Nord Stream
The new gas supply route for Europe

Nord Stream Project


| Rev. | Date | Description | Prepared | Checked | Approved | Checked | Approved |
|---|---|---|---|---|---|---|---|
| A | 2012-04-10 | Issue for Use / Construction | JLA | JCA | NES | SAN | NAN |
| | | | Ramboll | | | Nord Stream AG | |

RAMBØLL

Document Title

# Environmental monitoring in Danish waters, 2011

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|---|---|---|---|---|---|---|---|---|
| Company Representative | : | Werner Zirnig | | | | | | |
| Reference | : | | Document-No. | | | | | Rev. |
| PO. No. | : | PO10-1029 | G-PE-PER-MON-100-05070011 | | | | | A |
| Contractor Representative | : | Neel Strøbæk | | | | | | |
| Document Owner | : | Ramboll | Pipe line | Sub project | Discipline | Doc. Type | Originator ID | Unifier |

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## Abbreviations and definitions

| | |
|---|---|
| ADCP | Acoustic Doppler Current Profiler |
| ADF | Admiral Danish Fleet |
| AIS | Automatic Identification System |
| A&R | Abandonment and Recovery |
| Bcm | Billion cubic metres |
| CTD | Conductivity, Temperature and Depth |
| CTDO | Conductivity, Temperature, Depth and Oxygen |
| CMP | Construction Management Plan |
| CWA | Chemical Warfare Agents |
| $D_{50}$ | Median grain size of the sediment |
| DCC | Distance of Cross Course |
| DEMA | Danish Emergency Management Agency |
| DGPS | Differential Global Positioning System |
| DM | Dry Matter |
| DW | Dry Weight |
| EEZ | Exclusive Economic Zone |
| EIA | Environmental Impact Assessment |
| EOD | Explosive Ordnance Disposal |
| GVI | General Video Inspection |
| $H_2S$ | Hydrogen sulphide |
| HELCOM | The Helsinki Commission |
| HSE | Health, Safety and Environment |
| ESMS | Environmental and Social Management System |
| IMR | Inspection, Maintenance and Repair |
| IWs | Intervention Works |
| KP | Kilometre Point (starting with KP 0 km at Russian landfall) |
| LOI | Loss On Ignition |
| LOQ | Limit of Quantification |
| $m^3$ | Cubic meter |
| MBES | Multi Beam Echo Sounder |
| MMT | Marin Mätteknik AB |
| MSCS | Maritime Surveillance Centre South (Former Bornholm Marine District (BHM)) |
| Natura 2000 | An ecological network of protected areas in the territory of the European Union |
| OBS | Optical Back-Scatter |
| psu | practical salinity units |
| ROV | Remotely Operated Vehicle |
| RQ | Risk Quotient |
| SMHI | The Swedish Meteorological and Hydrological Institute |
| SSC | Suspended Sediment Concentration |
| Thermocline | A thin but distinct layer in which temperature changes rapidly with depth |

| | |
|---|---|
| TOC | Total Organic Carbon |
| TW | Territorial Water |
| VERIFIN | Finnish Institute for Verification of the Chemical Weapons Convention |

# 1 Summary

The construction of two offshore natural gas pipelines from Russia to Germany (the Nord Stream Pipeline) commenced in spring 2010 and is planned to be completed in 2012. The pipelines shall connect the large natural gas resources of Russia with the European natural gas pipeline network.

As part of the permit requirements for construction of the pipelines, an environmental monitoring programme covering activities in the period 2010-2016 within the Danish territorial water (TW) and exclusive economic zone (EEZ) was formulated by Nord Stream in collaboration with the Danish authorities.

The monitoring programme covers the following environmental and socioeconomic parameters:

Environmental parameters:

- Monitoring of fish along pipeline
- Monitoring of benthic fauna
- Monitoring of water quality
- Monitoring of hydrographic conditions in the Bornholm Basin.

Socioeconomic monitoring parameters:

- Monitoring of cultural heritage
- Monitoring of munitions
- Monitoring of chemical warfare agents (CWA) in the sediment
- Monitoring at national and international monitoring stations
- Monitoring of maritime traffic.

This document provides an overview of all environmental monitoring activities carried out by Nord Stream in 2011 within Danish waters. The document explains the status of monitoring in general terms in addition to the overall results. Detailed descriptions of monitoring activities and results for 2011 are presented in specific monitoring reports.

This document is the second of the planned annual reports, the purpose of which is to document the status and the results of the monitoring activities in the Danish waters and if necessary recommend appropriate adjustments to the monitoring scope.

## 1.1 Construction activities 2011

Line 1 was deployed east of Bornholm in November and December 2010. The pipe-lay was performed by the Castoro Sei supported by four pipe carriers and three anchor handling tugs. The anchor handling tugs positioned the lay vessel´s twelve anchors, moving the lay vessel slowly forward as the pipeline was lowered onto the seabed.

Post-lay trenching by ploughing of Line 1 was undertaken at two shallow sections east of Bornholm in February 2011. Due to hard and stony bottom trenching of the 2.8 km long Section 1 did not reach

the required depth to ensure proper on-bottom stability of the pipeline. Therefore spot rock placement was carried out on parts of this section in July 2011. Trenching of the 8.6 km long Section 2 proceeded as planned and no additional rock placement was needed.

## 1.2 Monitoring of fish along the pipeline

Field investigations were conducted during September 2011. Baseline monitoring was conducted in October-November 2010. Surveys are planned to continue in 2012-2014 with the overall objective to describe the qualitative and if possible the quantitative changes in the fish community in the immediate vicinity of the Nord Stream Pipeline and to compare the findings with the fish community of the surrounding seabed. The aim of the monitoring is to investigate whether the pipelines lead to a so-called reef effect and to determine the extent of changes in fish abundance.

The overall objective of fish monitoring is to measure impacts where the pipelines are established directly on the seabed and where trenching has been carried out. The monitoring of fish directly at and in the immediate vicinity of the pipelines is focused on demersal fish species, as no effects from the presence of the pipelines on the seabed are expected to occur for pelagic fish species. To obtain detailed information on species composition, and to estimate quantitative changes due to a potential reef effect, information is gathered through survey trawling and gill net fishery. Additionally, echo-sounder surveys, and visual inspections with a remotely operated vehicle (ROV) are carried out.

Investigations are undertaken at nine locations along the pipeline and at four reference stations (>1 km west of the pipeline). Five of these fish monitoring stations are so-called “hotspots” identified by Danish fishermen as particularly important for fishery along the Danish section of the Nord Stream Pipeline.

The northern locations, where the depth ranged from 60 to 90 m (KP1010, KP1046, KP1056 and KP1070), were partly or totally affected of hypoxia. This provides inadequate conditions for assessment of any difference in composition of fish species or quantity of fish in relation to the establishment of the pipeline. In the remaining locations, KP1050, KP1078, KP1100, KP1106 and KP1120, the depth varied between approximately 40 to 50 m and the hydrographical conditions, that might affect the presence of demersal fish, were similar between surveys and no hypoxia was observed. This provides favourable conditions for evaluating temporal differences in the demersal fish community.

The results of the 2011 survey compared with the baseline survey from 2010 shows that the structure of the demersal fish assemblage within the studied locations showed no difference between the two years. The focus of the study has been on cod since it is a demersal fish species in the areas, and because the catches of cod were high throughout the entire sampling.

Analysis of the results from station KP 1100 and KP 1106 (no hypoxia and no reference stations) showed no difference in biomass and abundance of cod between the baseline survey in 2010 and the survey in 2011. At the stations without hypoxia containing reference stations (KP 1050, KP 1078 and KP 1120) no differences for biomass and abundance of cod between impact and reference areas were detected in either 2010 or 2011.

Noticeable, in the three most southern locations, KP 1100, KP 1106 and KP 1120 an evident increase in flat fish (flounder and plaice) was observed in 2011 compared to in 2010. Only KP 1120 has reference stations and analysis showed no differences between impact and reference stations.

Other demersal fish species, e.g. shorthorn sculpin, four bearded rockling, turbot and lumpfish were only documented sporadically and in low numbers. The dominant species found during the baseline study and during the first investigation after the pipeline has been established, are common in the Baltic Sea fish community.

To summarize, the results from the first survey, after establishment of the Nord Stream Pipeline, temporal variations but no impact from the pipeline on fish composition or presence of cod was observed.

### 1.3 Monitoring of benthic fauna

The purpose of the monitoring programme for benthic fauna is to evaluate and document re-colonization and recovery of the infauna changes around the pipelines after their installation and to evaluate and document the establishment and growth of epifauna on the pipelines.

**Infauna**
The field survey was carried out in June 2011. The benthic infauna stations are located in areas where trenching was carried out, and where the most pronounced effects from sediment dispersion and re-sedimentation due to trenching can be expected. Two transects (B10 and B 11), each containing 15 stations located perpendicular to the Nord Stream Pipeline, are being monitored. The monitoring stations are located between 10 and 1000 meters from the pipeline.

