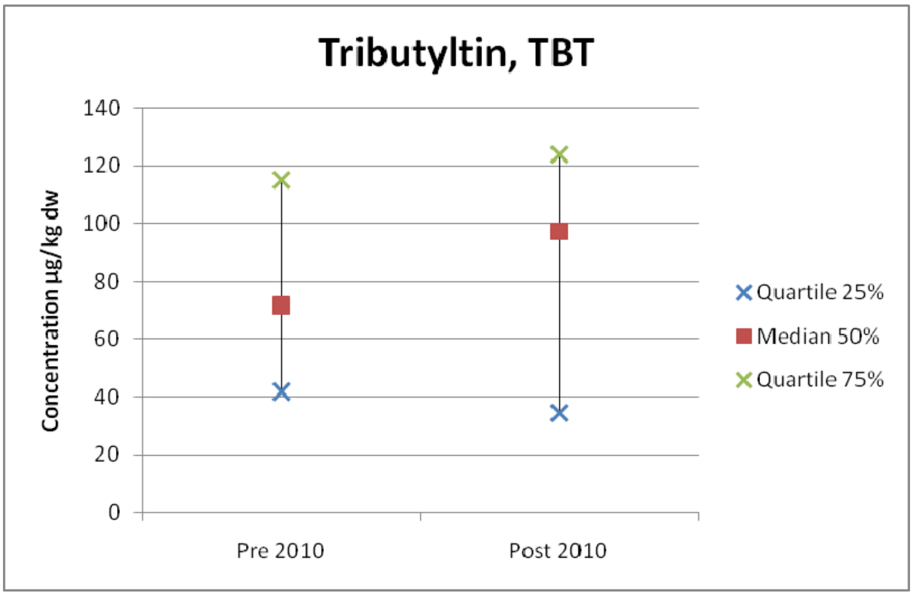


Figure 6.23 The boxplot for TBT /100/

As seen from Figure 6.23 the median concentration level of TBT was higher in the post activity monitoring in 2010, though the range between the 25 % and 75 % quartiles was more wide indicating larger variability of the concentrations.

The bar chart for TBT is displayed in Figure 6.24. The blue bars show results from the pre samples in 2010 and the red bars from the post samples in 2010.

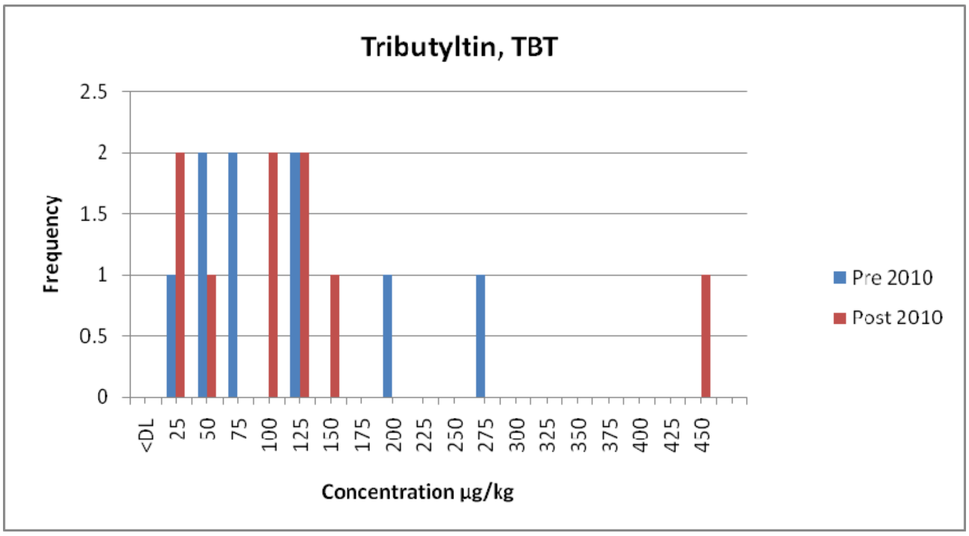


Figure 6.24 The bar chart for TBT /100/

One sample from SED2/2A (100 m from the rock berm) in the post monitoring in 2010 was measured with 450 µg TBT/kg dw, which is clearly and randomly higher than the other concentrations. There is no reasonable connection between the high TBT values and the rock placement activities.

The TBT data showed large variability and it did not follow the normal distribution. Based on this it was not possible to use the F-test for variance on TBT results and the nonparametric Wilcoxon rank sum test was used instead. The tested hypotheses were:

H_0: There is no difference in the concentrations in pre and post samples 2010 (µ1=µ2)
H_a: Contaminant concentrations are significantly higher in post samples 2010 (µ1<µ2)

The result of the Wilcoxon rank sum test was as follows:

Organotin compounds	Z	$Z_{critical}$	Decision
Tributyltin, TBT	0.044	-1.645	Do Not Reject H_0

For TBT the H_0 hypothesis was not rejected and therefore the pre and post sampling data sets do not represent significantly different data populations. Based on the test the same applied to MBT and DBT /100/.

6.2.4 Benthos

Benthos in surface sediment was monitored in connection with pre-lay rock placement at one location (BENT2). The station was located at the same site as the water quality monitoring station VOFIXIW1 (Figure 5.10). Sampling was undertaken before and after rock placement along a transect from seven locations that differed in terms of distance from the activity (see Table 6.12). Methods are described in detail in Chapter 5.1.

Since the 1990's invasive American polychaete worms of the genus *Marenzelleria* have spread extremely rapidly through sea floor sediments in all parts of the Baltic Sea. These worms dig into the top sediments down to depths of 20 cm. They can spread very effectively into areas with quite different depths and environmental conditions and survive even in sea floor sediments with extremely low oxygen content. *Macoma balthica* that normally dominates soft sea bottoms in the Baltic Sea can dig down about 10 cm into sediments /93/. *Marenzelleria arctia* and *M. balthica* were the only species present on the bottoms studied /41/.

Because of generally low oxygen levels, and also low amount of organic matter on the studied bottoms along the monitored transect BENT2, near the tie-in site, the number of macrozoobenthos species and abundances were very low or the benthic animals were totally lacking both in pre (spring) and post (late summer) samples, related to rock placement. Water depth at the transect BENT2 was on average 79 metres. The material on the sea floor consisted for the most part, depending on location, of clay. The proportion of organic material was low, varying from 0 % to 11 % dw (Table 6.12) In the sediment samples taken before and after rock placement, oxygen concentrations near the bottom varied between 0.2-5.6 mg O_2/l and 0.3-1.0 mg O_2/ on different locations, respectively. The highest number of benthos recorded was found at the furthest sampling site of the transect (BENT2/7) from the activity.

Some individuals of the species mentioned above were only present in pre and post samples at BENT2/7. However, even here total abundances of the species were extremely low, 6–54 ind./m^2, respectively (Table 6.12) /41/. It should be noted that due to bad weather conditions no post monitoring was possible from the locations BENT2/2 and BENT2/3. However, abundances of benthic animals was very scarce (0-3 ind./m^2) at these sites even before the rock placement works started.

As can clearly be seen from Table 6.12 there are practically no differences between pre and post sampling results. On the other hand the number of individuals per square metre could change

quite independently of, for instance, oxygen conditions. An example of this is the situation at the location BENT2/7, farthest away from the activity, where in spite of a remarkable decrease in oxygen level, the abundance of individuals was higher in the post sample.

Table 6.12 Benthos sampling results at the transect BENT2 before (6th April 2010) and after (2nd August 2010) rock placement activity at the tie-in site. Also the oxygen concentrations measured during sampling at different locations along the transect are included (data taken from /41/).

BENT2														
Location	**BENT2/1**		**BENT2/2**		**BENT2/3**		**BENT2/4**		**BENT2/5**		**BENT2/6**		**BENT2/7**	
Distance, m	50		100		200		400		800		1600		3200	
Water depth, m	79		77		77		84		82		79		75	
Phase	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
Dissolved oxygen, mg/l	0.3	0.3	1.6	0.3	2.9	0.3	0.2	0.4	0.5	0.9	3.6	1.0	5.6	0.5
Taxa	0	0	1	N/A	0	N/A	0	1	0	0	1	0	1	2
Individuals/m²	0	0	3	N/A	0	N/A	0	9	0	0	6	0	6	54
Total biomass, g ww/m²	0	0	0.06	N/A	0	N/A	0	0.12	0	0	0.11	0	0.02	0.13

N/A = not available
ww = wet weight

6.2.5 Wrecks, barrels and cables

According to the monitoring programme /2/ there are no wrecks, barrels or cables to be monitored during rock placement. No new relevant objects (e.g. barrels or munitions) were found near rock placement sites during the survey done prior to rock placement /101/.

6.2.6 Chance findings and unplanned events

According to Nord Stream, no chance findings were discovered nor were there any unplanned events related to rock placement performed in 2010.

6.2.7 Uncertainties

6.2.7.1 Water quality

There are always some unavoidable uncertainties concerning environmental monitoring surveys, no matter how carefully they are carried out. Based on experience during construction in 2010 the programme for water quality monitoring through vessel operated monitoring did not sufficiently consider the details of rock placement as a constantly moving activity and the related safety restrictions to the implementation of monitoring. To avoid any crossing movements, the orientation of the monitoring transects had to be predefined and adapted to the movement direction of the rock placement vessel. Depending on the prevailing current direction, this may limit the ability to monitor the extent of sediment plume dispersion. Due to such limitations, the monitoring results also include some uncertainties.

Suspended sediment particles were mostly monitored as turbidity units. However, in modelling the sediment resuspension and spreading was assessed as suspended solids. To create as reliable conversion factor as possible between these units, more water samples would have been needed where both parameters had been analysed concurrently (see Chapter 7.2.3).

6.2.7.2 Sediments

In the following the uncertainties concerning sediment surveys are discussed and qualified, and an attemption at quantification of the most relevant uncertainties for this monitoring is presented.

Qualification of uncertainties

The sediment sampling programmes include the same datasets to be analysed from the same sampling locations before and after the intervention works. In practice, however, it is impossible to get an exact matching location for the before and after sampling cores. The positioning of the sampling vessel and the lowering of the sampler will always include some deviation, and the increasing water depth makes this deviation even more probable. Thus the natural small scale variability (heterogeneity) of the seabed both for contaminants and for sediment type can have an influence ranging from negligible to significant on the samples and the consequent laboratory analyses results.

The natural sedimentation and the natural sediment transport and relocation processes to and from the seabed will contribute to the variability of sediment samples taken at the same location for the two monitoring periods, which differ in timing by months. It can be expected that the quality of the sediments will change more or less during the time period of months caused by natural processes. The current conditions at the work sites during activities will furthermore influence the spreading of sediment and contaminants. The different contaminants analysed also have different properties in relation to solubility, sorption to particles etc. which can influence spreading.

The accuracy of the analytical methods (i.e. laboratory treatments and analysing processes) will always add some uncertainty to the results. The further processing of the results (e.g. normalisation) can be one potential source of errors.

Quantification of uncertainties

The furthest sampling locations, situated 3.2 km from the rock placement location, have been used as control locations, since these locations are outside of the influence area of the sediment intervention works. The results from the two samples taken before and after the sediment intervention works can be used as to measure the natural variability of the seabed and to estimate the uncertainty in collecting two samples from the same location. Based on control dataset analysis /100/ the control samples indicated uncertainty of natural seabed variability and sampling in the range of 10-40% for heavy metal concentrations and even larger for concentrations of organic compounds. The potential inaccuracies of analytical methods are included in the uncertainty estimates, but since the analyses are done in the same laboratory, this factor can be estimated to be small compared to other uncertainties.

For analytical methods the level of accuracy for the analyses results for metals is in the order of ±20-35 %, for dioxins in the order of ±20-30 % and for organotin compounds in the order of ±20-33 %. However, according to the laboratory certificates concerning this study, the 95 % confidence limits for the analysed concentrations of harmful substances are between ±8-25 %, depending on the substance.

Even though sediment sampling and analyses are influenced by uncertainties, which in the worst case can be considered to be large, the results of the datasets usually indicate reliably enough possible distinct changes in the concentration levels.

6.3 Mattress installation

Prior to the installation of the mattresses the cables were located and crossing positions were verified. For the first pipeline (north-west) the crossing positions for the cables FEC-2, EE-SF3 and Estlink had to be adjusted. FEC-2 was adjusted 1.3 m east, EE-SF3 0.3 m west and for the Estlink the adjustment was 0.25 m. The other crossing positions for the first pipeline (north-west) were as planned. Along the second pipeline (south-east) the crossing positions for the eight cables were as planned and position for the cable EE-SF3 had to be adjusted 3 m east. /14 - 31/

The results of the as-built surveys carried out after the installations were:

- All mattresses except one were installed in position as planned within prescribed tolerances. One of the mattresses at the Unknown cable crossing (KP 234, second pipeline (south-east)) was out of tolerance and consequently there appeared to be a gap of approximately 40 cm between two mattresses. However, the Unknown cable was still covered with the mattresses. This malposition of one mattress was due to poor visibility.
- It was confirmed by using Pipetracker TSS 440 that the cables were under the Type 1 mattresses
- No significant debris was found during the installations at the crossing locations.
- Estimated embedment of the mattresses was 0.4 m at maximum, depending on the seabed type. Some of the mattresses were partially covered by the sediment after the installation (Figure 6.15).
- At the Pangea Seg 3 (KP 442, second pipeline (south-east)) one corner of the mattresses had settled in a naturally occurring depression on the seabed that was approximately 0.4 m deep. /14 - 31/

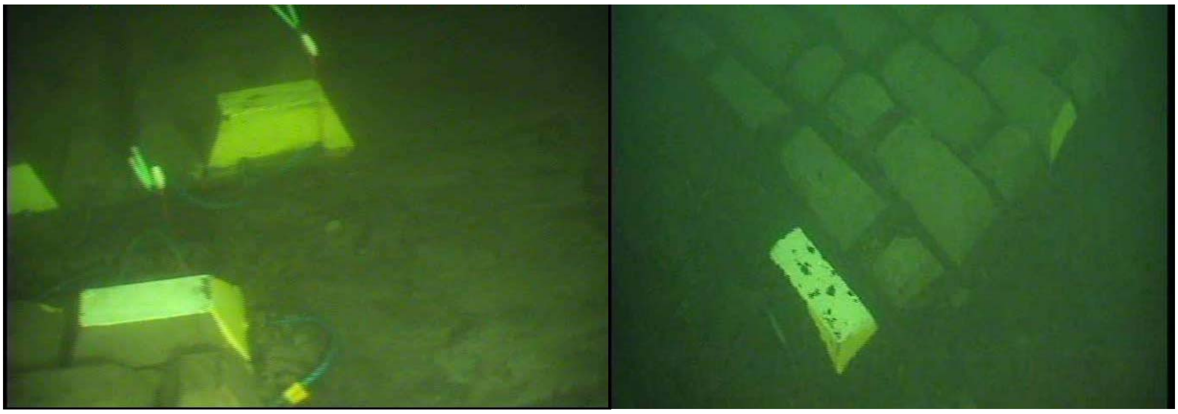


Figure 6.25 Left, a gap of approximately 40 cm between two mattresses at the Unknown cable crossing (KP 234, second pipeline (south-east)). Right, an example of mattress embedment. Estimated embedment of the mattresses was 0.4 m at maximum.

6.4 Pipelay with anchored lay barge

This chapter summarises the monitoring results from the pipeline section laid with anchored lay barge from KP 350 to KP 498 (Figure 6.26).

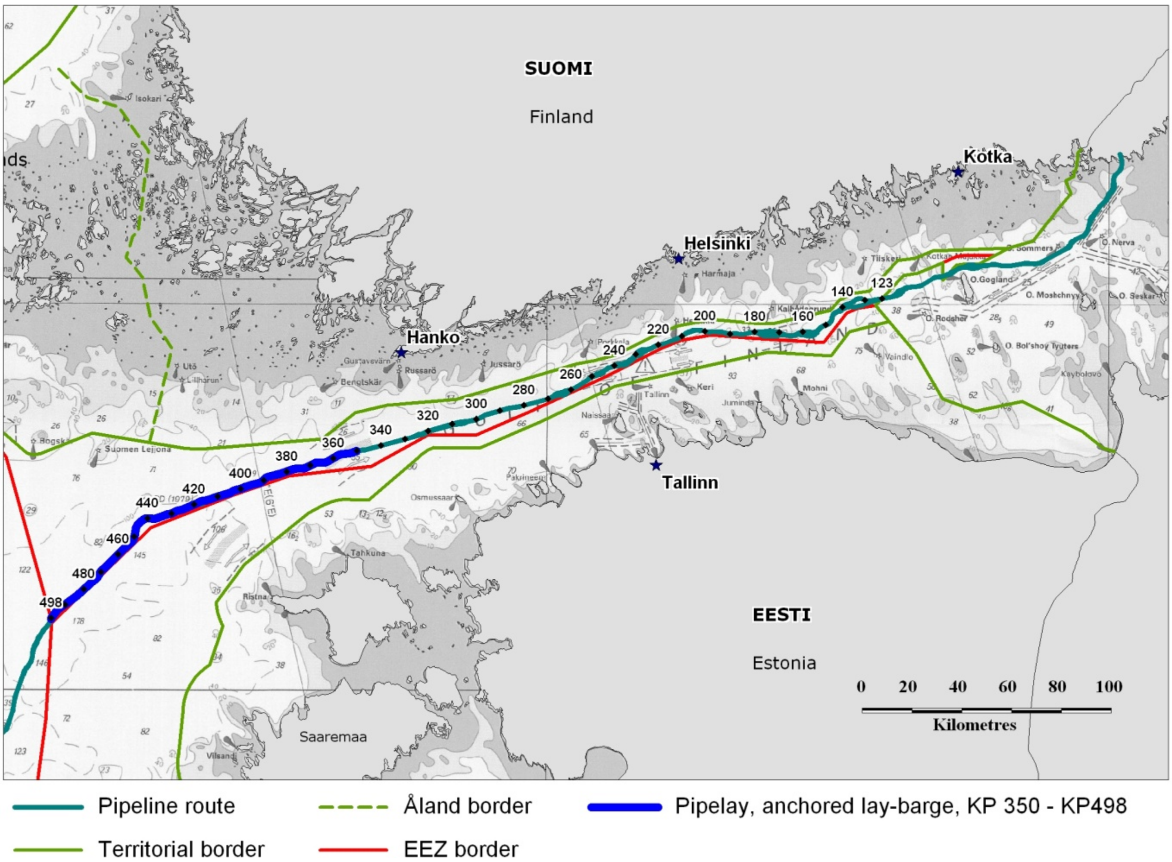


Figure 6.26 Pipeline section laid with anchored lay barge in 2010

6.4.1 Seabed morphology, obstacles and pipeline

Seabed morphology and possible obstacles in the installation corridor have been surveyed prior to pipelay. After pipelay, the pipeline seabed configuration was surveyed.

6.4.1.1 Pre-lay survey

The pre-lay survey results for the installation corridor from KP 350 to KP 498 are presented in sections in the pre-lay survey field reports /59-61/. This section summarizes the main pre-lay survey findings.

The pre-lay survey findings for the installation corridor from KP 350 to KP 498, where pipe was laid during Q2 and Q3/2010 by the anchored lay barge *Castoro Sei* are presented in Table 6.13. The seabed bathymetry of this route section varies from a minimum depth of 65 m at KP 367 to a maximum depth of 194 at KP 495.

Table 6.13 Munitions, debris and engineering features (cable crossings, rock berms) identified in the pre-lay survey between KP 350 and KP 498 /59-61/

Features found in pre-lay survey between KP 350 and KP 498			
Feature	**Feature type**	**Number of features**	**Note**
Munitions		0	All munitions identified in earlier surveys were cleared.

Debris	Drum / possibly drum	1	Identified in earlier surveys.
	Wreck	0	
Engineering features	Pre-lay rock berm	0	No berms installed in this section.
	Cable mattress installation	2	Crossings installed for pipeline 1.
	Crossing with out-of-service cable (UCCBF / unknown cables)	0	

6.4.1.2 As-laid survey

As-laid pipeline results from KP 350 to KP 498 are presented in sections in the as-laid survey field reports /75-81/ and associated as-laid pipeline charts. The following section summarizes the main as-laid pipeline survey findings compared to design regarding the pipeline alignment and profile, freespans and post-lay rock placement needs. The exact location and details of the pipeline as a structure on the seabed will be reported when the whole pipeline is constructed.

<u>As-laid pipeline alignment with respect to installation accuracy to Route C16.5 /102-106/</u>
Pipeline 1 has been installed by the anchored pipelay barge *Castoro Sei* from KP 498 to KP 350. Within this section the pipeline deviated outside the specified lay tolerance of ±7.5 m on four occasions as shown in Figure 6.27 and defined below:

- KP 359.499 to KP 359.676 (maximum offset -8.51 m) - Straight section of route
- KP 368.276 to KP 368.390 (maximum offset -8.04 m) - End of curve
- KP 416.116 to KP 416.518 (maximum offset -9.59 m) - Curved section of route
- KP 444.501 to KP 445.088 (maximum offset -9.68 m) - Curved section of route

In accordance with Water Permit provision 1 'Pipeline location and structures' the pipeline shall be constructed within an installation accuracy of ±7.5 m on straight sections and ±15 m on curved sections.

Consequently over a length of 177 m between KP 359.499 and KP 359.676 the pipeline has been installed outside the installation accuracy boundary of the permit provision. The reason for this deviation was to ensure pipeline integrity by avoiding three boulders located within the installation corridor during the pre-lay survey at KP 359.573, KP 359.564 and KP 359.558.

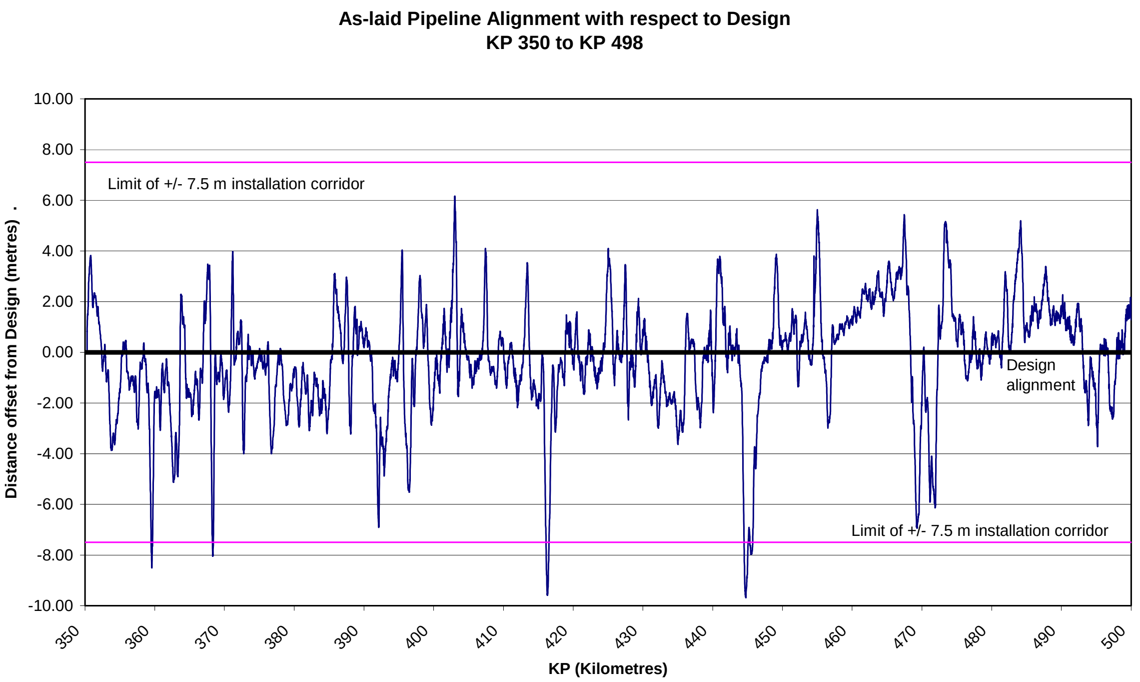


Figure 6.27 As-laid pipeline alignment with respect to design from KP 350 to KP 498

<u>As-laid pipeline profile: vertical offset with respect to design pipe profile /102-106/</u>
The as-laid pipeline profile from KP 350 to KP 498 is generally slightly deeper than predicted in the design. This is due to higher pipeline embedment observed over the majority of the section. Figure 6.28 shows an example of an approximately 50 % embedded pipe at KP 420. The higher embedment is most likely a result of conservatively considering the upper bound soil properties (stiffer than actual) for design.

Locally, at discreet locations the pipeline profile is higher than expected due to outcrops, for example at KP 354.59, KP 359.69 and KP 438.25.

Figure 6.28 Field joint showing approximate 50% pipeline embedment at KP 419.975

<u>As-laid pipeline freespan comparison with respect to design</u>
The summary of observed freespans, including all freespans with a length of greater than 10 m, based on as-laid surveys of the pipeline 1 from KP 350 to KP 498 are presented in Table 6.14. The results in Table 6.14 reflect the situation prior to any post-lay rock placement, which started in December 2010. The as-built survey of the entire pipeline, providing the final information about the pipeline embedment and freespans after construction, will be performed in 2012.

Table 6.14 Summary of observed freespans from KP 350 to KP 498 based on as-laid data /75-81/

Pipeline section	Total no. of free spans[1]	Maximum free span length, m	Maximum free span height, m
KP 350 - KP 380	39	176 KP 368.454 - KP 368.630	1,20 KP 368.454 - KP 368.538, KP 367.020 - KP 367.148
KP 380 - KP 400	18	70 KP 397.093 - KP 397.163	1,50 KP 397.093 - KP 397.163
KP 400 - KP 420	14	78 KP 401.618 - KP 401.696	1,10 KP 401.618 - KP 401.696
KP 420 - KP 440	14	202 KP 438.167 - KP 438.369	2,30 KP 438.167 - KP 438.369
KP 440 - KP 470	95	175 KP 467.637 - KP 467.812	3,10 KP 451.912 - KP 452.081
KP 470 - KP 490	81	259 KP 478.601- KP 478.860	2,9 KP 481.198 - KP 481.401
KP 490 - KP 500	23	193 KP 491.159 - KP 491.352	1,40 KP 495.689 - KP 495.858, KP 496.235 - KP 496.379

[1] Including all freespans greater than 10 m in length.

Based on comparisons of pipeline as-laid and design data, the as-laid freespans are generally shorter than design freespans, with the following main exceptions: KP 359.69, KP 367.09, KP 438.25 (Figure 6.29), KP 447.6, KP 448.2, KP 467.7, KP 478.7, KP 481.3, KP 491.3 and KP 496.1.

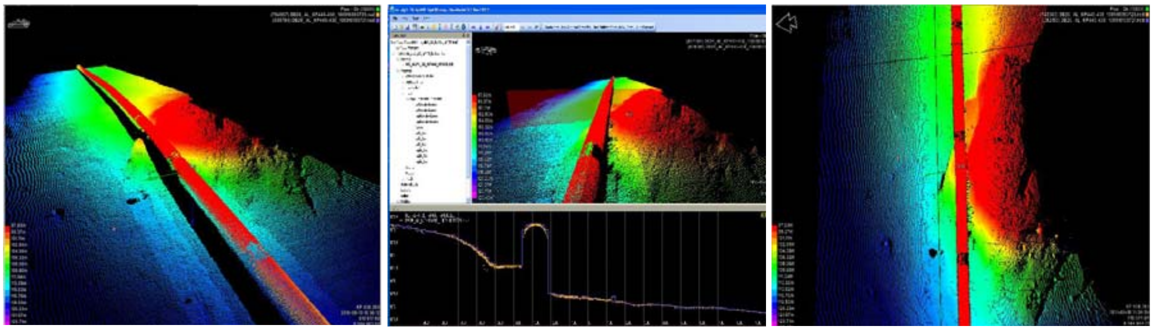


Figure 6.29 Freespan from KP 438.167 to KP 438.369 (length 202 m and maximum height 2.30 m). Pipeline traversing the edge of seabed mound at KP 438.254.

Based on the engineering assessment of the as-laid configuration of the pipeline from KP 350 to KP 498 only three of the fourteen design post-lay rock placement works are still required, namely W2373 (KP 368.6), W2341 (KP 438.3), W2347 (KP 452.0). These berms belong to Phase 2 rock placement (before flooding) and W2373 and partly W2341 were constructed in December 2010. Six rock berms not foreseen in the design were added for pipeline flooding, pressure test and operating conditions. These berms are W2379 (KP 354.621), W2380 (KP 367.050), W2381 (KP 367.116), W2382 (KP 368.512), W2378 (KP 438.240) and W2645 (KP 467.153). All these berms except W2645 belong to Phase 2 rock placement and were constructed in December 2010. Berm

W2645 is required for fatigue in long term (operation) condition and may be installed during the Phase 3 rock placement (after dewatering).

The following Table 6.15 shows the comparisons of the calculated design and as-laid post-lay rock volumes. For those berms constructed in December 2010, the as-built rock volumes are presented in Appendix 4. As shown, there is a very slight decrease in the total calculated rock volume, however, the majority of post-lay rock berms will or have been installed during Phase 2.

Table 6.15 Comparison of the calculated design and the as-laid post-lay rock volumes. For as-built rock volumes of the phase 2 berms constructed in December 2010 see Appendix 4.

	Design /110/	**As-laid Assessment** /102-106/
Number of post lay rock berms Phase 2 (before flooding)	6	8
Calculated rock volume phase 2	11986 m^3	16474 m^3
Number of post lay rock berms Phase 3 (after dewatering)	8	1
Calculated rock volume phase 3	5172 m^3	454 m^3
Total calculated rock volume	**17158 m^3**	**16928 m^3**

The exact location and details of the pipeline as a structure on the seabed will be reported when the whole pipeline is constructed.

6.4.2 Water quality

Pipelay with an anchored lay barge was executed in the western Finnish EEZ in a section between KP 350- KP 498 (Figure 6.26). Water quality monitoring with fixed sensors at LAY2 (KP 495) station was carried out in June - July 2010. Water depth at the locations of the sensors was 183 m (at a distance of 50 m from the pipeline alignment) and 191 m (at a distance of 800 m from the pipeline alignment). Vessel operated monitoring was performed between KP 491 and KP 493 in the end of June 2010 during one day and lasted for approximately 13 hours (Chapter 5).

6.4.2.1 Transects

Vessel operated monitoring was conducted by gathering data from surface to bottom with a self-logging instrument along transect, once in two transects (Figures 5.11 and 5.12 in Chapter 5). Results showed some increased turbidity in transect B in the lowermost 10 m water layer above the seabed, approximately 100 m behind the touchdown point of the pipe at KP 491.2 (Figure 6.30).

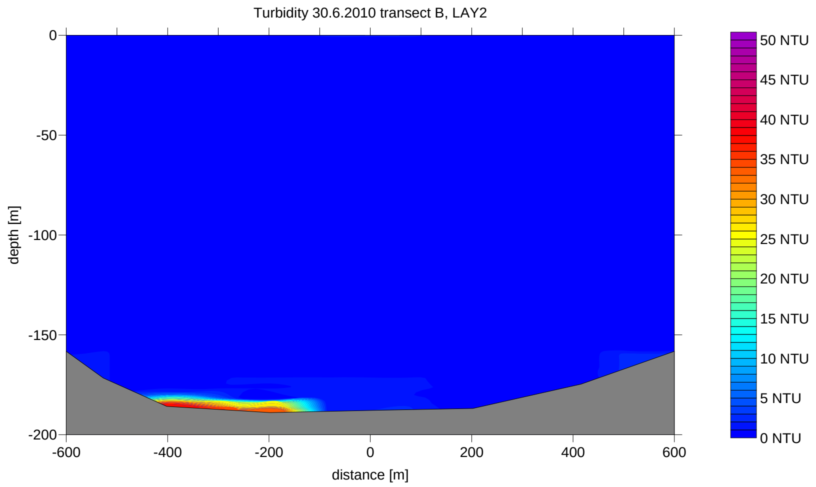


Figure 6.30 Turbidity increase near the bottom, recorded during vessel operated monitoring in transect B (see Figure 5.12), perpendicular to the pipeline installation corridor. The zero distance point represents the location of the pipeline. Negative distances are measured southwards and positive ones northwards /39/.