Results showed that the benthic community was dominated by the same species along transect B10 and transect B11. However, the structure of the benthic community was significantly different at transect B10 and B11 due to differences in abundance and biomass of the dominant species. The main differences were a dominance of the bivalve *Astarte borealis* along the deeper transect B10 and a dominance of the bivalve *Macoma balthica* and the polychaete *Pygospio elegans* along the more shallow transect B11. Other characteristic species were the polychaete *Scoloplos armiger*, the common mussel *Myilus edulis*, the crustacean *Diastylis rathkei* and the Pripulid *Halicryptus spinulosus*.

Since 2010 the abundance of the polychaete *Bylgides sarsi* and the crustacean *Diastylis lucifera* has declined at transect B10 and B 11. However, the average abundance and biomass of the benthic fauna has increased since 2010. The increases are most pronounced at transect B10.

Analysis of the structure of the benthic fauna 10 m, 50 m and >50 m from Line 1 revealed no spatial or temporal changes along transect B10.

At transect B 11 the structure of the benthic community 10 m and 50 m from the pipeline was different from the benthic fauna >50 m from Line 1. However, the abundance of the benthic fauna was higher at 10 m and 50 m stations than at stations > 50 m from the pipeline. In addition, the predominance close to the pipeline of the polychaete *Pygosio elegans*, likely to be sensitive to

burial, lead to the conclusion, that the spatial and temporal changes at transect B11 are result of natural changes since 2010 and not caused by trenching of Line 1 in 2011.

To monitor long-term effects and potential cumulative effects from construction of Line 2 the survey for benthos is planned to be repeated in 2012-2013.

**Epifauna**

The field survey was undertaken in July 2011. Inspection of colonisation and growth of epifauna on the pipelines is undertaken by visual inspections of the pipeline structures in areas with relatively shallow depths. Visual inspections are conducted at nine locations in which the growth of benthic epifauna are described and evaluated.

The results of the monitoring were reported separately ultimo 2011 in /1/.

The results from the video recordings and still photos from the nine locations in Danish waters in 2011 did, as expected, not reveal any establishment of sessile epifauna on the pipeline. Only one mobile species, the crustacean *Saduria entomon*, could be identified on and at the pipeline. An explanation for no s essile species being present at the pipeline might be the relatively short time period between establishment of the pipeline and the survey. Trenching in the analysed areas took place in February/March 2011, and the video recordings were performed in July 2011.

The monitoring for epifauna growth on the pipeline is planned to be continued once a year in 2012-2014.

## 1.4 Monitoring of water quality

Vessel-based monitoring of sediment spreading was carried out during post-lay trenching in Danish waters as part of the Nord Stream monitoring programme in February 2011.

The results of the monitoring in Danish waters were reported separately ultimo 2011 in /2/. It concluded that the sediment spill rate was approximately one third (around 7 kg/s) of the sediment spill rate assumed in the numerical modelling of sediment spreading (16 kg/s) that made the basis for the Danish EIA.

Therefore, the results of the water quality monitoring during construction of Line 1 in Danish waters confirmed that the assumptions regarding sediment spill and sediment spreading for the EIA for the Danish part of the pipeline were conservative (i.e. on the safe side).

## 1.5 Monitoring of hydrographic conditions in the Bornholm Basin

Monitoring of hydrographic conditions in the Bornholm Basin was undertaken in January 2010 and ended in January 2011. The purpose of the hydrographic monitoring programme in Danish and Swedish waters was to establish documentation for the theoretical analysis of the possible blocking of the water inflow to the Baltic Sea caused by the presence of the Nord Stream Pipeline.

Oceanographic measurements (velocity, temperature, salinity) were carried out initially during a period of 9 months (including approximately 1 month down period) at KP 1036 northeast of

Bornholm at a water depth of approximately 90 m. In autumn 2010 the monitoring station was moved to KP 966 in order to also record measurements from shallower water depths (approximately 68 m).

In addition to the fixed station, line transects of currents have been carried out by ADCP. A total of 6 transects have been carried out.

The results of the monitoring were reported separately ultimo 2011 in /3/. It was concluded that the mixing caused by the pipelines in the Bornholm Basin will at most be 20% of the worst case estimations presented in /4/, and even these were well below any level of effect that could be measurable as being a result of the pipelines being established on the seabed.

### 1.6 Monitoring of cultural heritage

Monitoring of two wrecks located within 50 meters of the Nord Stream Pipeline is part of the Danish environmental monitoring programme. The wreck monitoring is carried out as visual inspection with ROV before and after pipeline installation. The purpose of the monitoring programme for cultural heritage is to document that cultural heritage sites under protection are not damaged or disturbed during the construction of the Nord Stream Pipeline and that the presence of the pipelines does not cause any erosion around protected wrecks.

Wreck monitoring after installation of the first pipeline and prior to Line 2 installation was conducted in January 2011. Post-lay wreck monitoring for the Line 2 installation is planned to be carried out in summer 2012 and hence no results are available at present time (spring 2012). Comparison of the wreck condition before and after Line 2 installation will be made after the post-lay monitoring and will be presented in the monitoring report for 2012.

Monitoring will be carried out again in 2014 and 2016 to check that no erosion has taken place around the wrecks as a result of the pipelines being present on the seabed. Erosion patterns may be altered slightly due to local changes in the current in the areas where the pipelines are placed directly on the seabed.

Detailed surveys have led to the discovery of a number of wrecks and cultural heritage sites east and south of Bornholm. On behalf of the Heritage Agency of Denmark the Viking Ship Museum have assessed the sites and it has been agreed with the Heritage Agency that protection zones of 200 m should be established around 27 cultural heritage locations during pipeline installation in Danish waters. In summer 2011, prior to installation of Line 2, Nord Stream however agreed with the Viking Ship Museum/Heritage Agency of Denmark to investigate the positions of protected wreck sites, in order for the Viking Ship Museum to perform an assessment of the wreck locations.

The investigations commenced in July 2011, when Marin Mätteknik AB performed a survey of the wreck locations. The survey included a ROV-based multibeam survey and ROV video inspection. The result of the investigations and assessment from the Viking Ship Museum was that 10 exclusion zones were removed and a few were reduced in size from a 200 m radius to a 100 m radius. The remaining exclusion zones were established and respected during the installation of Line 2 in Danish waters.

## 1.7 Monitoring of munitions

Detailed munitions surveys have led to the discovery of five chemical munitions objects east of Bornholm. The Admiral Danish Fleet have assessed these objects and it has been agreed with the Admiral Danish Fleet that the chemical munitions are to be left on the seabed and not disturbed during installation of the Nord Stream Pipeline. During installation of both Line 1 and 2 this was ensured by using a controlled pipe-lay with ROV monitoring.

As part of the environmental monitoring programme, monitoring of chemical munitions has been included. The munitions monitoring is being carried out by visual inspection using an ROV before and after pipeline installation. The inspections serve to enable an evaluation of any disturbance, which may have occurred to the chemical munitions objects during pipeline installation.

Munitions monitoring after installation of the first pipeline, and prior to Line 2 installation, was conducted in January 2011. The post lay monitoring of munitions in Denmark for Line 2 is planned to be conducted in summer 2012, and hence no results are available at present time (spring 2012). Comparison of the munitions conditions before and after Line 2 installation will be made after the post-lay monitoring and will be presented in the monitoring report for 2012.

During the pre-lay survey for Nord Stream Line 2 (autumn 2011) and a survey carried out for wreck inspections in summer 2011, two additional chemical munitions objects were found in Danish waters. The two object finds have been reported to the Admiral Danish Fleet and will be included in the remaining monitoring work Nord Stream is conducting.

In compliance with the Danish permit requirements /5/, safety precautions and emergency plans for handling of chemical munitions have been followed during installation of Line 1 and 2 in Danish waters. Accordingly, the Admiral Danish Fleet has been onboard the laying vessel during the entire pipeline installation in Danish waters from October to November 2011, and onboard the plough support vessel in February 2011. They have assisted with detection of chemical warfare agents and cleaning in connection with cable crossings, recoveries of the pipeline due to rough weather and ploughing operation.

## 1.8 Monitoring of chemical warfare agents (CWA) in sediment

As part of the monitoring programme for Danish waters a programme for chemical warfare agents (CWA) has been developed. The monitoring programme includes monitoring in 2008 and 2010 – 2012 with monitoring in 2008 and 2010 as baseline. Monitoring of CWA is conducted with the overall objective to enable assessments of impacts on changes in the risk due to CWA in the seabed due to Nord Stream Pipeline construction work. Monitoring is focused on impacts from trenching as this is the activity which is assessed to have the greatest impact on the seabed environment and thereby the greatest potential for disturbing buried CWA residues.