The highest recorded value was 37 NTU, one metre above the seabed, 100-400 m south of the pipeline. In transect A (see Figure 5.12) parallel to the installation corridor, 50 metres away from the pipeline alignment, only a small increase in turbidity (<10 NTU) was recorded /39/.

The anchor locations reported in anchor logs have been compared with the locations where the increased turbidity was measured. The comparison showed that the anchors were not placed in the vicinity of the area where the turbidity increase was recorded. Hence such anchor handling operations like anchor lay-down or anchor retrieval is unlikely to have caused the change in water quality /39/.

As-laid survey data showed that the pipeline was partly buried into soft bottom at KP 491.1 which is most likely the source of the detected turbidity cloud. It has been concluded that the most likely reason of sediment release was a repair on pipelay barge. The repair caused a 45 min delay, during which the vessel was kept stationary and during which the pipe was also at the same touchdown point at KP 491.1. During this period some variations in anchor tensions could have allowed for small horizontal barge movements which could have resulted in small vertical pipe movements (lifting and lowering) at the same touchdown point, where the pipeline was supported by soft clay ‘ridge’ between two free spans resulting in substantial embedment of the pipe. The vertical movements of the embedded pipe in the soft clay, at the touchdown point, may have brought the sediment into suspension, which subsequently slowly flowed into the seabed depression at KP 491.2 (see Figure 5.12) and settled there /39/.

6.4.2.2 Water samples

The results of water samples taken from five locations ('Water sample 1-5'; Figure 5.11) during transects monitoring showed that oxygen condition was poor (≤1 mg/l) at depths over 150 metres. Phosphorus concentrations were high (100 – 110 µg P/l) and turbidity values were generally low (0.36 – 1.2 FNU). Concentrations of heavy metals in water were in the background level. /39/

6.4.2.3 Fixed sensors

The nearest fixed sensor, 50 m from the pipeline route, showed a minor increase in turbidity up to 3.4 NTU during a period when the pipelay works took place in the vicinity (Figure 6.31). The duration of the turbidity elevation was less than two hours. Peaks of up to 4 NTU were also detected during the time period, when the pipelay was performed tens of kilometers away from the fixed sensors. Therefore these peaks cannot be attributed to Nord Stream Project.
800 metres away from the pipeline alignment, at the location of the farthest sensor, no increase in turbidity was observed.

Bottom close waters (1.5- 2.0 m above the seabed) at the sensor locations were free of oxygen during the monitored period, 23rd June – 27th July 2010.

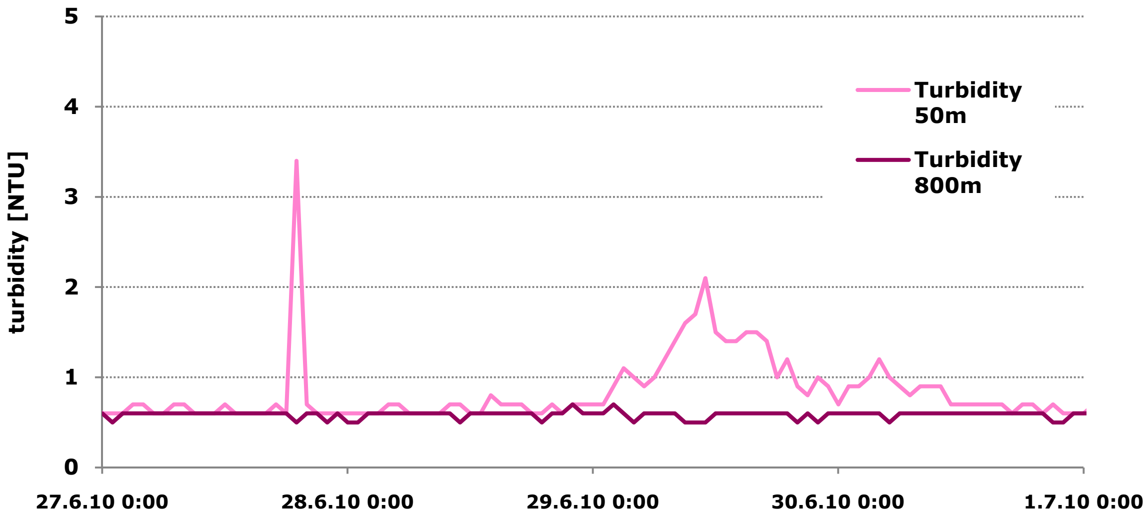


Figure 6.31 Turbidity recordings of the two fixed sensors from 27th June – 1st July 2010 at LAY2, when pipelay was conducted in the vicinity of the station (data from /39/)

6.4.3 Wrecks, barrels and cables

No new relevant objects (e.g. barrels or munitions) were found during pre-lay survey done for the anchored lay barge section /59-61/.

6.4.3.1 Wrecks

During 2010 pre- and post-lay surveys were carried out for four wrecks: S-13-31313, S-13-34523, S-15-35565 and S-16-36567. They are located in the anchoring corridor of Castoro Sei in the section between KP 350 and KP 498. Selected still images of prominent features of the monitored wrecks taken prior to and after the pipelay are presented in Figures 6.32 - 6.35. On the basis of comparison of all the still images from pre-lay and post-lay surveys, the pipelay activity, the pipeline itself or the anchoring did not have any effects on the wrecks /48-51/.

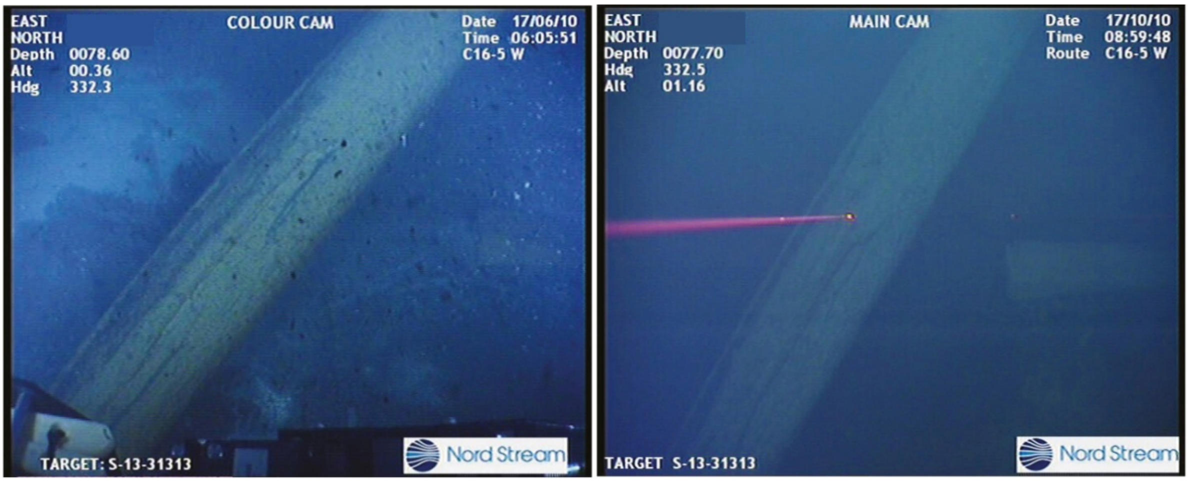


Figure 6.32 Still image of the wreck S-13-31313 from pre-lay (left) and post-lay (right) survey. Mast lying on the sea bottom. /48/

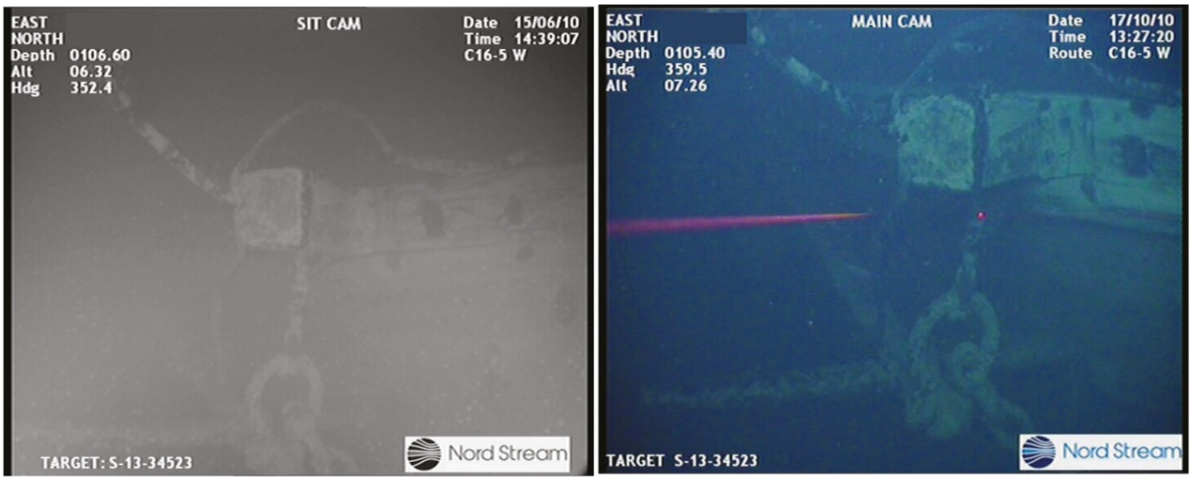


Figure 6.33 Still image of the wreck S-13-34523 from pre-lay (left) and post-lay (right) survey. Port anchor and anchor outrigger. /49/

Figure 6.34 Still image of the wreck S-15-35565 from pre-lay (left) and post-lay (right) survey. Rope attachment. /50/

Figure 6.35 Still image of the wreck S-16-36567 from pre-lay (left) and post-lay (right) survey. Bowsprit with carved details. /51/

6.4.3.2 Cables

During 2010 the cable crossings for the cable EE-S1 at KP 448 and for the cable Pangea Seg 3 at KP 442 along the first pipeline (north-west) were included in the monitoring through as-laid and as-left surveys. According to the as-laid survey performed for the pipeline at the crossing points and the as-left surveys performed for the crossing structures and cables, the pipeline was laid over the mattress arrangements within the specified lay tolerances (+/-2.5 m) /53-54/. Other results of the as-left surveys were:

- General video inspection showed that the mattresses were partly embedded to the seabed. For some of the mattresses at the crossing for the cable EE-S1 the top surface of the mattresses was almost level with the seabed. All the mattresses at the crossing for cable Pangea Seg 3 were settled into the sediment to varying degrees and some of them were barely visible because of the sediment.
- General video inspection showed that the pipeline was partly not in touch with the mattresses, but above them at the crossing for cable EE-S1. This was not the case at the crossing for cable Pangea Seg 3.
- Compared to the surveys performed before pipelay no movement in the mattresses positions were found in the MBES survey.
- No cable damage caused by anchors was found in the visual survey covering +/-1,000 m from the crossing point along the cable /53-54/.

6.4.4 Chance findings and unplanned events

During pipelay with anchored lay barge, three unplanned events occurred: three waste dumpings. A subcontractor to Saipem had on three occasions emptied a container filled with concrete coating material into sea from *Castoro Sei* /107/. According to incident reports, the amount of concrete dust in the container was approximately 1 m^3 /107/. The dates of these incidents were 14.8.2010, 19.8.2010 and 23.8.2010. The following corrective actions were implemented to prevent reoccurrence of similar unplanned events:

- Official *tool box talk* has been arranged with *Castoro Sei* and all subcontractors' personnel. It was highlighted that all waste dumping into sea is strictly forbidden according to the vessel's waste management plan and MARPOL 73/78 and HELCOM guidelines. If this practice will not be followed, disciplinary actions will be taken.
- The management team on *Castoro Sei* have informed electronically the personnel of Saipem and their subcontractors and leaflets have been placed on the ship's information boards highlighting that waste dumping into the sea is strictly prohibited.
- Additional waste containers were ordered to ensure that all concrete waste can be collected and delivered for treatment onshore.

- Environmental inspection focusing on waste management was conducted on *Castoro Sei* on the 6th- 7th of September 2010 by Environ and Nord Stream.

Notification of these events has been submitted to the Finnish authorities on 7th of September 2010.

6.4.5 Uncertainties

Impacts on water quality from the pipelay by the anchored lay barge could not be monitored through vessel operated monitoring exactly as planned in the monitoring programme. As presented in the monitoring programme, vessel operated monitoring was performed along two predefined transects, the locations of which were confirmed in consultation with the pipelay contractor. The location of the parallel monitoring transect in relation to the lay barge and anchor handling tugs was moved behind the lay barge and closer to the pipeline due to safety reasons, e.g. related to anchor wires.

During the vessel operated monitoring, some monitoring points along the transects also had to be re-located in the field based on the instructions given by the lay barge. When the monitoring vessel enters the safety zone of the lay barge, it must work as part of lay barge's spread for safety reasons. These interruptions caused several delays to monitoring activities in the field and each transect could be performed only once. As stated above in section 6.2.7, the need to perform turbidity monitoring along predefined transects and following the instructions of the lay barge restricts the ability to monitor the extent of sediment plume dispersion.

Increased turbidity registered on a transect perpendicular to the pipeline alignment was attributed to a repair onboard the lay barge during pipelay that resulted in the pipe being at the same touchdown point for a longer time. The explanation for the change in water quality is impossible to fully verify due to the lack of current data from the site.

6.5 Pipelay with DP lay barge

This chapter summarises the monitoring results from pipeline section laid with dynamically positioning laybarge from KP 123 to KP 350 (Figure 6.36).

6.5.1 Seabed morphology, obstacles and pipeline

Seabed morphology and possible obstacles in the installation corridor have been surveyed prior to pipelay. After pipelay, the pipeline seabed configuration was surveyed in 2010 from KP 123 to KP 270. The as-laid survey of the remaining section of the first pipeline laid by *Solitaire* (KP 270 - KP 350) was completed in Q1/2011. All the as-laid results for KP 123 - KP 350 will be reported as a complete package in the first quarterly report of 2011.

6.5.1.1 Pre-lay survey

The pre-lay survey results for the installation corridor from KP 123 to KP 350 are presented in sections in the pre-lay survey field reports /55-58/. This section summarizes the main pre-lay survey findings.

The pre-lay survey findings for the installation corridor from KP 123 to KP 350, where pipe was laid during 2010 by the dynamically positioning lay barge *Solitaire* are presented in Table 6.16. The seabed bathymetry of this route section varies from a minimum depth of 41 m recorded over the rock berm at KP 223 to a maximum depth of 93 m at KP 335.

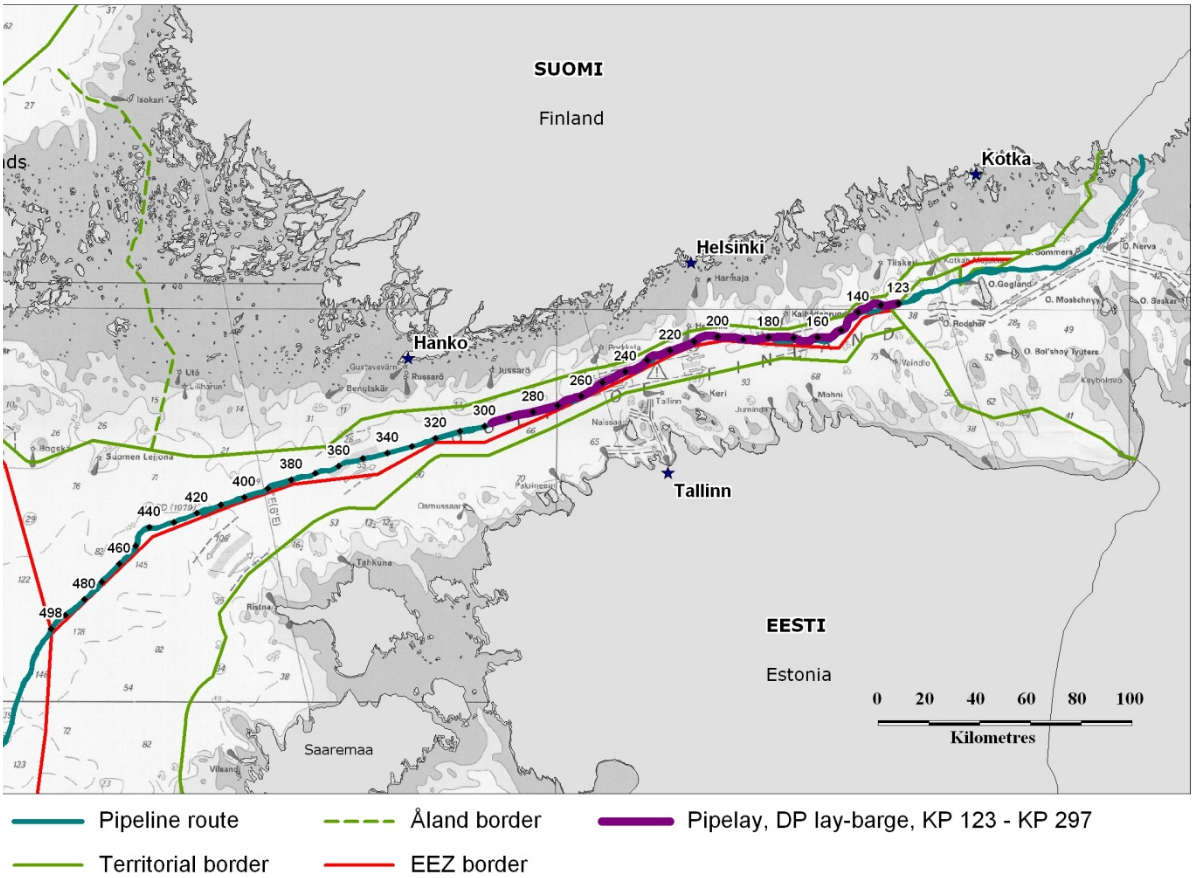


Figure 6.36 Pipeline section laid with dynamically positioning lay barge in 2010.

Table 6.16 Munitions, debris and engineering features (rock berms, cable crossings) identified in the pre-lay survey between KP 123 and KP 350 /55-58/

Features found in pre-lay survey between KP 123 and KP 350			
Feature	**Feature type**	**Number of features**	**Note**
Munitions		0	All munitions identified in earlier surveys cleared.
Debris	Drum/ possibly drum	12	Identified in earlier surveys
	Wreck	1	Identified in earlier surveys as target S-10-3237. According to FNBA of no high cultural value[1].
Engineering features	Pre-lay rock berm	13	Berms installed for pipeline 1.
	Cable mattress installation	7	Crossings installed for pipeline 1
	Crossing with out-of-service cable (UCCBF/ unknown cables)	10	All identified in earlier surveys
	Crossing with a linear feature, identified as unknown cable, at KP 233.609[2]	1	Not identified in earlier surveys

[1] Finnish National Board of Antiquities 2009. Evaluation of Underwater Cultural Heritage in the Finnish EEZ.

[2] For further details and planned action see Section 6.5.4.

6.5.2 Water quality

Pipelay with a DP lay barge was executed in the eastern and central Finnish EEZ in a section between KP 123- KP 297 /40/ (Figure 6.36). Water quality monitoring with fixed sensors at LAY1 (KP 184) station, approximately 50 m from the pipeline alignment, one on both sides, was carried out in November- December 2010. The water depth at the locations of the sensors, was approximately 65 m. Vessel operated monitoring was performed at approximately KP 179 during one day in November 2010 (Chapter 5).

6.5.2.1 Transects

The monitoring results showed no measurable increase in turbidity in the vertical profiles along the transects

6.5.2.2 Water samples

Water samples taken from five locations during monitoring showed that oxygen was present at all locations (Figure 5.13). Turbidity values were low (around 1 FNU). Concentrations of heavy metals were normally at a background level. An exception was the point where the transect A crossed the previously laid pipeline section ("Water sample 2" in Figure 5.13) where concentrations of chromium and nickel in seawater were elevated from the corresponding values at the other sampling points. Analysed concentrations were 8.1 µg Cr/l and 1.7 µg Ni/l compared to the reference values (average concentrations of the other water samples taken) 0.1 µg Cr/l and 0.8 µg Ni/l (Appendix 5).

6.5.2.3 Fixed sensors

During pipelay in the vicinity of the sensors there were no turbidity recordings that would have differed from the background values. Minor turbidity peaks (1-3 NTU) near the bottom were attributed to the prevailing wind conditions in late autumn. Typically all those small turbidity elevations were preceded by strong winds when the highest recorded readings of the wind speed were over 20 m/s (Figure 6.37). Vertical profiles of temperature and salinity show that stratification of these parameters was low and therefore the effects of wind on mixing of the water mass was high (Figure 6.38). Oxygen concentration in water was between 2-4 mg/ during the days pipelay took place in the vicinity of the sensors.

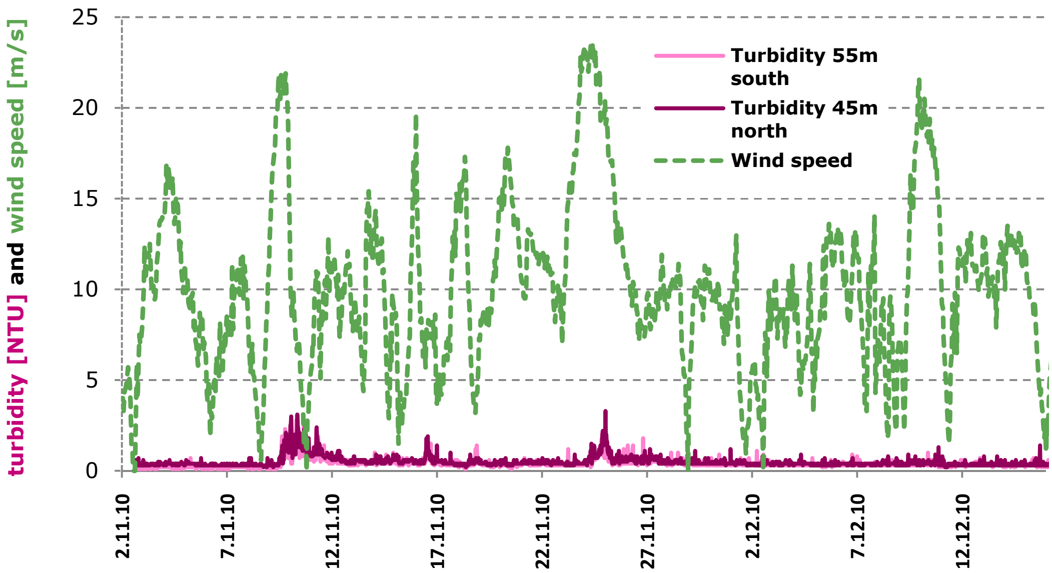


Figure 6.37 Turbidity recordings of the two fixed sensors in near bottom waters at LAY1. Pipelay was performed in the vicinity of the monitoring sensors during 14-15 November 2010 /40/.

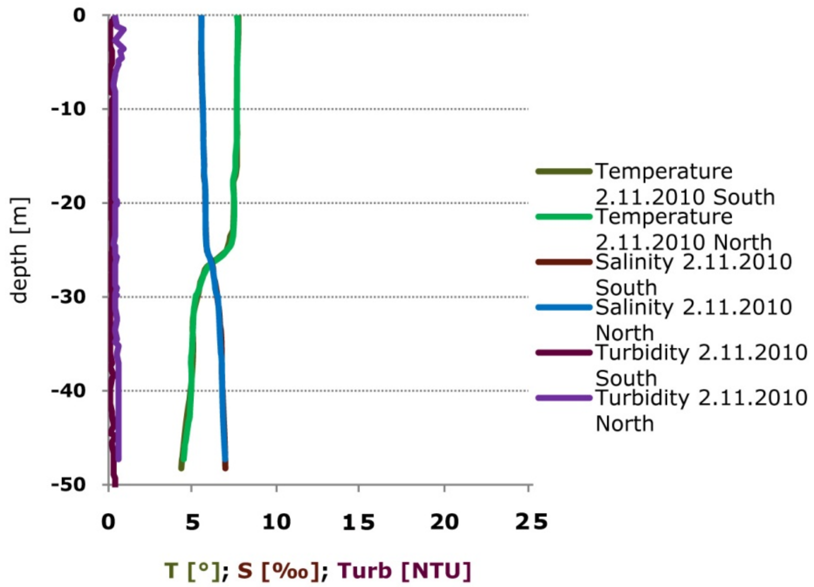


Figure 6.38 Vertical profiles at the locations of the fixed sensors in November 2010 /40/

6.5.3 Wrecks, barrels and cables

A previously unidentified cable was found at KP 233.6 during pre-lay survey done for the dynamically positioned lay barge section. See Chapter 6.5.1 for further details. No other new relevant objects (e.g. barrels or munitions) were found during the pre-lay survey done for the dynamically positioned lay barge section /55-58/.

Prior to pipelay, the pre-lay survey of four wrecks and four barrels located between KP 123 and KP 350 was performed as described in Chapter 5.5.3. The post-lay surveys of these objects will be/were performed in Q1 and Q2/2011 and the monitoring results will be reported in the subsequent quarterly reports.

During 2010 the cable crossings for the cables FEC-2, EE-SF2, Pangea Seg 3 (at KP 219), Unknown cable (at KP 234), EE-SF3, Estlink and FEC-1 along the first pipeline (north-west) were included in the monitoring through as-laid and as-left surveys. According to the as-laid survey performed for the pipeline at the crossing points and the as-left surveys performed for the crossing structures and cables, the pipeline was laid over the mattress arrangements within the specified lay tolerances (+/-2.5 m) /70-72, 87-90, 127-129/. The pipeline appeared to be partly in freespan over the mattresses at the crossings for cables EE-SF2, Pangea Seg 3 and the Unknown cable /87-90, 127-129/.

6.5.4 Chance findings and unplanned events

Relating to the pipelay with DP lay barge, one oil spill was reported and one unknown cable found.

The oil spill happened on the 8th September 2010 from the pipe supply vessel *Maersk Fetcher*, which belongs to *Solitaire*'s pipelay spread, in the Kotka harbour. The oil spill into the sea was estimated to be up to 50 l and the spill retained on board >200 l. The spill was most probably a result of ineffective repair or maintenance. The Kotka Port Authority was notified verbally about the spill and confirmed to *Allseas* that no further action is required /107/.

During the pre-lay survey of the installation corridor of Pipeline 1 from KP 123 to KP 350 a previously unidentified linear feature (Fig 6.39) was recorded at KP 233.609. *Allseas* interpreted

the feature as an unknown cable and the finding was reported to the authorities in the Q3/2010 report. Based on existing cable databases, discussions with various cable owners in the permitting phase and consultations with Finnish authorities about planned infrastructure projects in the Gulf of Finland, Nord Stream is unaware of an active cable at this location.

Nord Stream contacted the cable owners closest to the suspected unknown cable and the Finnish Navy after the finding but no information about a cable at this location was available. As no crossing mattresses have been installed and in order to clarify the situation a visual and multibeam survey of the linear feature was performed as part of the as-laid pipeline survey. The suspected unknown cable was observed to cross the second pipeline (East) alignment at KP 234.036 and, as a precautionary measure, Nord Stream will install mattresses at this location for the crossing with the second pipeline. The authorities were notified about the measures taken and planned action on 14th March 2011.

Figure 6.39 The linear feature, identified as an unknown cable, at KP 233.609 during the pre-lay survey /56/

6.5.5 Uncertainties

Current measurements at LAY 1 station would have helped interpreting the water quality monitoring results and verifying the results, that pipelay with a DP lay barge did not cause any changes in water quality. However, in terms of vessel operated monitoring, the same restrictions apply to the movements of the monitoring vessel within the safety zone as during the monitoring of the pipelay with the anchored lay barge. That is the turbidity monitoring has to be performed along predefined transects and following the instructions of the lay barge.

With regard to the water sampling results from LAY1 station, it is impossible to make any further conclusions of the impacts of some elevated metal concentrations in water just above the pipeline, based on only one water sample.

6.6 HELCOM benthos monitoring stations

In autumn (27th September – 2nd October) 2010 the Finnish Environment Institute (SYKE) executed a study to identify possible alternative benthos monitoring locations to the current HELCOM stations (LL5, LL6A and LL7; Figure 6.40) in case the gas pipeline on the seabed should

affect the longevity of data collection and the comparison of data gathered during different times from these stations. Possible impacts could be an alteration to the bottom close currents and subsequently sedimentation patterns that again would induce changes in living conditions of macrozoobenthos species. Another aim was to collect pre-lay data on benthic communities both from the current stations and the alternative locations. Quantitative results of macrozoobenthos species (numbers, abundances and biomasses) are presented in Chapter 6.6.4.

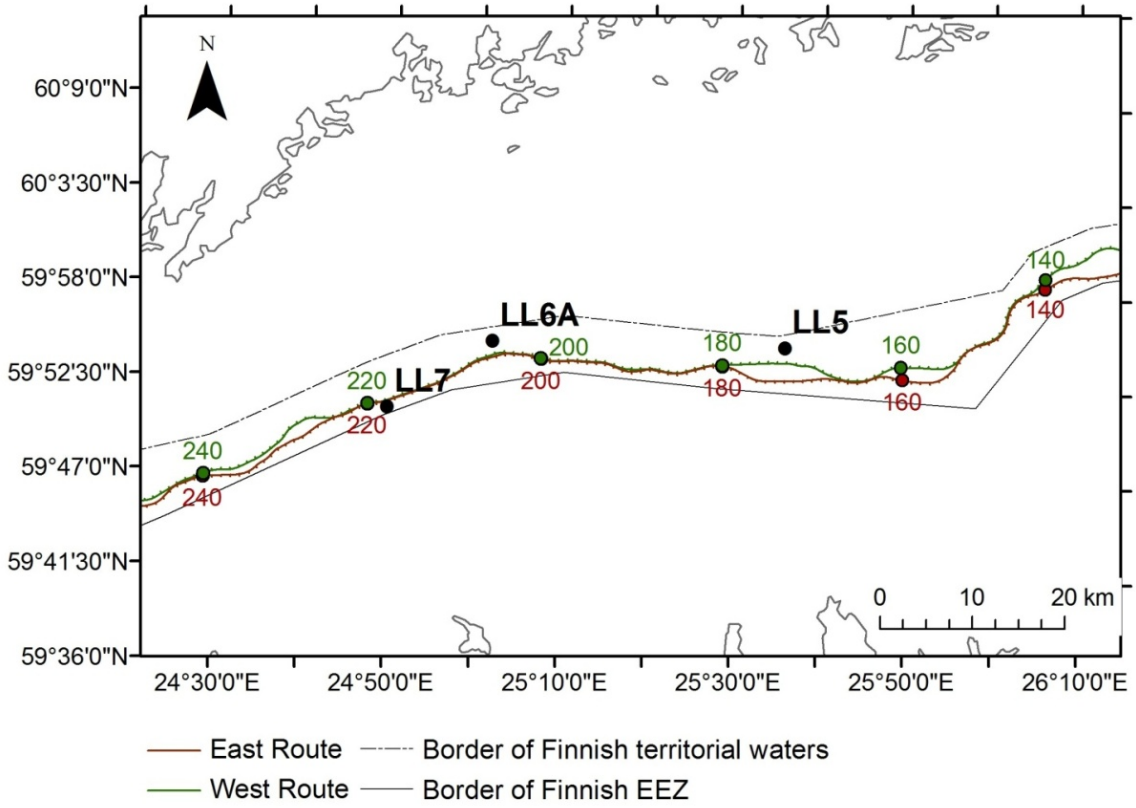


Figure 6.40 Locations of the current HELCOM benthos monitoring stations in relation to the gas pipeline routes (the numbers refer to KP- points along the pipeline alignment) /91/

The possible compensatory monitoring locations were chosen in a two phase process: First there was a desktop study to determine environmentally similar areas to the current HELCOM stations and after that a field study was carried out to map the predetermined areas for their suitability.