The survey in 2011 was confined to 23 stations distributed over the total length of the pipelines and five transects each with 15 sampling stations. The transects were located perpendicular to the pipelines, three of them on sections where the pipelines are trenched into the seabed. The sampling programme ended up covering 98 sample stations.

In all of the samples analysed no intact warfare agents, i.e. sulphur mustard (the so-called mustard gas) (H), Adamsite (DM), Clark I (DA), α-chloroacetophenone (CN), Tabun (GA), were found. Degradation products were found in 10 of the 98 samples. Altogether degradation products from 5 of the 10 intact chemical warfare agents were found. In some of the 10 samples more than one degradation product was found. Degradation product of Adamsite (DM), Clark I (DA), Lewisite II - L2, phenyldichloroarsine (PDCA) and a degradation product Trichloroarsine (TCA) were detected.

In 2008 degradation products were found in 8 samples (0.08%), in 2010 only in 2 samples (0.02%), and in 2011 in 10 samples (0.1%). However, when comparing the results it must be noted that the limits of quantification were generally higher in 2010 and the reporting units differed from 2008 to 2010 and 2011 . The highest concentration found in any sample is 330 µg/kg dw found in 2011, which in general means that the CWAs have only been found in rather low concentrations in the sediments. In 2008 and 2010 the highest concentration found was 310 µg/kg dw and 200 µg/kg dw, respectively. This shows that there was no major difference in concentrations between the different years.

In the Danish EIA it was concluded that the increase in concentrations of chemical warfare agents in the water environment from sediment disturbance during construction works on the seabed, and thereby the risk of impacts on the fish community from CWA, will be insignificant /6/.

In the assessment the risk to the fish community is defined by the risk quotient (RQ = PEC/HC5), and as long as the RQ is below 1, no effect to the exposed fish community is expected. Based on stations with content of CWA residues in the sediment, the calculated total added CWA risk from suspended sediment with CWA residues during installation of the pipeline was calculated to be highest at station CWA 10.45 and CWA 11.60, both with RQ=0.003, i.e. significantly below 1 /7/.

Comparing the sampling rounds (2008; 2010 and 2011) suggest that the detection frequencies and levels of CWA residues are comparable between the years, and that the potential CWA-related risks towards the fish and benthic communities are also comparable and low.

The survey in 2012 is planned to take place in June/July. The 2012 survey will be performed using the same procedures as in the 2011 survey.

## 1.9 Monitoring of other parameters

**Cable crossings**
Monitoring in relation to cable crossings for Line 1 and Line 2 was finalised in 2010 and reported in /8/.

**National and international monitoring stations**
Monitoring in relation to national and international monitoring stations was finalised in 2010 and reported in /9/ and /8/.

**Maritime traffic**
Almost all types of construction activities which are planned within the Nord Stream Project in Danish waters have already been carried out several times during 2010 and 2011 . Precautionary

safety measures have been successfully implemented and the construction activities have all been performed without any accidents with third party vessels.

# 2 Introduction

Nord Stream is an offshore natural gas pipeline from Russia to Germany. The Nord Stream Pipeline will connect the large natural gas resources of Russia with the European natural gas pipeline network. At full capacity, it will provide 55 billion cubic metres (bcm) of natural gas per year to European consumers.

The length of the entire two-pipeline system ('the Nord Stream Pipeline') is approximately 1,224 km. The pipeline crosses the exclusive economic zones (EEZ) of Russia, Finland, Sweden, Denmark and Germany, and territorial waters (TW) of Russia, Denmark and Germany. The construction of the first pipeline was commenced in April 2010, and was completed in 2011. The second pipeline is planned to be completed in 2012. The Nord Stream Pipeline is designed to operate for 50 years.

## 2.1 Construction permit and conditions for environmental monitoring

Nord Stream AG has applied by letter of 3 March 2009 to the Danish Energy Agency (DEA) for permission to construct two parallel natural gas pipelines in Danish sea area in the Baltic Sea east and south of Bornholm.

The permit for construction including installation of the natural gas pipelines in Danish sea area was given by DEA on 27 October 2009. The permit is issued in accordance with the Continental Shelf Act, cf. Consolidated Act no. 1101 of 18 November 2005, as amended by Act no. 548 of 6 June 2007 and Act no. 1400 of 27 December 2008, the State Sovereignty over territorial waters, as well as Executive Order no. 361 of 25 April 2006 on certain pipeline installations for transport of hydrocarbons in territorial waters and on the continental shelf.

The permit is based on the following conditions regarding monitoring which are stated in the permit /5/ conditions nos. 4-6:

4. *Nord Stream AG must prepare a monitoring programme for the construction phase, including pipeline installation on the seabed. The monitoring programme must encompass environmental conditions and be approved by the authorities before pipeline installation on the seabed.*
5. *Nord Stream AG must prepare a monitoring programme for the operational phase. The monitoring programme must encompass the environmental conditions and be approved by the authorities before pipeline commissioning.*
6. *Nord Stream AG must prepare a monitoring programme for the operational phase. The monitoring programme must encompass the safety conditions. The monitoring programme must be approved by the Danish Energy Agency before pipeline commissioning.*

The environmental monitoring programme for both the construction and the operational phase, referred to in permit conditions 4 and 5, was discussed and agreed with Danish authorities ahead of commencement of construction works. This report includes the initial results from those agreed monitoring activities. The monitoring referred to in permit condition 6 relates to operational control

and maintenance during the operational phase. These topics are not addressed in this report, but they are important parts of the application for the operation permit for Line 1, which Nord Stream filed to the Danish Energy Agency in March 2011.

Nord Stream AG must apply to DEA for an operation permit before the pipelines are taken into operation, ref § 2 of Executive Order no. 361 of 25 April 2006 on certain pipeline installations for transport of hydrocarbons in territorial waters and on the continental shelf. The permit to operate Line 1 was granted in July 2011.

## 2.2 Environmental monitoring within the Danish territorial water and EEZ

To accommodate the conditions laid out in the construction permit, a programme for environmental monitoring within Danish waters was compiled by Nord Stream in collaboration with the Danish authorities. The environmental monitoring programme was presented to, and discussed with the Danish authorities at a meeting held on 9 February 2010.

The environmental monitoring programme comprises the following documents:

- Ramboll O&G/Nord Stream AG. Environmental Monitoring Programme Denmark. G-PE-EMS-MON-100-05110000-C /10/.
- Ramboll O&G/Nord Stream AG. Scope of Work for Monitoring of Mobilised Sediments during Construction in Danish waters. G-PE-EMS-MON-100-05120000-C /11/
- Ramboll O&G/Nord Stream AG. Scope of Work for Visual Monitoring of Munitions and Cultural Heritage in Danish waters. G-PE-EMS-MON-100-05130000-C /12/
- Ramboll O&G/Nord Stream AG. Scope of Work for Monitoring of Seabed Sediments, Benthic Fauna and Demersal Fish in Danish waters. G-PE-EMS-MON-100-05140000-C /13/
- Ramboll O&G/Nord Stream AG. Hydrographic Effects: Deep Water Inflow in the Bornholm Basin (Danish EEZ). 15.03.2010. G-PE-PER-REP-000-HydrogSE-B /14/.
- Ramboll O&G/Nord Stream AG. Monitoring Stations in Danish Waters. G-PE-EMS-MON-100-05160000-C /15/.

In the Danish Environmental Impact Assessment /16/ all potential impacts from construction and operation of the Nord Stream Pipeline were assessed to be minor. Consequently, monitoring would not necessarily be required, but it is considered important to employ additional effort to validate the accuracy of the impact assessment on certain fit-for-purpose activities and to achieve the main monitoring objectives for the project.

In order to measure the effectiveness of the monitoring and mitigation measures, relevant receptors and indicators identified within the monitoring programme are characterised by the following:

- Low natural variability and broad applicability;

- Measurable; and
- Appropriate to the scale of impact, the impact mechanism as well as to temporal and spatial dynamics.

Monitoring of potential environmental factors and related impacts considers:

- Emission intensity; and
- Sensitivity of the receptor and conservation value.

A project-based concept in relation to overall oceanography follows the evaluation of potential environmental impacts with consideration to the following:

- Focus on shallow waters providing habitats for conservation objectives;
- A general approach to potential impact areas for waters between 80 m and 30 m water depth; and
- No biological investigations below the halocline at 80 m water depth if alternative options are available, in view of the anoxic conditions at these depths.

Nord Stream's environmental monitoring in Danish waters therefore varies in spatial range, temporal frequency and duration, depending on the nature of the parameters monitored and in accordance with the potential impacts predicted and in relation to potential receptors. According to local variations in environment and construction works, certain investigations are conducted only at selected sites.