6.6.1 Hydrographical conditions at the HELCOM stations

The water depth at the current HELCOM benthos monitoring stations LL5, LL6A and LL7 is 69, 71 and 77 m, respectively. Based on the determinations on 29th September 2010 all the stations had a pronounced vertical density gradient approximately between depth zone 20-50 metres, depending on the station, where the oxygen concentration decreased steeply. At a depth of 1 meter above the seabed half of the stations and the alternative locations were suboxic (<2 ml O_2/l) but none anoxic (without any oxygen). Figure 6.41 shows exemplary vertical profiles of temperature, density, salinity and oxygen from LL7 station, typical to the open areas of the Gulf of Finland.

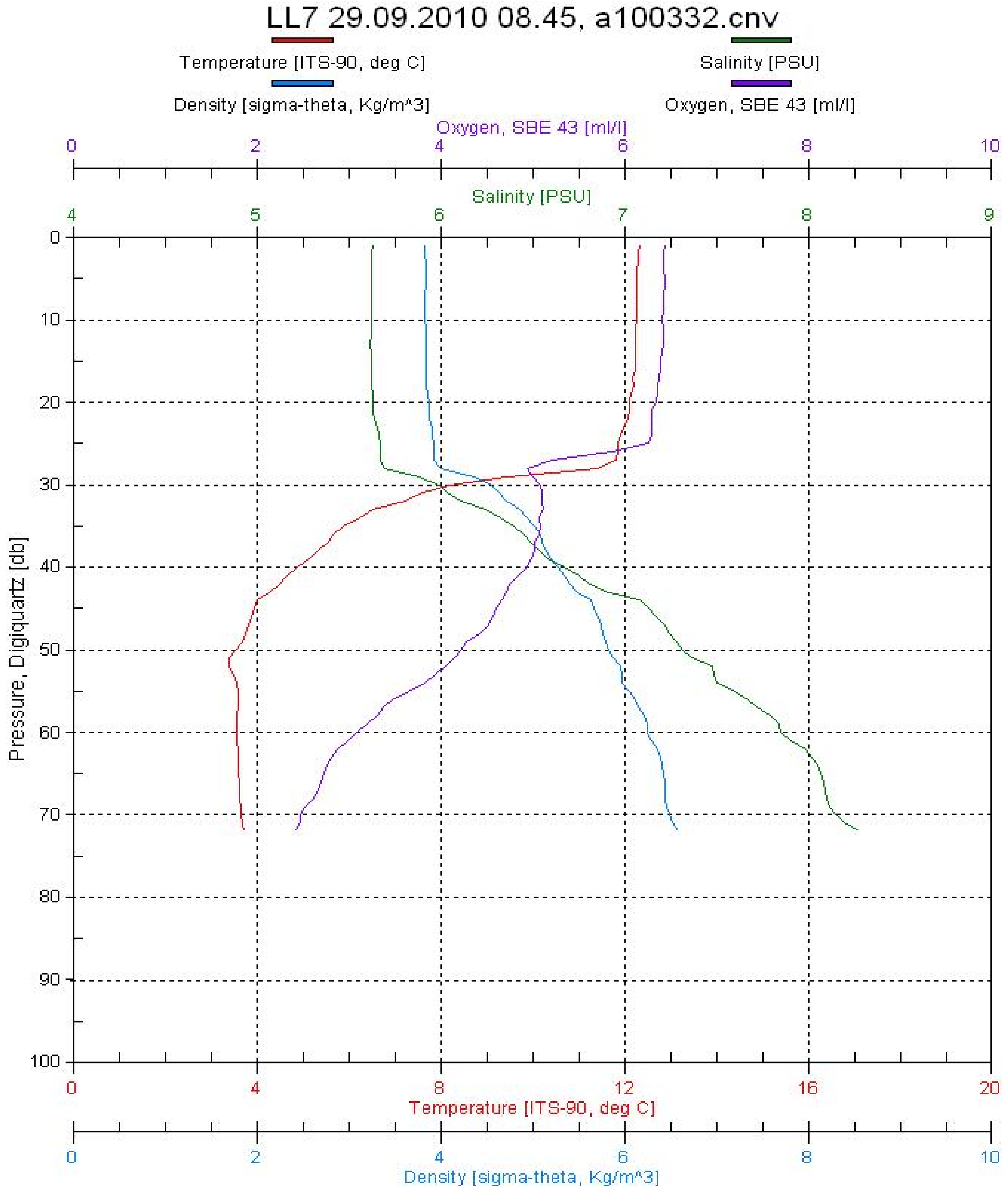


Figure 6.41 Vertical profiles of certain parameters in a water column at the HELCOM station LL7 /91/

Oxygen levels in near bottom waters are highly dependent on the mixing up of different water columns that differ by their salinity characteristics. A distinct halocline is normally present in the Gulf of Finland at these water depths in question. At the beginning of 1990s there was a temporary improvement in oxygen conditions for many years, when salinity decreased to a level where strong halocline weakened and at the same time improvement in oxygen situation was remarkable (Figure 6.42). As can be seen from the Figure 6.42 during the past decade the situation has become worse in this respect.

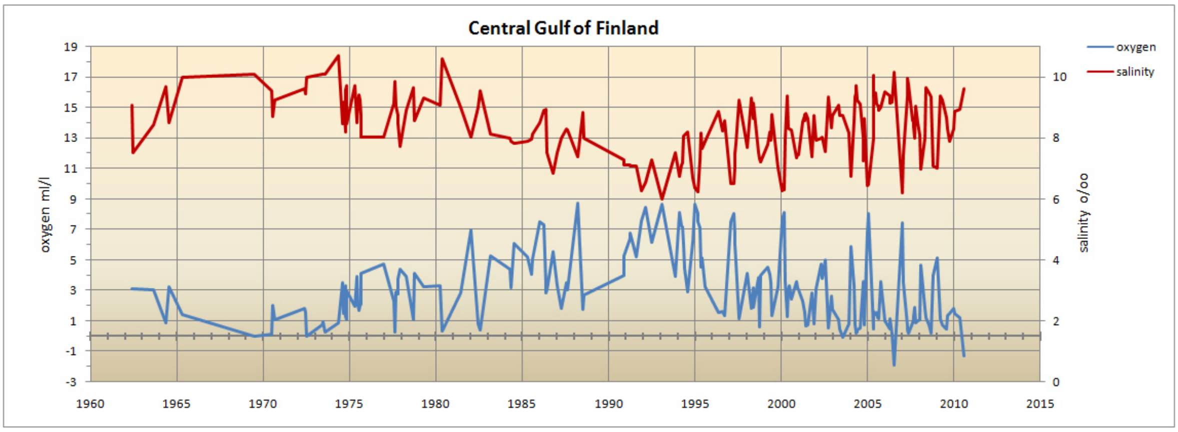


Figure 6.42 Long-term variation in the oxygen concentration and salinity at one metre above the seabed in the area of the HELCOM station LL7. Negative oxygen levels are based on hydrogen sulphide measurements /91/.

In Figure 6.43 the overall picture of the state of the water column just above the seabed in late summer 2009 and 2010 is presented. Red areas refer to anoxic conditions.

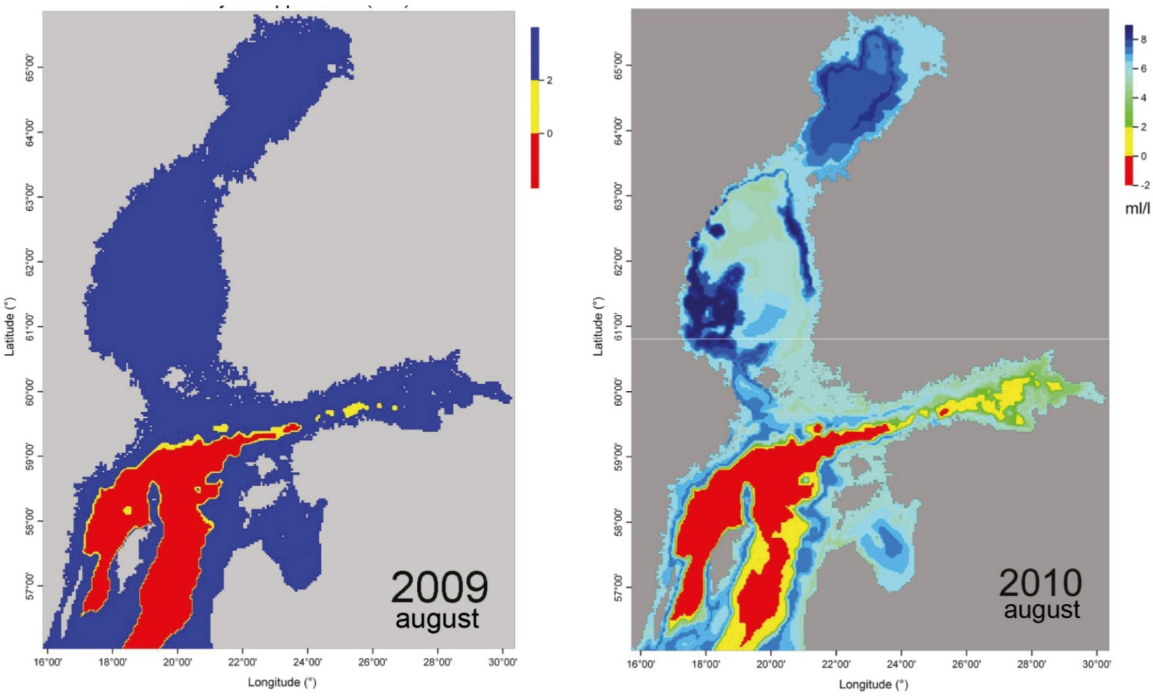
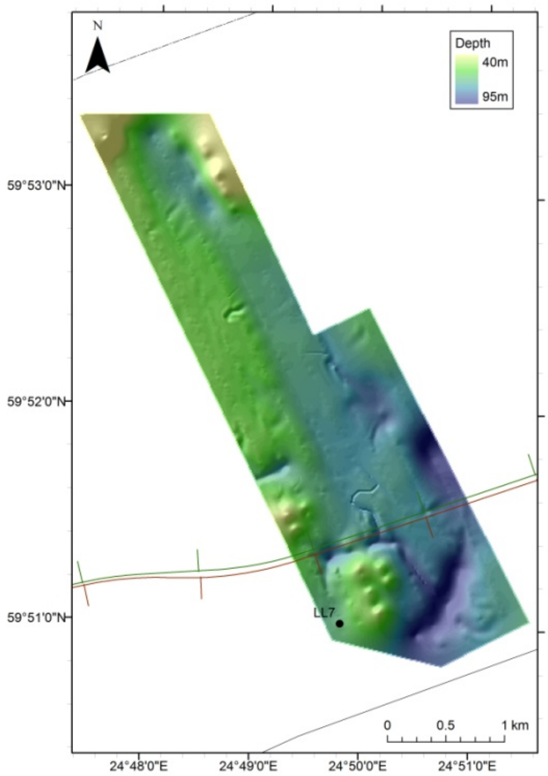


Figure 6.43 Oxygen conditions near the seabed in August 2009 (left) and 2010 in the Baltic Sea (right) according to SYKE. Note that the concentration scale is finer in the right image.

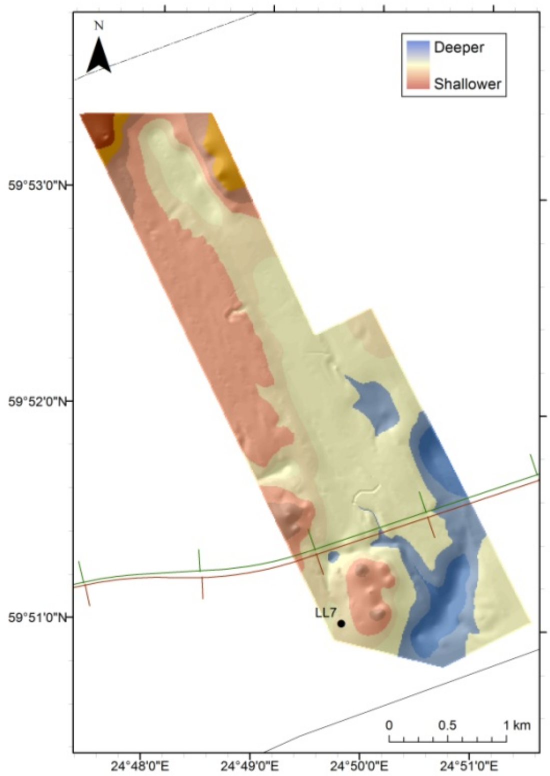
6.6.2 Similarity of the current HELCOM stations and new areas

Water depth, bottom substrate and clay thickness were the main criteria in an environmental suitability analysis where a correspondence between the current stations and the possible alternative locations was investigated (Figure 6.44). Descriptions of the field findings of the different areas are presented in more detailed in /91/.

A.



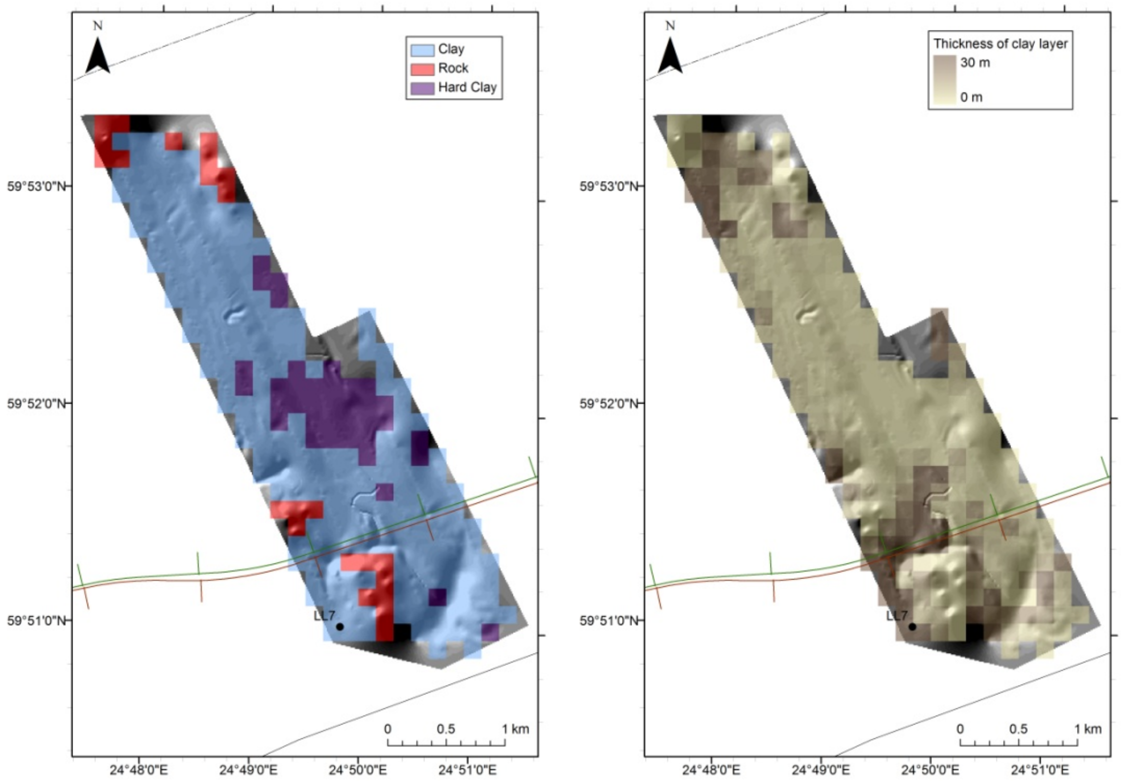
B.



A. ***Depth*** *in the area around LL7 covered by the acoustic grid survey. The map is an interpolation based on the echo sounder depth measurements along the grid lines.*

B. ***Variation in depth*** *from the current monitoring station LL7. Darker red colours indicate increasingly shallower areas, whilst darker blue colours indicate increasingly deeper areas.*

C. **D.**



C. ***Substrate*** *map for the acoustic survey area around LL7. The map is based oninterpretation of surface material from echograms along the acoustic survey grid lines and generalized to the surrounding area in ArcGIS.*

D. The map shows the ***thickness of the clay substrate layer around LL7****. The thickness of the clay layer was calculated from visual interpretation of the echograms along the acoustic survey grid lines and generalized to the surrounding area in ArcGIS.*

Figure 6.44 Environmental similarity of the LL7 area /91/

Based on the results, environmentally similar areas around LL6A and LL7 made up approximately 6 % of the total mapped area (Figure 6.45).

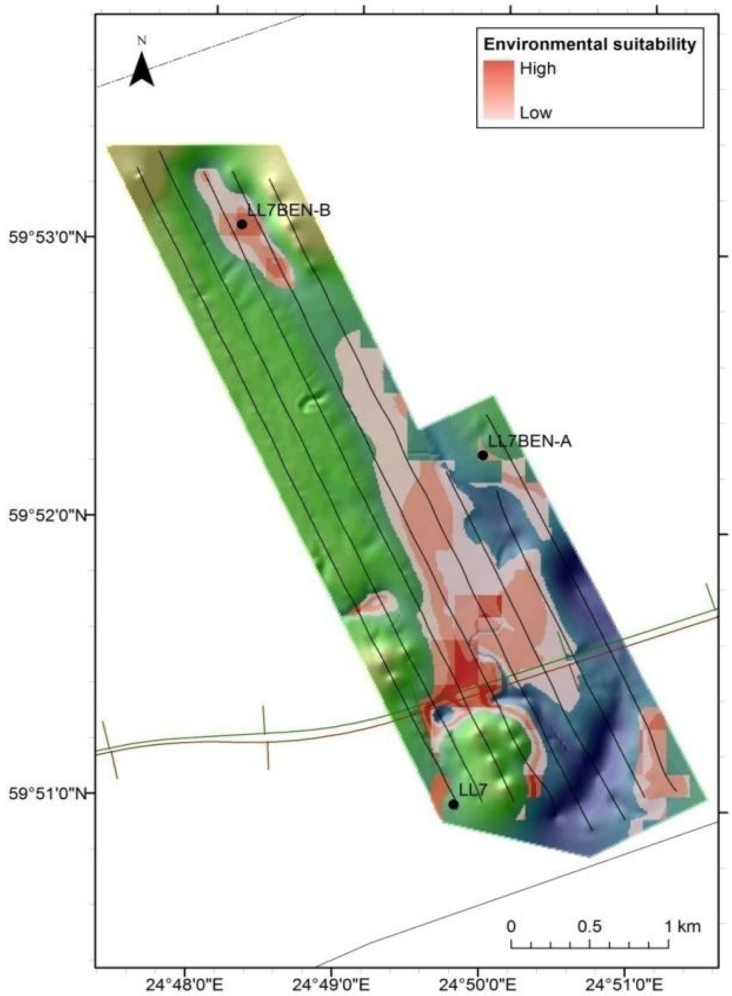


Figure 6.45 Environmental similarity of the seabed to that at the existing HELCOM benthos monitoring station LL7. The location LL7BEN-B was chosen as the best alternative site /91/.

The analysis for the LL5 area differed from the two others due to the shallowness of the survey area. The current HELCOM station (LL5) itself had a hard clay surface on top of the sea floor, whilst many locations around, in the acceptable depth range, had a very soft surface. Therefore the environmental suitability was graded based on the water depth as well as on the thicknesses of the mud and the clay layers. Finally the alternative location was chosen especially for its proximity to a rocky outcrop, which is similar to the current LL5 station.

6.6.3 Sediment quality

The sediment descriptions for the HELCOM stations LL7, LL6A and LL7 and their two alternative sites A and B studied are presented in /91/. The descriptions are based on visual examinations only and do not include any chemical analysis.

In all sites surface sediment was fluffy and rich in organic matter. Water content was normally high. Depending on the site the color varied from greenish brown to brown, dark grey, or black (as an example see Figure 6.46). The smell of hydrogen sulphide was detected at almost every sampling site. This was a clear sign of anoxia.

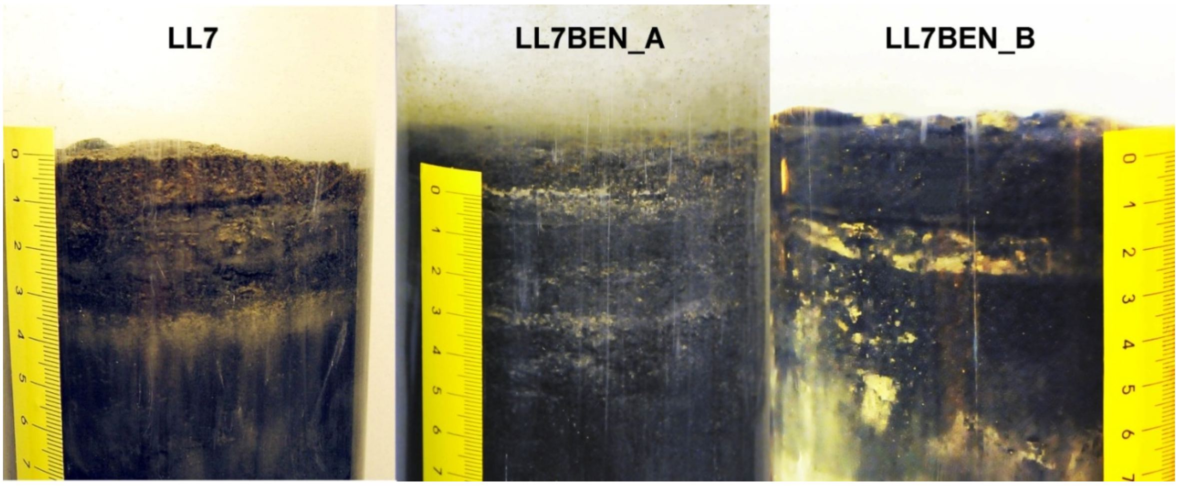


Figure 6.46 Quality of surface sediment at the HELCOM station LL7 and at the alternatives locations A and B studied. In the sediment profile LL7BEN_A surface layer was elevated in the core (ca. 2 cm within 1 h) due to gas formation in the sediment /91/.

The main reason for the very poor situation on the bottom was low oxygen concentrations.

Also, based on the sediment properties exact compatibility between current stations and possible alternative locations was not found. The outcome of the study is presented in Table 6.17.

Table 6.17 The best alternatives for the current HELCOM benthos monitoring stations and grounds for the choices /91/. Location of stations is presented in Figure 5.15.

Current HELCOM station	Alternative site	Grounds for the choice	Location
LL7	LL7BEN-B	Closest resemblance to the structure of surface sediment	• 4 km to the north from LL7 • 3.4 km to the north from the pipeline alignment
LL6A	LL6ABEN-A	Closest resemblance to the structure of surface sediment	• 2 km to the north from LL6A • 3.4 km to the north from the pipeline alignment
LL5	LL5BEN-A	Closest resemblance to the structure of surface sediment	• 6.4 km to the north from LL5 • 4.8 km to the north from the pipeline alignment

6.6.4 Macrozoobenthos

In 1990s, when living conditions on the bottoms studied were favourable for benthic species, the dominant species were the amphipods *Pontoporeia femorata* and *Monoporeia affinis*. Other typical species were the isopod *Saduria entomon* and the polychaete *Bylgides (Harmothoe) sarsi*. Nowadays, the invasive polychaete *Marenzelleria* sp. is the dominant species. The highest abundance of macrozoobenthos measured at the HELCOM station LL7 in 1995 was over 7,000 individuals/m^2 /108/.

In autumn 2010 the most common macrozoobenthic species at those stations/sites where animals existed was *Marenzelleria sp*. with very low abundances between 1-18 individuals/m^2 (Table 6.18). The total wet biomass was clearly < 1 g/m^2 at every site. Also some

representatives of benthic crustaceans were observed. Only these small animals that were not captured with a 1.0 mm sieve, were present at LL7. No fundamental differences in the abundances existed between the different locations /108/. Because of generally low numbers of species and individuals of benthos, macrozoobenthic communities could not be used as a reliable factor in the selection of possible alternative locations for the current HELCOM benthos stations.

Table 6.18 Macrozoobenthos species, abundances and biomasses in autumn 2010 at the HELCOM stations and mapped alternative sites /108/. ww= wet weight; dw= dry weight; aw= ash weight.

Macrozoobenthos in Nord Stream HELCOM monitoring 2010							
Station	**Mesh size mm**	**Number of replicates**	**Species**	**Ind m^{-2}**	**ww mg m^{-2}**	**dw mg m^{-2}**	**aw mg m^{-2}**
LL5	1.0	3	No life				
	0.5	1	No life				
LL5BEN-A	1	10	*Marenzelleria sp.*	3	16.3±3.1	1.7±0.3	0.5±0.0
	0.5	1	No life				
LL5BEN-B	1.0	10	*Marenzelleria sp.*	16	114.4±11.8	9.4±0.9	1.2±0.1
	0.5	1	*Marenzelleria sp.*	18	15.2	1.8	1.8
LL6A	1.0	3	*Marenzelleria sp.*	6	40.8±7.9	5.1±0.9	0.3±0.0
	0.5	1	No life				
LL6ABEN-A	1.0	10	No life				
	0.5	1	Ostracoda*	938			
LL6ABEN-B	1.0	10	*Marenzelleria sp.*	1	0.6±0.2	0.2±0.0	0.1±0.0
	1.0	10	*Mysis mixta*	1			
	0.5	2	*Marenzelleria sp.*	5	12.9	0.4	0.0
	0.5	2	Ostracoda*	71			
LL7	1.0	3	No life				
	0.5	2	Ostracoda*	18			
LL7BEN-A	1.0	10	*Marenzelleria sp.*	1	9.5±3.3	0.5±0.1	0.4±0.1
	1.0	10	*Mysis relicta**	1			
	0.5	1	No life				
LL7BEN-B	1.0	10	*Marenzelleria sp.*	3	23.9±4.9	2.1±0.5	0.4±0.0
	0.5	1	*Marenzelleria sp.*	9	8.9	1.8	0.9
	0.5	1	Ostracoda*	9			

*not weighted

6.7 Long term water quality and current monitoring

Long term water quality monitoring has been carried out at the CONTROL1 and CONTROL2-stations, near Natura 2000 areas in the western and eastern Gulf of Finland (Figure 5.7). The corresponding water depths at the stations are 43 m and 47 m. The character of the areas differs in terms of eutrophication status so that more nutrients in water and hence more intense algal growth during summertime is prevailing in the eastern parts of the Gulf of Finland. This phenomenon has a big influence on the oxygen conditions in hypolimnion during thermal stratification. Monitoring commenced in autumn 2009, before the munitions clearance started, and will continue until the end of the construction period in 2012.

As for the project, data from the CONTROL- stations serve as background information of natural, season related changes in sea water quality, mainly near the bottom, in different parts of the Gulf. Hydrological conditions (stratification patterns of temperature and salinity) in the water column at the sites have been studied by producing vertical profiles of temperature and salinity but also turbidity. These stations have also provided valuable data on the prevailing currents, their magnitude and direction and possible changes throughout the water column /42/.

6.7.1 Water quality

6.7.1.1 Temperature and salinity

Changes in temperature profiles at both stations are typical in relation to different seasons during a year. In autumn, a clear temperature rise is connected to the breakdown of stratification in water column and the following turnover will make water temperature uniform from surface to bottom. After that temperature typically decreases rapidly towards winter (Figure 6.47).

The same trend is also seen on the salinity graphs (Figure 6.48). Average salinity concentration is almost the same at both stations. Short-term changes in salinity are a sign of replacement of different water masses by strong winds or bottom close currents induced by winds.

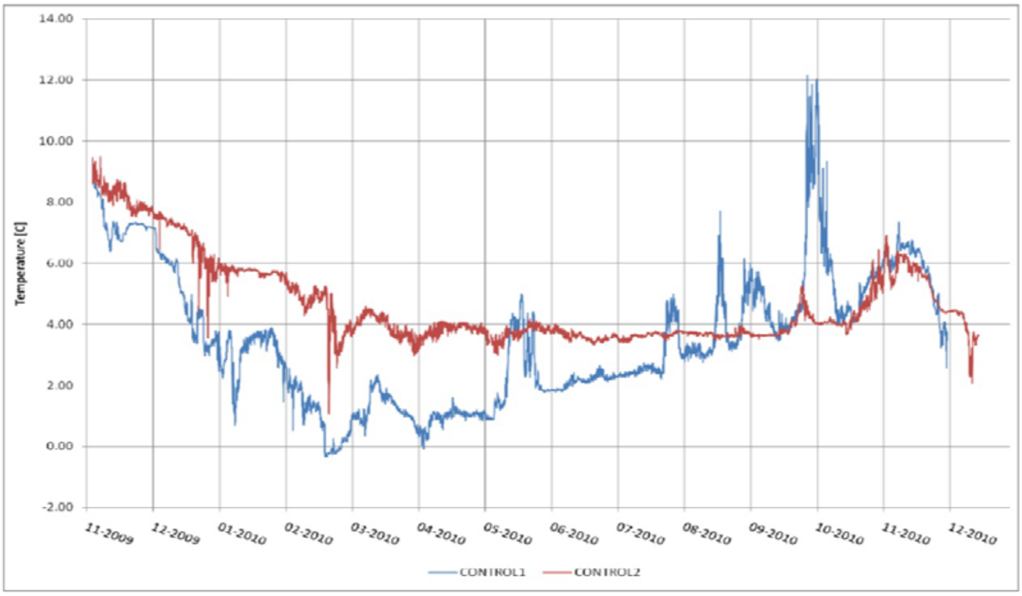


Figure 6.47 Time series of temperature in sea water, near the bottom, between 4.11.2009-2.12.2010 (CONTROL1) and 4.11.2009-16.12.2010 (CONTROL2) at the CONTROL stations /95/

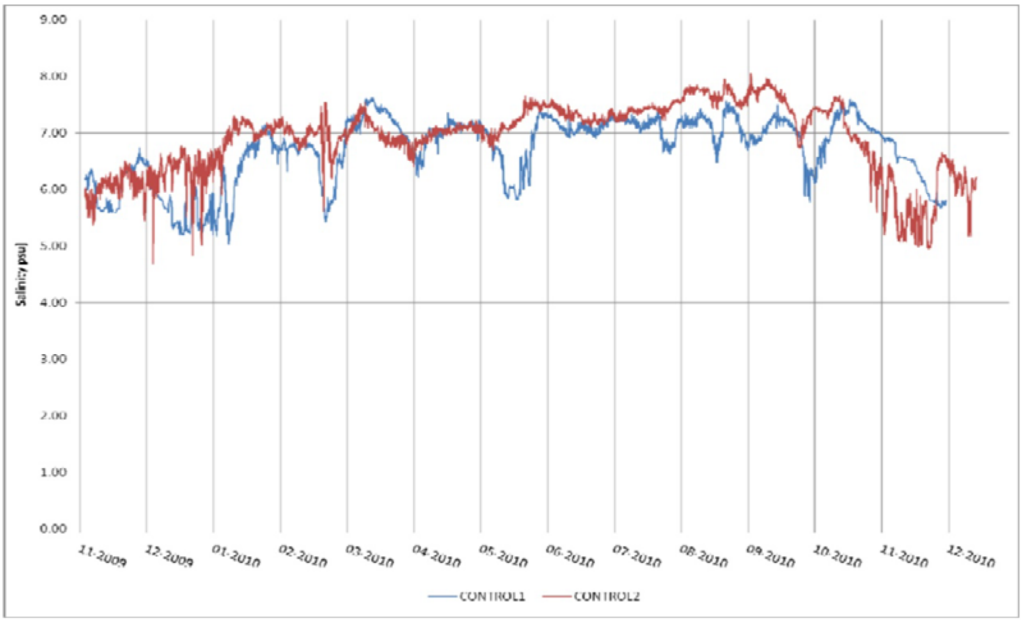


Figure 6.48 Time series of salinity in sea water, near the bottom, between 4.11.2009-2.12.2010 (CONTROL1) and 4.11.2009-16.12.2010 (CONTROL2) at the CONTROL stations /95/

6.7.1.2 Oxygen and turbidity

At about the same total depth the average oxygen level was clearly higher at CONTROL1 compared to CONTROL2 (Figure 6.42). This feature clearly indicates the different status of the areas as to the presence of nutrients and organic matter in sea water. Breakdown of organic material in hypolimnion consumes oxygen that will dramatically decrease in the water above the seabed in stratified conditions. However, the overall situation in these comparatively shallow areas is still different from the open, deeper waters of the Gulf of Finland, where bottom close situation is currently very poor because of permanent halocline. At the CONTROL1 station the seabed was well oxygenated even in late summer, whereas at CONTROL2 oxygen situation was already poor from July until October (Figure 6.49).