The environmental and socioeconomic monitoring comprises the following main objectives:

*Change monitoring:* to detect environmental changes that may have occurred as a result of project implementation. This includes monitoring undertaken before construction (baseline monitoring), during construction (not necessarily in direct connection to construction activities in a specific area) and during the first years of operation (post-construction).

*Compliance monitoring:* periodic sampling or continuous recording of specific environmental and social quality indicators for a defined purpose to ensure project compliance.

*Pro-active monitoring*: timely routine and periodic checks by observation, measurement and evaluation for a defined purpose, which includes corrective action.

### 2.2.1 Construction and environmental control

Besides the additional environmental monitoring, which comes as a result of permit conditions and authority discussions, and which is the focus of this report, Nord Stream also has its own overall system in place to manage and control all aspects of environmental relevance of the project. This control structure is called the Environmental and Social Management System (ESMS). To a large extent, the ESMS is guided by the findings and recommendations of the National Environmental Impact Assessments (EIAs), Environmental Studies (ESs), and the Espoo Report, as well as EU EIA directive requirements, lenders' requirements and requirements of the relevant authorities. The purpose of the ESMS is as follows:

- Establish a framework for implementation of mitigation and management measures and to monitor the effectiveness of those measures
- Provide assurance to authorities and other stakeholders that their requirements will be met, with respect to environmental and social performance
- Provide for the implementation of corrective measures where required
- Establish a framework for performance monitoring to enable Nord Stream to ensure that its commitments and policies are met, with respect to environmental and social performance

A number of management plans have been designed to structure the requirements for the different construction activities and/or areas. Each management plan provides detailed information, requirements and minimum environmental standards relating to either a specific construction activity (e.g. seabed intervention) or an environmental/social issue (e.g. waste management). Thus the environmental and social management as well as mitigation and monitoring actions to be undertaken by Nord Stream and its contractors are clearly stated, the roles defined and adherence easily ensured. Nord Stream has also prepared bridging documentation to align the contractor's management system with that of Nord Stream.

Contractor compliance, of both documentation and the work itself, is further controlled and supervised by a number of internationally renowned independent environmental and technical consultants (such as Det Norske Veritas, Global Maritime and Environ). These companies have provided support in ensuring that the contractors have followed and implemented Nord Stream's obligations and commitments as appropriate, and as described in the management plans, during the first year of construction. The contractor's compliance with the defined procedures has been carefully monitored through offshore inspections and reporting throughout the construction phase, for example through vessel safety audits by a marine warranty surveyor prior to mobilisation and periodical on-site environmental and safety inspections by an environment, health and safety representative.

## 2.3 Purpose of the document and reading instructions

This document provides an overview of all environmental and socioeconomic monitoring activities carried out by Nord Stream in 2011 in Danish TW and EEZ. It is the second of the planned annual reports with the purpose to document the status and the results of the monitoring activities in Danish waters and if necessary recommend appropriate adjustments to the monitoring scope. The reports will be submitted each year and cover all activities undertaken the previous year. The monitoring programme for the Danish EEZ covers activities from 2010-2016.

The document starts with a description in Chapter 3 of all construction activities undertaken in 2010. In Chapter 4, the status of the monitoring of the environmental parameters is described followed by status of the monitoring of socioeconomic parameters in Chapter 5. A comparison with the results of the monitoring and the assessments made in the Environmental Impact Assessment is presented in Chapter 6, followed by conclusions and recommendations in Chapter 7.

The monitoring activities that have required more detailed studies and/or field studies have been divided into seven different modules:

- Monitoring of fish along the pipeline (reef effect)
- Monitoring of benthic fauna
- Monitoring of water quality
- Monitoring of hydrographic conditions in the Bornholm Basin
- Monitoring of cultural heritage
- Monitoring of munitions
- Monitoring of chemical warfare agents (CWA) in the sediment

A brief presentation of the status of each module is given in this main report along with the overall results in Chapter 4 and 5. The module reports are based on reports elaborated by the companies that have undertaken the actual monitoring tasks. Each task has been tendered in fair competition among the most respected and competent specialist companies in the region with in-depth knowledge of the specific conditions governing the natural environment in the Baltic Sea.

# 3 Construction activities in 2011

Construction in 2011 in Danish waters commenced on 8 February with post-lay trenching of the laid pipeline and was followed by installation of cable crossing mattresses and pipe-laying. On 15 October 2011 the vessel Castoro Sei (C6) started laying the second (southeast) pipeline in Danish waters south of Bornholm at KP (kilometre point) 1142 (coming from Germany). It continued to KP 1004 where it left Danish waters and entered Swedish waters on 22 November 2011.

The following chapters provide further information on the completed construction activities during 2011 in the Danish EEZ which included:

- Cable crossing (mattress installations)
- Pipeline installation, KP 1142 to KP 1004
- Post-lay trenching

## 3.1 Cable crossing (mattress installation)

Construction of the pipelines necessitates the crossing of several cables. These cables are used mainly for telecommunications and electric power transmission.

Prior to construction, Nord Stream AG approached the owners of the active cables in order to reach mutual agreements concerning rights and obligations, crossing procedures etc. Prior to concluding the agreements, Nord Stream AG provided crossing designs and installation procedure information.

The design of each crossing takes into consideration the specific locations of the cables including crossing angle and cable burial depth. The data is based on collated data from the side-scan sonar, towed magnetometer, sub-bottom profile and gradiometer surveys conducted within the installation corridor.

Flexible concrete mattresses have been selected for placement over the cables at the crossing locations to increase the bending radius imposed on the cables and to ensure a permanent vertical separation between the pipeline and the cables. In cases where the cables have been buried at a lesser depth, neoprene pads have been added to the lower surface of the mattresses. For some crossings, concrete beam mattresses have been selected for placement under the pipelines at locations adjacent to the crossing locations to provide additional bearing support thereby reducing the load on the cables at the crossing locations.

Monitoring of the existing cables and the constructed crossings during 2011 was done by visual inspection using an ROV (remotely operated vehicle) to identify the target position and condition immediately prior to and after crossing installation. In doings so, the crossing point and the intended position of the mattresses were already verified during the mattress installation. After the installation, a general video inspection (GVI) was made of the crossing structure. In addition, the as-left crossing survey was done to confirm the position, alignment and status of the pipeline in relation to the cable crossing and mattresses.

In Danish waters three existing cables were crossed and mattresses where installed (Figure 3.1):

- Baltica Seg 1: Mattress installation on 01 June 2011 (crossed: 30 October 2011)
- DK-RU1: Mattress installation on 30 May 2011 (crossed: 30 October 2011)
- DK-PL2: Mattress installation on 31 May 2011 (crossed: 19 November 2011).