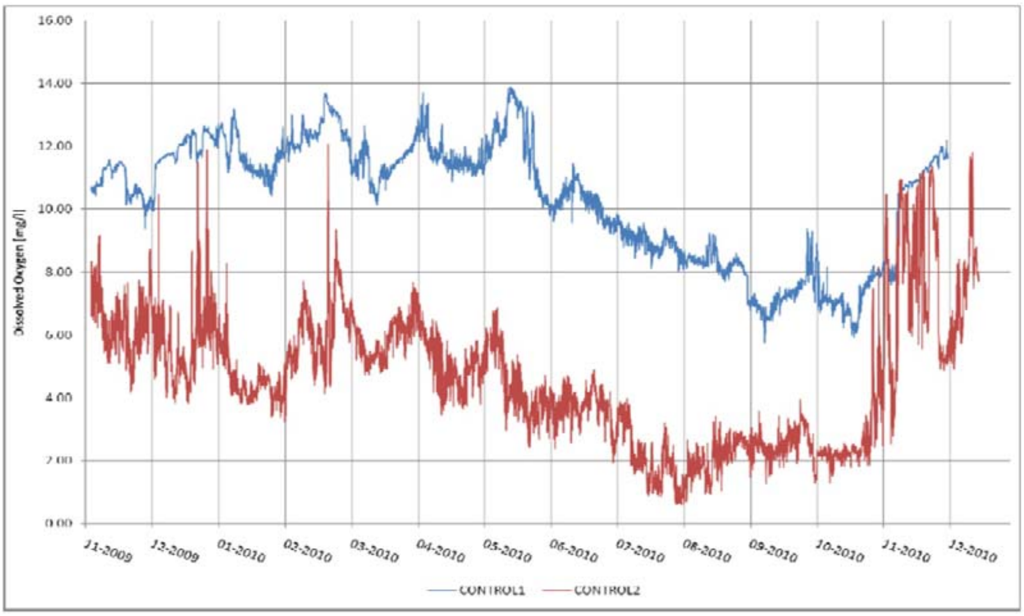


Figure 6.49 Time series of dissolved oxygen in sea water, near the bottom, between 4.11.2009-2.12.2010 (CONTROL1) and 4.11.2009-16.12.2010 (CONTROL2) at the CONTROL stations /95/

General turbidity (~1 NTU) in bottom close waters was low at both stations. Also the turbidity trends during the studied period were quite similar. However, some short-term peaks were recorded in late autumn that reached values around 8-9 NTU, when stratification had been broken out (Figure 6.50). In this situation sediments will be easily disturbed by strong winds. Turbidity value 10 NTU is considered as a limit for visible turbidity (Figure 6.50).

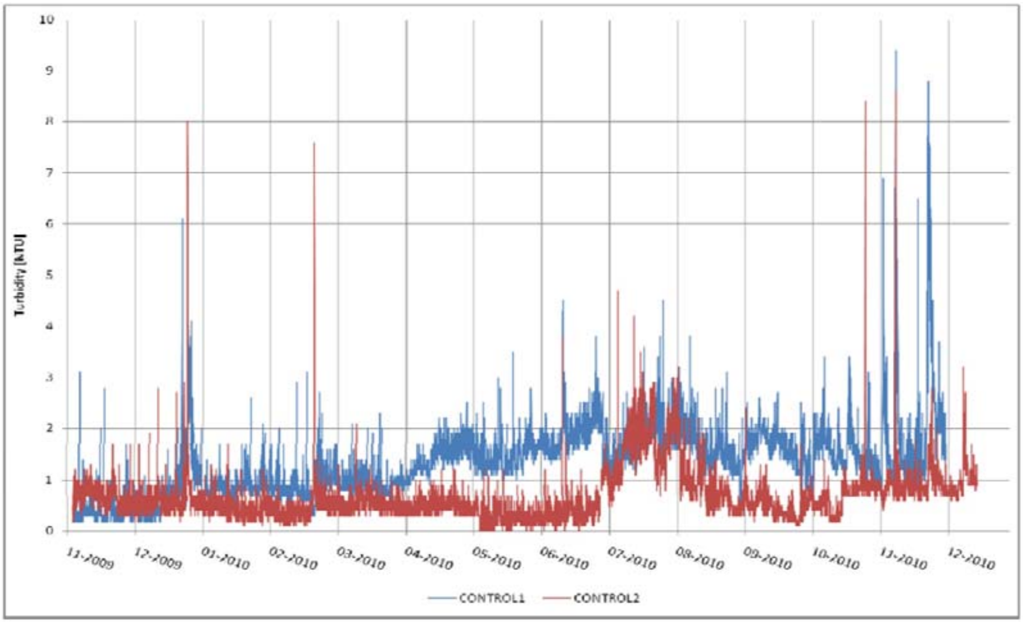
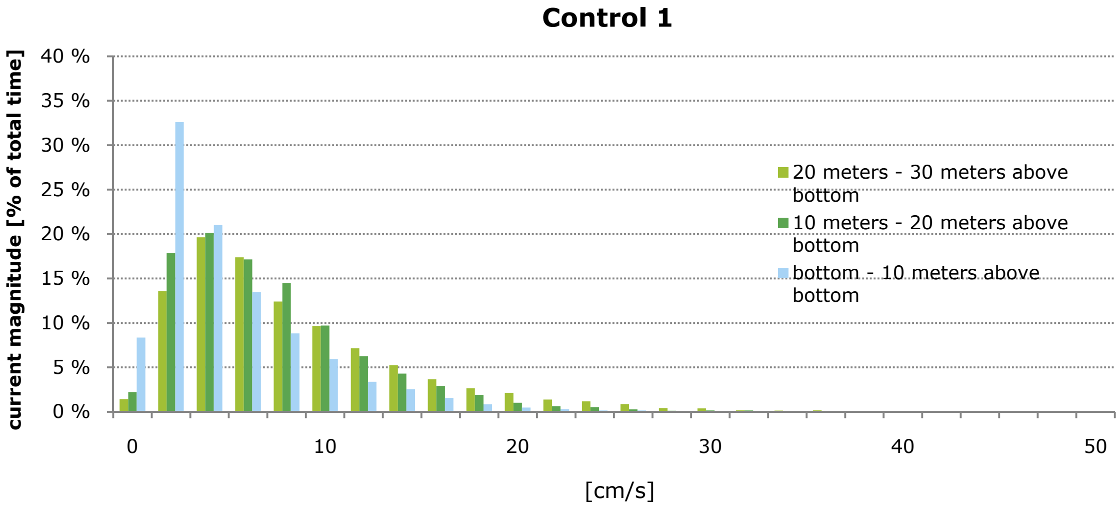


Figure 6.50 Time series of turbidity in sea water, near the bottom, between 4.11.2009-2.12.2010 (CONTROL1) and 4.11.2009-16.12.2010 (CONTROL2) at the CONTROL stations /95/

6.7.2 Currents

Current speed and direction in the whole water column at the CONTROL1-2 stations is presented in the next figures.

Average current magnitude at CONTROL1 was around 6 cm/s in bottom and 10 cm/s in the uppermost layers. The highest recorded value in the bottom layer was 37 cm/s. Corresponding values at CONTROL2 were 6 cm/s and 9 cm/s, respectively. The highest recorded current manitude in the bottom layer was 51 cm/s.



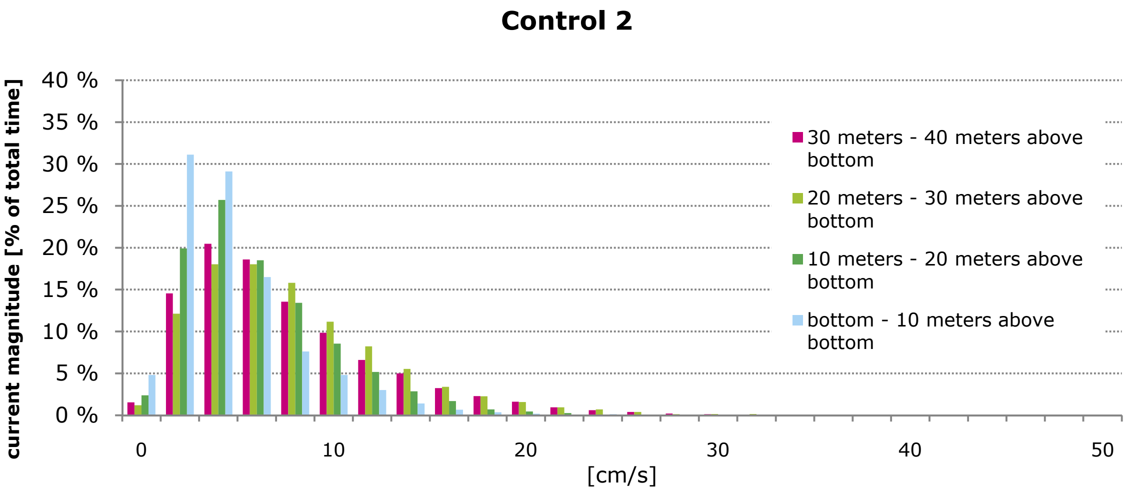
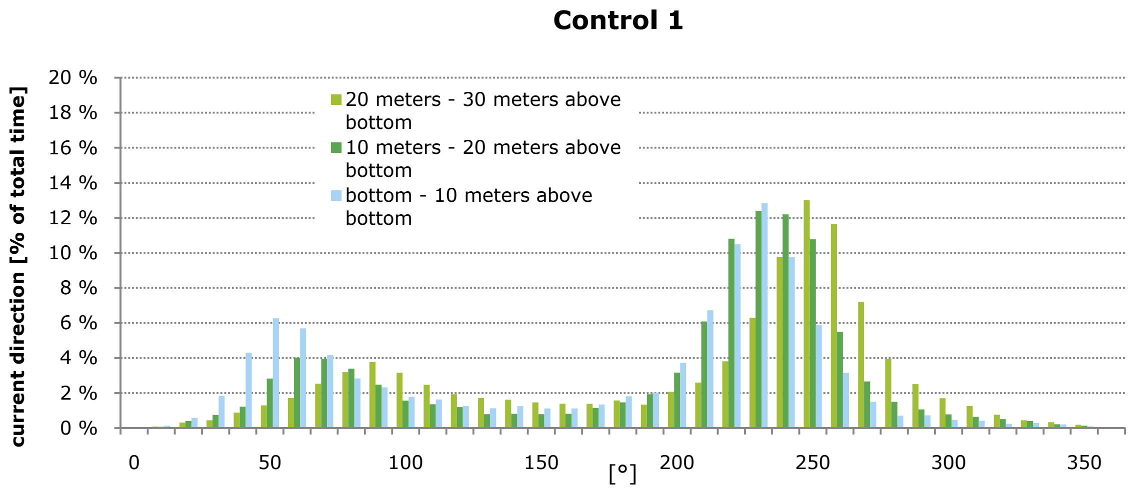


Figure 6.51 Histograms of current magnitude at the CONTROL stations between 6.11.2009-2.12.2010 (CONTROL1) and 4.11.2009-16.12.2010 (CONTROL2) /42/

The typical current directions at CONTROL1 have been towards southwest and to a lesser extent towards northeast. At CONTROL2 the current directions vary more. Southeast directions have been slightly more typical than the other directions near the bottom (Figures 6.52, 6.53 and 6.54).



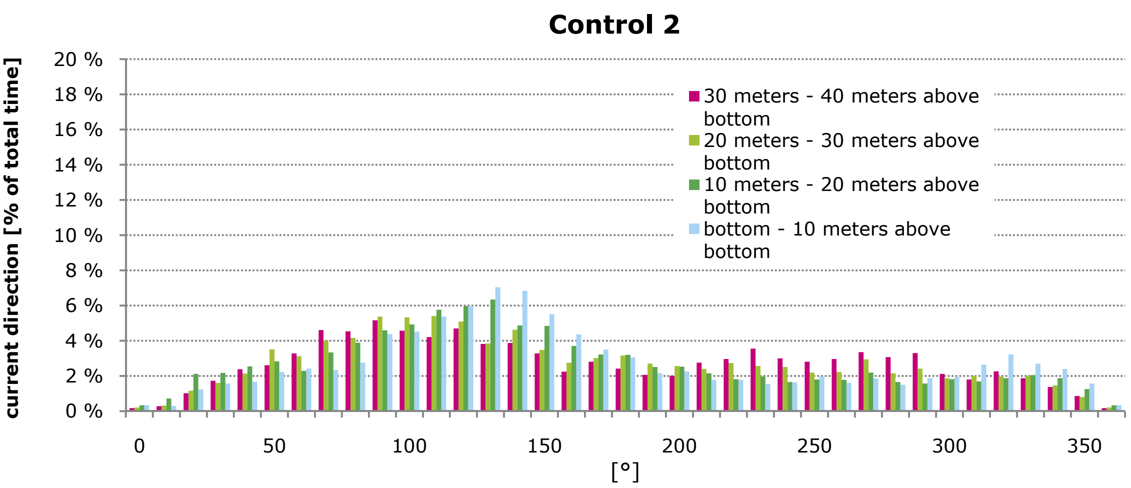


Figure 6.52 Histograms of the current directions at the CONTROL stations between 6.11.2009-2.12.2010 (CONTROL1) and 4.11.2009-16.12.2010 (CONTROL2) /42/

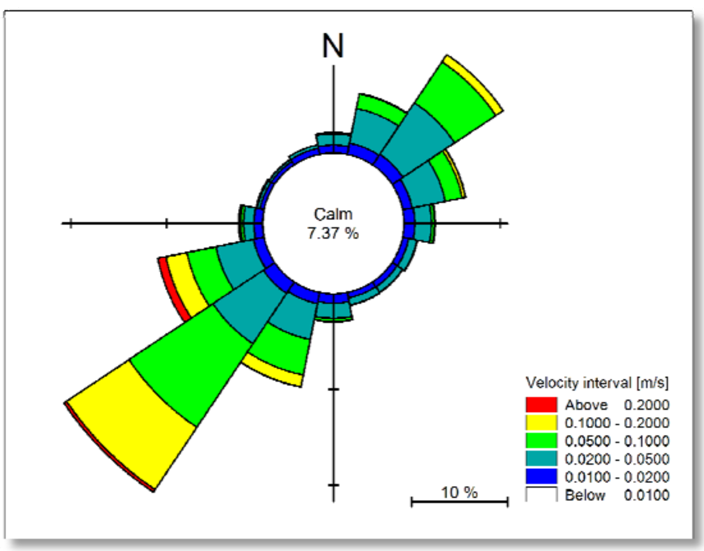


Figure 6.53 Current rose for the observed current speed (m/s) and distribution at CONTROL1 /95/

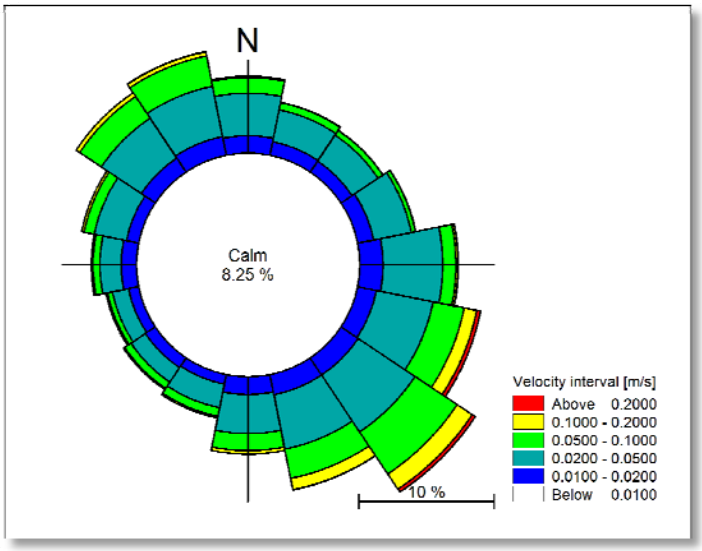


Figure 6.54 Current rose for the observed current speed (m/s) and distribution at CONTROL2 /95/

6.8 Ship traffic

Nord Stream has during the period November 2009 - December 2010 provided 14 notifications for pipelay construction activities to the Border Guard and the Finnish Transport Agency before vessels entered Finnish Waters. The submitted notification documents have been prepared according to the information requested by Finnish authorities. In addition Nord Stream has submitted both monthly forecasts and monthly reports to the authorities. The vessels have provided weekly and daily progress reports to the relevant authorities. Several meetings to present construction activities and agree communications procedures were held.

Vessel movements have been monitored by GOFREP. The Finnish Transport Agency has published notices to mariners on project activities.

Safety zones to avoid adverse impacts on commercial shipping were established around all construction activities such as munitions clearance, rock placement, mattress installation and pipelay

During munitions clearance, prior to every detonation, shipping has been notified according to the agreed procedures. The safety zones were calculated based on net explosive quantity, but were in general: 1,000 metres for the clearance preparation phase and 2,000 metres for the actual clearance phase. During the preparation phase in November 2009, a speedboat with a representative of the press came within the safety zone without permission. The vessel did not respond to requests to stay outside of the safety zone. The event had no consequences because the detonation was planned to be postponed. During spring 2010 interference with yachtsmen increased but never led to delays or problems. Some of cleared munitions required temporary suspension of the TSS (Traffic Separation Scheme) area in Porkkala during the first half of 2010. The munitions that required TSS suspension were agreed with Finnish Transport Agency. No incidents were reported.

The mattress installation and rock placement vessels required safety zone of 500 meters around the vessel at each construction location. During second quarter of 2010 one incident related to communication procedures occurred with "*DFPV Sandpiper*". The incident was reported by GOFREP and appropriate corrective actions were implemented.

Pipelay required following safety zones; for the anchored lay barge *Castoro Sei* 2,5 – 3 km and for the DP lay barge *Solitaire* 2 km radius around the vessel. Finnish authorities raised concern of possible impact from *Solitaire* pipelay to ship traffic at TSS areas in Kalbådagrund and Porkkala. Based on agreed mitigation measures to reduce the risk of grounding or collision of third party vessels, Nord Stream contracted an intervention tug to support construction at the TSS areas in November - December 2010. No incidents were reported.

6.8.1 Compliance monitoring of vessels used in monstruction

To confirm that the vessels involved in the Nord Stream constructions are compliant with the environmental regulations for operating within the Baltic Sea and Gulf of Finland periodic environmental audits are performed. The audit team is lead by Environ and the vessels are audited against Nord Stream's construction management plans (CMP) for 'Vessels and Marine Transport' and 'Pollution Prevention'.

The objectives of the audits are:

- To verify the vessel operator's compliance with the applicable permit requirements and conditions.
- To assess the vessel operator's performance with respect to HSES issues in accordance with the relevant legislative requirements and regulatory standards as well as best international practice.
- To verify the effective implementation of the vessel operator's management systems and HSE Plans during contracted activities.

The scope of work for each audit typically includes:

- inspection of the vessel (in port or offshore), focusing on points of environmental interest such as waste storage areas, hazardous material storage areas, bunkering points and engineering areas;
- discussions with representatives onboard the vessel from both Contractor and Nord Stream;
- review of relevant documentation such as QHSE management system procedures, work instructions and records (e.g. relating to waste, ballast water, oil transfers, bunkering activities, training, HSE meeting minutes) ; and,
- assessment of compliance with a sample of commitments from relevant Nord Stream Construction Management Plans (CMPs).

In addition, a compliance assessment is conducted against the requirements of the "International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto" (MARPOL) and the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM).

A summary of the health, safety, environment and social (HSES) audits conducted up to end of December 2010 are presented in Table 6.19

Table 6.19 Summary of Construction Vessel HSES Audits conducted by Nord Stream (up to end of April 2011)

Audit Ref.	Audit Date	Vessel - Activity	Audit Scope	Relevant Nord Stream Construction Management Plans (CMPs)
T3-MCV-LET-NOV09	06/11/09	John Lethbridge – Munitions clearance vessel	Pre-mobilisation environmental audit of the vessel whilst in port in Portland, UK (inc. compliance assessment against MARPOL and HELCOM).	Munitions Clearance, Vessels and Marine Transport, Waste, Pollution Prevention and Employment & Training

Audit Ref.	Audit Date	Vessel - Activity	Audit Scope	Relevant Nord Stream Construction Management Plans (CMPs)
T3-RPV-SEA-FEB10	15/02/10	Seahorse – Rock Placement Vessel	Pre-mobilisation environmental audit of the vessel whilst in port (inc. compliance assessment against MARPOL and HELCOM).	Seabed Intervention, Vessels and Marine Transport, Waste, Pollution Prevention and Employment & Training
T3-MCV-FRE-MAR10	11/03/10	Edda Freya - Munitions Clearance vessel	Pre-mobilisation environmental audit of the vessel whilst in port in Gothenburg, Sweden (inc. compliance assessment against MARPOL and HELCOM).	Munitions Clearance, Vessels and Marine Transport, Waste, Pollution Prevention and Employment & Training
T3-RPV-ROL-APR10	08/04/10	Rollingstone – Rock Placement Vessel	Pre-mobilisation environmental audit of the vessel whilst in port (inc. compliance assessment against MARPOL and HELCOM).	Seabed Intervention, Vessels and Marine Transport, Waste, Pollution Prevention and Employment & Training
T3-MCV-SIN-APR10	15/04/10	Noordhoek Singapore - Munitions clearance vessel	Pre-mobilisation environmental audit of the vessel whilst in port in Sheerness, UK (inc. compliance assessment against MARPOL and HELCOM).	Munitions Clearance, Vessels and Marine Transport, Waste, Pollution Prevention and Employment & Training
T3-RPV-SAN-APR10	30/04/10	Sandpiper–Rock Placement Vessel	Pre-mobilisation environmental audit of the vessel whilst in port (inc. compliance assessment against MARPOL and HELCOM)	Seabed Intervention, Vessels and Marine Transport, Waste, Pollution Prevention and Employment & Training
T3-PSV-C6-APR10	15/06/10	M/V Normand Flipper - Pipe Supply Vessel	Operational environmental audit of the vessel whilst it was loading pipes in Slite, Sweden (inc. compliance assessment against MARPOL & HELCOM)	Vessels and Marine Transport, Waste, Pollution Prevention, Hazardous Materials and Employment & Training
T3-PB-SEI-APR10	19/06/10	Castoro Sei - C6 - Pipelay Barge	Operational environmental audit of the vessel whilst at sea off coast of Sweden (with focus on contractor procedures/records and compliance with MARPOL & HELCOM)	Offshore Pipelaying, Vessels & Marine Transport, Pollution Prevention, Waste, Hazardous Materials and Employment & Training

Audit Ref.	Audit Date	Vessel - Activity	Audit Scope	Relevant Nord Stream Construction Management Plans (CMPs)
T3-PB-SOL-AUG10	13/08/10	Solitaire - Pipelay Vessel	Pre-mobilisation HSES audit of the vessel whilst in Port of Rotterdam (with focus on contractor procedures/records and compliance with NSP H&S requirements, MARPOL & HELCOM)	Offshore Pipelaying, Vessels and Marine Transport, Pollution Prevention & Employment and Training
T3-PB-SEI-JUL10	07/09/10	Castoro Sei - C6 - Pipelay Barge	Operational HSES audit of the vessel whilst at sea off Finland (with focus on contractor procedures/records and compliance with NSP H&S requirements, MARPOL & HELCOM)	Offshore Pipelaying, Vessels & Marine Transport, Pollution Prevention and Employment &Training
T3-OTH-SKA-SEP10	17/09/10	Skandi Arctic – Dive Support Vessel	Pre-mobilisation ES audit of the vessel whilst in Port of Haugesund, Norway (inc. compliance assessment against MARPOL & HELCOM)	Pre-Commissioning, Offshore Pipelaying, Vessels & Marine Transport, Waste, Pollution Prevention and Employment & Training
T3-PB-SOL-SEP10	29/11/10-30/11/10	Solitaire – Pipelay vessel	Operational HSES audit of the vessel whilst at sea off Finland (with focus on contractor procedures/records and compliance with NSP H&S standards, MARPOL & HELCOM).	Offshore pipelaying, Vessel & Marine Transport, Waste, Hazardous Materials, Emergency Preparedness and Employment & Training
T3-RPV-ROL-DEC10	13/12/10-15/12/10	Rollingstone – Rock Placement Vessel	Operational ES audit whilst vessel was conducting rock placement in Gulf of Finland (with focus on rock placement operations and waste management).	Seabed Intervention, Vessel & Marine Transport, Waste, Hazardous Materials, Emergency Preparedness and Employment & Training

6.9 Transboundary monitoring

6.9.1 Dredging in Russian landfall

A fixed sensor (multiparameter sonde) was installed at FIX3 station on 5 May 2010, i.e. approximately four weeks before the start of the dredging works at the Russian landfall. Monitoring ended on 2nd September 2010, eight weeks after the end of dredging works. The water depth at the station was 42 m /42/.

The recorded turbidity and oxygen concentration data near the seabed (1.5-2.0 m above) is presented in the graphs in the following figures. The complete results from FIX3 are presented in Appendix 5.

6.9.1.1 Turbidity

Recorded turbidity data stayed at background levels during the entire monitoring period. According to the turbidity values recorded, there was no sign of any effects in the Finnish waters caused by the dredging activities at the Russian landfall (Figure 6.55).

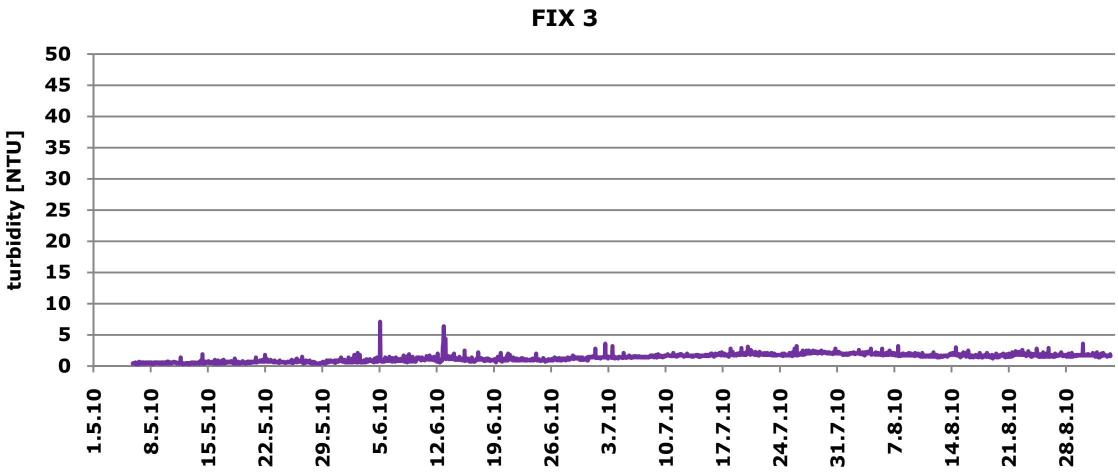


Figure 6.55 Fixed sensor. Turbidity (NTU) near the seabed at FIX3 on 5.5.-2.9.2010 /42/.

6.9.1.2 Oxygen

Oxygen concentration level at FIX3 varied from relatively poor to very poor during the whole recording period. The oxygen situation was at its poorest in late summer (Figure 6.56).

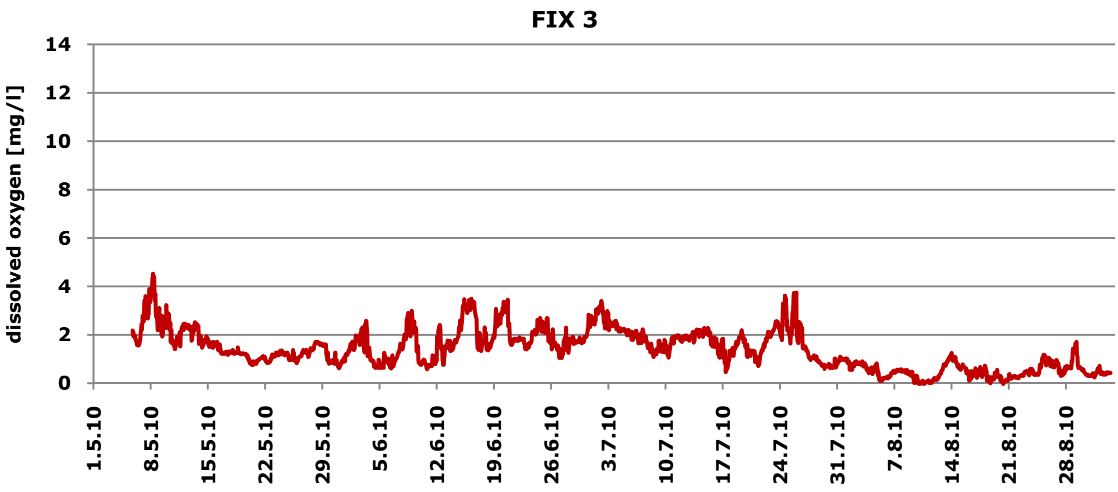


Figure 6.56 Fixed sensor. Oxygen concentration (mg/l) near the seabed at FIX3 on 5.5.-2.9.2010 /42/.

6.9.1.3 Water samples

Water samples were taken from FIX3 in June and in September 2010. The sampling depth was 1.5-2.0 m above the bottom (approx. 40 m). Based on the results the water quality at FIX3 reflected typical increase of eutrophication status in the Gulf of Finland toward the east compared to the quality at the CONTROL stations, which are located in more westerly parts of the Gulf of Finland (Appendix 5).