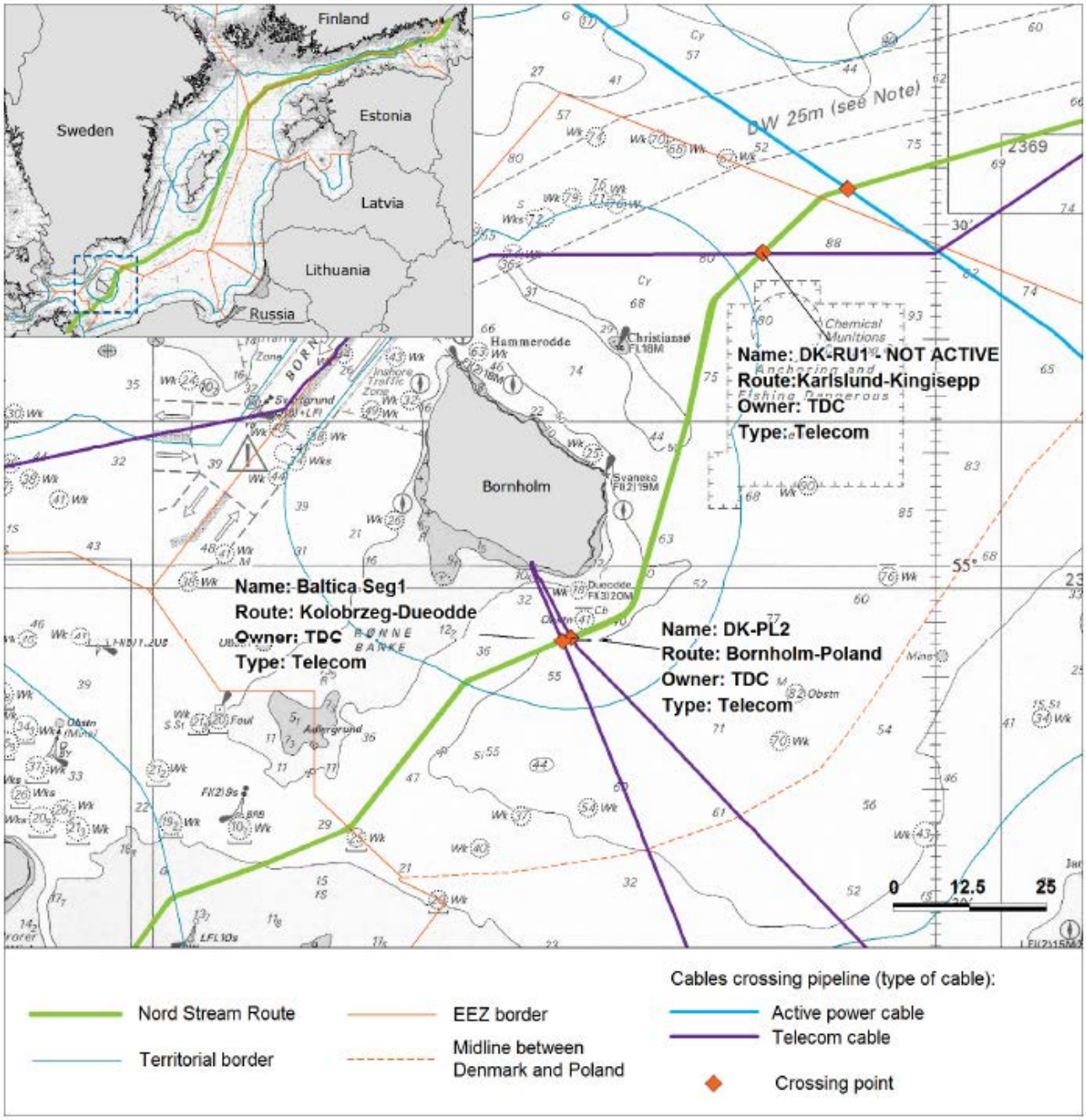


**Figure 3.1** Three cable crossings in Danish waters.

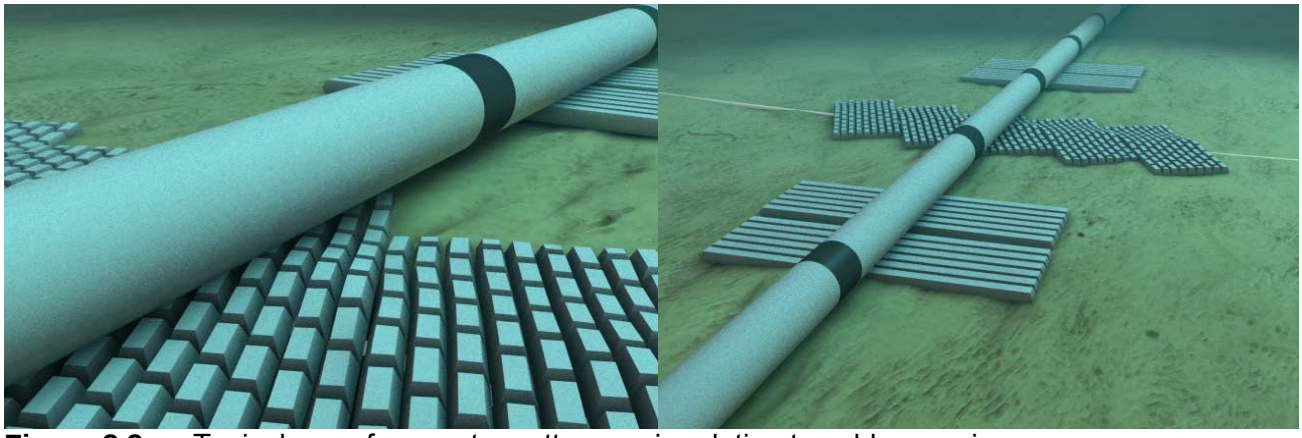

**Figure 3.2** Typical use of concrete mattresses in relation to cable crossings.

The number of mattresses to be used for the cable crossings has been defined on the basis of detailed engineering performed by Saipem Energy Services, previously Snamprogetti. Criteria for defining the initial crossing design were governed by the crossing angle and specific survey results detailing installed cable state of burial.

**Table 3.1** Use of concrete mattresses at cable crossings.

| Name | Route | Owner | Pipeline | Flexible mattresses | Beam mattresses |
|---|---|---|---|---|---|
| DK – PL2 | Bornholm (DEN – Poland (POL) | TDC | Line 1 | 3 | - |
| | | | Line 2 | 3 | - |
| Baltica Seg 1 | Bornholm (DEN) – Poland (POL) | Polish Telecom | Line 1 | 3 | 2 |
| | | | Line 2 | 3 | 2 |
| DK-RU1 | Denmark (DEN – Rusiia(RU) | TDC | Line 1 | 5 | - |
| | | | Line 2 | 5 | - |

### 3.1.1 Baltica Seg 1 cable monitoring

After pipeline installation, an as-left survey of the Baltica Seg 1 cable route was conducted to confirm the position, alignment and status of the cable, mattresses and pipeline.

All five mattresses at the Baltica Seg 1 crossing location showed degrees of settlement into the seabed. The three central mattresses appeared to have between 50% and 75% settlement into the seabed. The two outer mattresses appeared to have settled more significantly with between 75% and 100% settlement with silting observed on the southern extents of mattress 2. The settlement did not obscure positive identification of the mattress extents, observable by the white paint coating on the mattress corners.

The Line 2 (East) pipeline was observed to be well aligned on the mattresses over the cable crossing and the pipeline was installed within the +/- 2.5m installation corridor. The pipeline appeared to be supported by the mattress arrangements. This meant that there was no discernible lifting of the pipeline from the seabed by the mattresses and the pipeline appeared to be in contact with the seabed throughout the crossing.

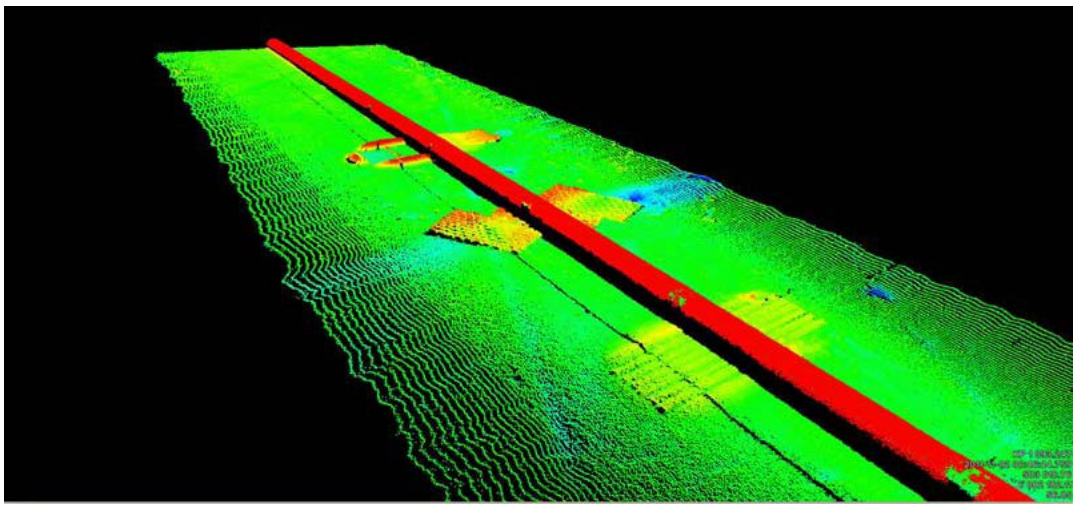

**Figure 3.3** Line 2 (east) - Baltica Seg 1 Cable Crossing Viewed from East

### 3.1.2 DK-PL2 cable monitoring

An as-left survey of the DK-Poland 2 cable route was conducted to cover the extents of the Castoro Sei anchor corridor.

All three mattresses at the DK-Poland 2 crossing location showed moderate settlement into the seabed with between 30% and 50% embedment. The southernmost corner of mattress 3 appears to be curled and buried into the seabed. The Line 2 pipeline was observed to be well aligned on the mattresses over the cable crossing and it was also confirmed that the pipeline was installed within the +/- 2.5m installation corridor. The pipeline appeared to be very well supported by the mattress arrangement and no discernible freespans occur.

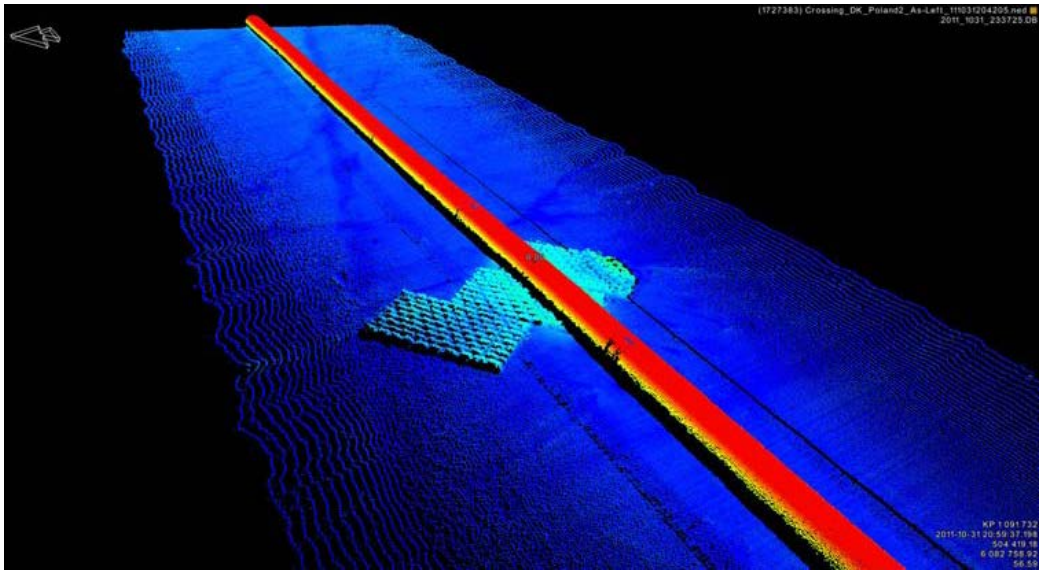

**Figure 3.4** Line 2 (east) - DK-Poland 2 Cable Crossing viewed from Southeast

### 3.1.3 DK-RU1 cable monitoring

An as-left survey of the DK-RU1 cable route was conducted to cover the extents of the Castoro Sei anchor corridor.

All five mattresses at the DK-RU1 crossing location showed settlement into the seabed with sediment occasionally preventing a positive identification of the mattress extents. The Line 2 (East) pipeline was observed to be well aligned on the mattresses over the cable crossing and within the +/- 2.5m installation corridor.

The pipeline was well supported by the mattress arrangements and no discernible freespans occur. No discernible freespans were evident throughout the crossing.

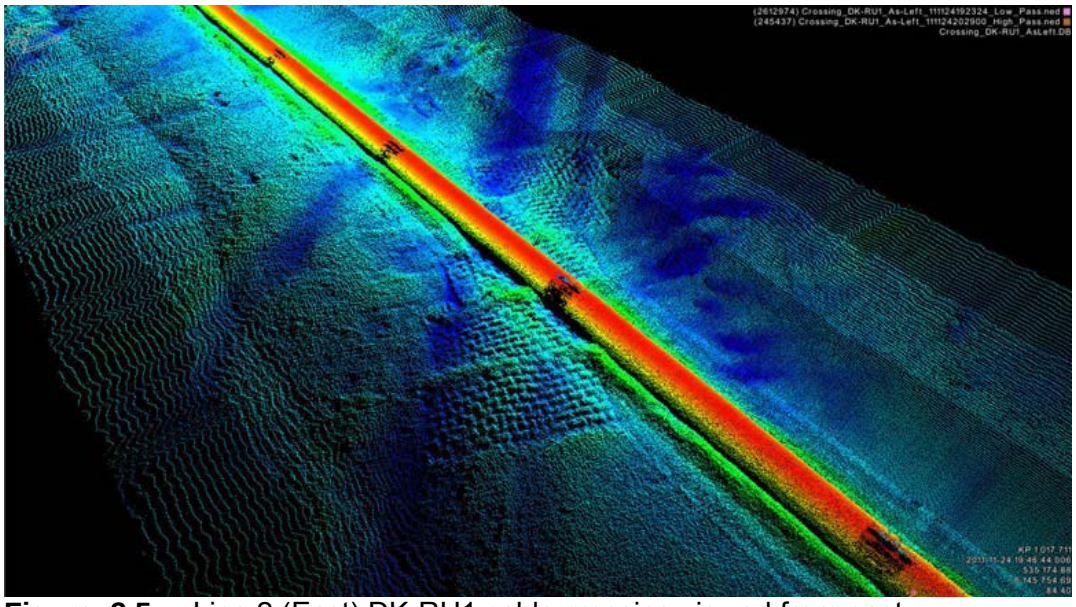

**Figure 3.5** Line 2 (East) DK-RU1 cable crossing viewed from east.

## 3.2 Pipe-lay, KP 1142 to KP 1004

Pipe-lay activities for Line 2 commenced in Danish waters on 15 October 2011. The work performance was satisfactory and in accordance with expectations. The pipe-lay from KP 1142 to KP 1004 was successfully completed on 22 November 2011 and the operations continued into Swedish EEZ.

The Castoro Sei pipe-lay vessel and its support vessels, namely the survey vessel, anchor handling tugs and supply vessel, are manned and equipped to lay pipe 24 hours a day, seven days a week. The operation on the pipe-lay vessel comprises several steps from loading the pipes onto the pipe-lay vessel to lowering the pipeline onto the seabed. There are exact procedures defined for each process to ensure consistent quality and compliance with health and safety regulations. On the Castoro Sei pipe-lay vessel, the process on board includes the following steps:

- Single pipe joint supply
- Single pipe joint storage on deck
- Activities in the double-joint Plant
    - Pipe joint bevelling
    - Double-joint welding
    - Double-joint inspection (non-destructive testing (NDT))
- Double-joint cleaning, pre-heating, and transfer to the firing line (main production line)
- Activities in the firing line
    - Double-joint alignment and welding to mainline
    - Field joint inspection (non-destructive testing (NDT))
    - Field joint coating (main line and double joint)
    - Field joint inspection
- Lay vessel move-up
- Pipeline advance to seabed.

During the performance of pipe-lay in Danish waters, the pipeline had to be laid and picked up again on a few occasions due to rough weather. This operation is called "Abandonment and Recovery" (A&R).

To enable the laying of the pipeline it has to be sealed watertight. This is achieved by welding a lay down head to the end of the pipe string in the firing line. This lay down head will be attached to the A&R wire and connected to the A&R winch at the top of the firing line. Then, the vessel will slowly move up while paying out A&R wire, thus allowing the pipe end to move through the firing line and down the stinger. The operation is monitored by ROV and tension is reduced until the A&R head touches down on the seabed. During recovery, the pipeline is pulled up on the wire, over the stinger, and into the firing line. Once it has moved past the first tensioner, all tensioners will be closed, and the tension will be transferred from the A&R cable to the tensioners. The A&R head and wire will be removed and normal pipe-laying continues.

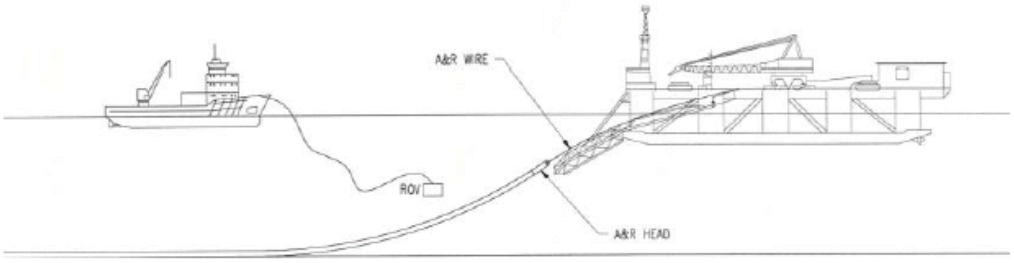


**Figure 3.6** Pipe-laying.

During pipe-lay Castoro Sei used 10-12 anchors to ensure the correct position of the barge. The anchors, which are moved by designated anchor handling vessels, are placed up to approximately 1000 metres from the pipeline alignment. A typical anchor pattern is outlined in Figure 3.7. Three anchor-handling vessels supported Castoro Sei during the construction works in Danish waters. Additionally, four pipe carriers provided the pipes for the lay vessel. Pipes were supplied from the

stockyard at Mukran in Germany to the lay barge. Supplies to the Castoro Sei were shipped from the supply base in Norrköping in Sweden.

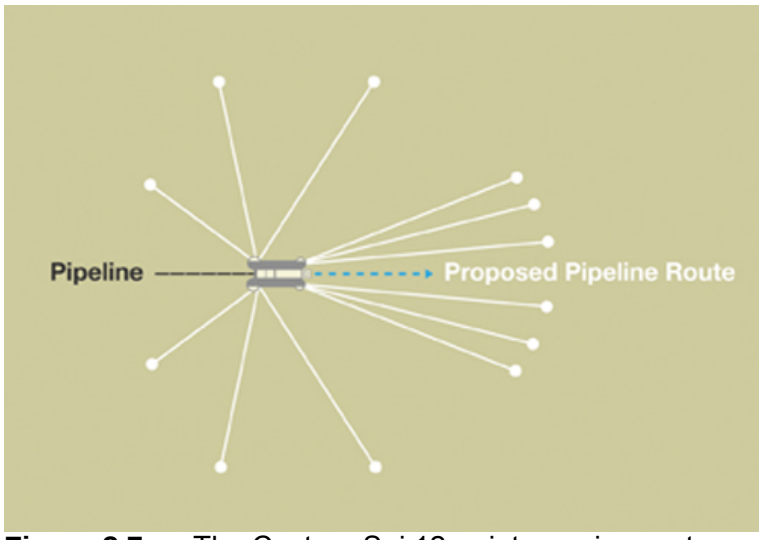


**Figure 3.7** The Castoro Sei 12-point mooring system.

During construction the Castoro Sei is normally positioned by means of a 12-point mooring system. This system enables it to maintain accurate positioning. Each of the 12 mooring lines, or anchor lines, is controlled by a tension winch weighing 124 tonnes. The vessel also features thrusters to further ensure precise positioning.

### 3.3 Post-lay trenching

According to the Danish Construction permit (ref 1110/8609-0002/003/004, 20 October 2009) and Technical Update document (ref G-PE-PER-REP-100-05150000, 23 June 2010) the Nord Stream Pipelines are to be trenched in two sections in Danish waters.

Trenching took place between 8 and 17 February 2011. Lowering of the pipeline onto the seabed using a plough ensures that the pipeline will remain stable in its position throughout its lifetime. Subsea ploughs work much in the same way as their land-based farming equivalents, except in this case the pipeline is passed through a pair of roller boxes in the body of the plough whilst the seabed is excavated as the plough advances. The PL3 plough raises the pipeline into its roller boxes using hydraulic grabs, and is then towed by the vessel Far Samson, creating a trench of pre-determined length, depth and width into which the pipeline is laid as the plough progresses. Natural sediment movements from waves and currents will gradually backfill the ploughed trench. The PL3 plough used for the Nord Stream pipeline was towed by purpose-built vessel Far Samson. The Far Samson has a hybrid propulsion system and is extremely fuel efficient; its generator engines are equipped with catalytic converters which result in 95 percent $NO_X$ reduction.

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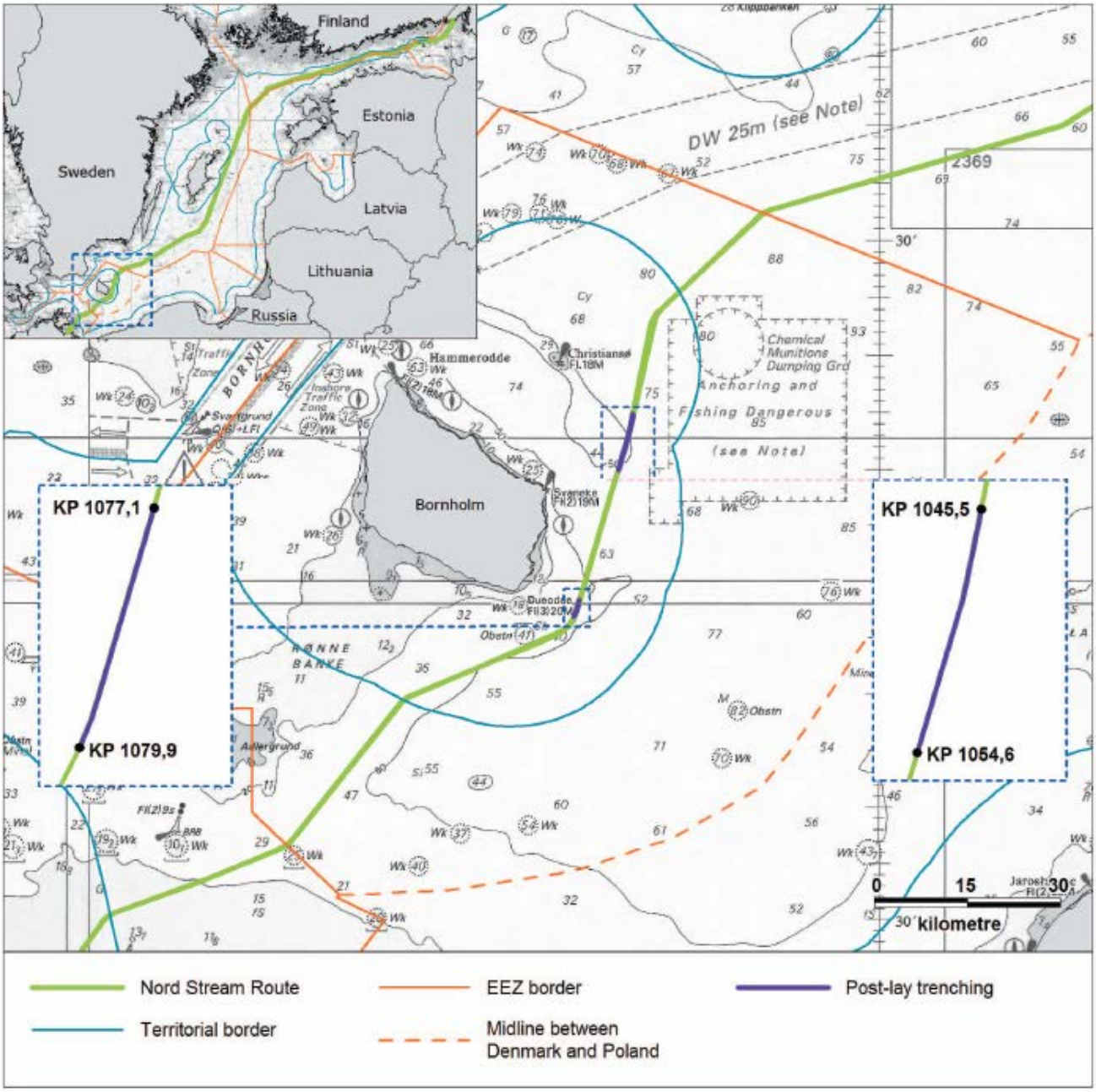


**Figure 3.8** Sections with post-lay trenching in Denmark.

The trenching in general went well and nothing unforeseen happened, however the check on trench depth immediately showed that there was a section where the pipe remained exposed due to hard soil. Since it was deemed unfeasible to perform a second pass with the plough, one section in the trenched area, KP 1078.6 to KP 1079.4, required rock placement intervention. All other sections in Denmark including those outside the ploughed zones were accepted without need for additional intervention works.

### 3.4 Post-lay rock placement

The term 'rock placement' covers gravel works where coarse gravel and small stones are placed to locally reshape the seabed to ensure the long-term integrity of the pipeline.

Gravel and stones are transported by ship to each particular position where rock placement is required. The rock material is loaded into the fall pipe by conveyors on the ship. The rock material falls through the water column in the fall pipe. The geometry of each gravel support has been designed by the engineers according to seabed conditions, bathymetry in the surroundings, currents, etc. The lowest part of the fall pipe is equipped with nozzles to allow a very precise shaping of each gravel support. The rock placement process is supervised by an ROV and the final geometry is controlled by surveying.

Subsea rock installation was executed by a Dynamically Positioned Fallpipe Vessel (DPFV).

A Dynamically Positioned Fallpipe Vessel is a seagoing self-propelled vessel with a fallpipe, designed to be lowered underneath the vessel. At the lower end of the fallpipe a ROV is installed. By a so-called dynamic positioning system, the vessel can stay in exact position or be guided along a predefined track. Installation through the fallpipe system makes it possible to place the rock in a controlled manner.

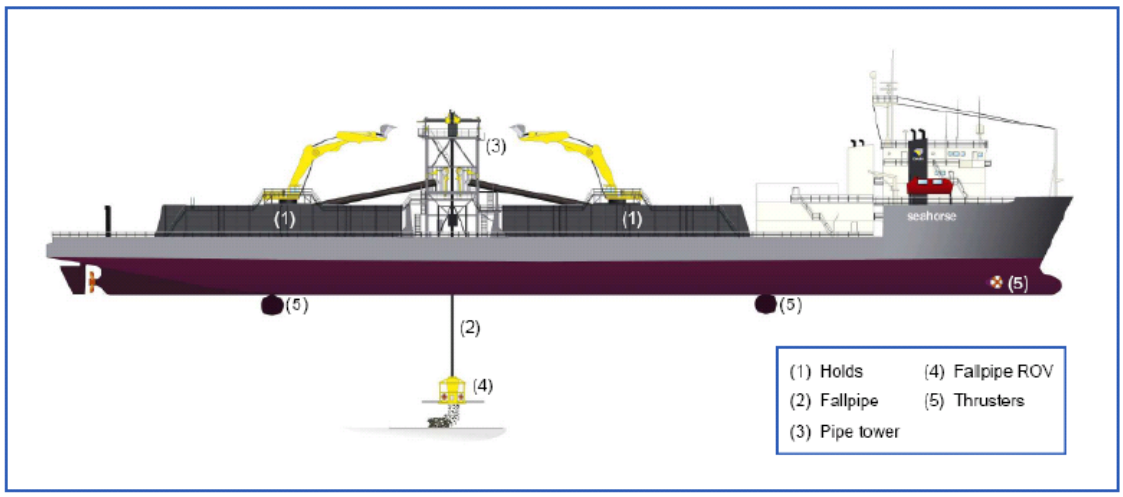


**Figure 3.9** The DPFV Seahorse

Since it was deemed unfeasible to achieve necessary stability through embedment with the plough, one section, KP 1078.6 to KP 1079.4, required rock placement intervention. The DPFV Simon Stevin performed rock placement activities in Danish sector on 28-29 August 2011 in accordance with the approval from the Danish Energy Agency.

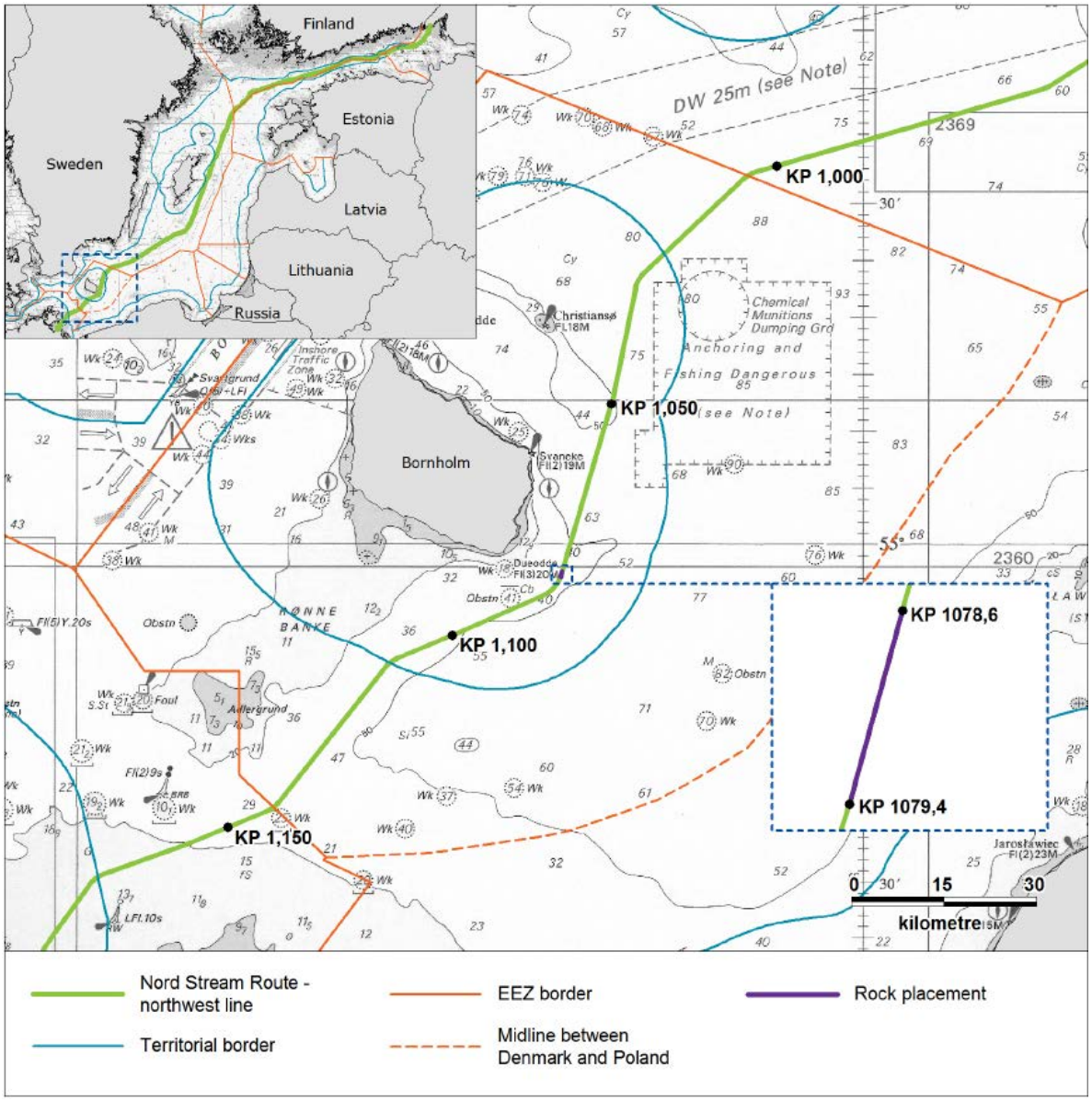


**Figure 3.10** Section with post-lay rock placement in Denmark.

## 3.5 Assistance from ADF/Bornholm Marine District and DEMA

Maritime Surveillance Centre South (MSCS) is responsible for two main areas: Ship traffic surveillance and EOD (Explosive Ordnance Disposal) tasks. The EOD team comprises nine people and is the unit handling chemical warfare agents (CWA) finds in the Baltic Sea. They have a 24-hour call service, with three people on duty, ready to act in case of an emergency related to CWA chance finds.

Upon specific request, MSCS agreed to assist Nord Stream in the vicinity of the known chemical munitions areas. As a preventive measure MSCS mobilised its munitions team and brought the

team on board Nord Stream's operative units during the period of pipe lay in Danish waters with the aim of assisting Nord Stream with visual inspection, consultancy and tracing of chemical munitions.

MSCS assisted Nord Stream during pipe lay in Danish waters by being present on the lay barge and anchor handling tugs. MSCS paid extra attention to the following events:

- Pipe lay activities
  - Three cables were crossed in the Danish section. The anchors are brought on deck when a cable is crossed to avoid potential damage of the cable by anchor-cable interaction.
  - The pipe had to be "abandoned" on the seabed on a few occasions (due to rough weather) and then had to be recovered back onto the vessel from the seabed. The procedures for detection and cleaning were to wash down the pipe head and stinger thoroughly and check for traces of warfare agents with detection powder or paper.
- Seabed intervention work (post-lay trenching by ploughing)
  - Two sections of the pipeline were ploughed in Danish waters. The ploughing sections were approximately 3 km and 9 km. Nord Stream considered it necessary to have MSCS onboard the tow vessel during these operations as the plough is brought up onto the vessel's deck after each section is ploughed, thus having been in contact with the seabed.
  - The following procedure was taken in action for cleaning of the plough: after ploughing of the first section (southern section) was completed the plough was recovered and washed thoroughly. When ploughing of the second section was completed the plough was brought to a sheltered place where DEMA (Danish Emergency Management Agency) performed a full cleaning of the plough before it left Danish waters for further work in Sweden.

No chemical warfare agents were detected under any of the construction works performed in Danish waters.

# 4 Environmental monitoring within the Danish territorial water and EEZ

This chapter briefly presents the environmental monitoring programme in Danish water and lists the monitoring activities undertaken in 2011.

## 4.1 Monitoring of fish along pipeline

### 4.1.1 Monitoring programme, purpose and period of monitoring

The monitoring programme for fish along the pipeline is described in /10/ and /13/, and is designed in alignment with a similar programme for the Swedish sector. The programme will be carried out before and after the establishment of the Nord Stream Pipeline.

The purpose of the monitoring module of fish along the pipelines is to evaluate and document the qualitative and if possible the quantitative changes in the demersal fish communities in the area adjacent to the Nord Stream Pipeline, compared to the fish community of the surrounding seabed.

The aim of the monitoring programme is to investigate whether the presence of the pipelines lead to a so-called "reef effect"[1] and to determine the extent of changes in fish abundance and composition of species.

Fish monitoring is carried out at the following types of locations:

- Where the pipelines are established directly on the seabed
- Where trenching is carried out
- In five hotspot areas (identified by Danish fishermen)
- At four reference locations ≥1 km from the pipelines.

Table 4.1 and Figure 4.1 show the locations of the fish monitoring areas. Investigations are undertaken in 9 areas (including reference areas/stations). Monitoring of fish along the pipeline will be undertaken once per year in September/October in the years 2010-2014.

**Table 4.1** Monitoring areas for monitoring of fish along the pipeline in Denmark. The hotspot zones refer to areas of intensive bottom trawling.

| Areas investigated | KP points |
|---|---|
| Pipelines laid directly on seabed | 1010, 1120 |
| Pipelines laid directly on seabed (hotspot) | 1046, 1056, 1070, 1100, 1106 |
| Pipelines trenched into the seabed by post-lay trenching | 1050, 1078 |
| Reference stations | 1 km west of:<br>KP 1010, KP 1120, KP 1050, KP 1078 |

[1] The hard structure of the pipeline creating new reef-like habitats.

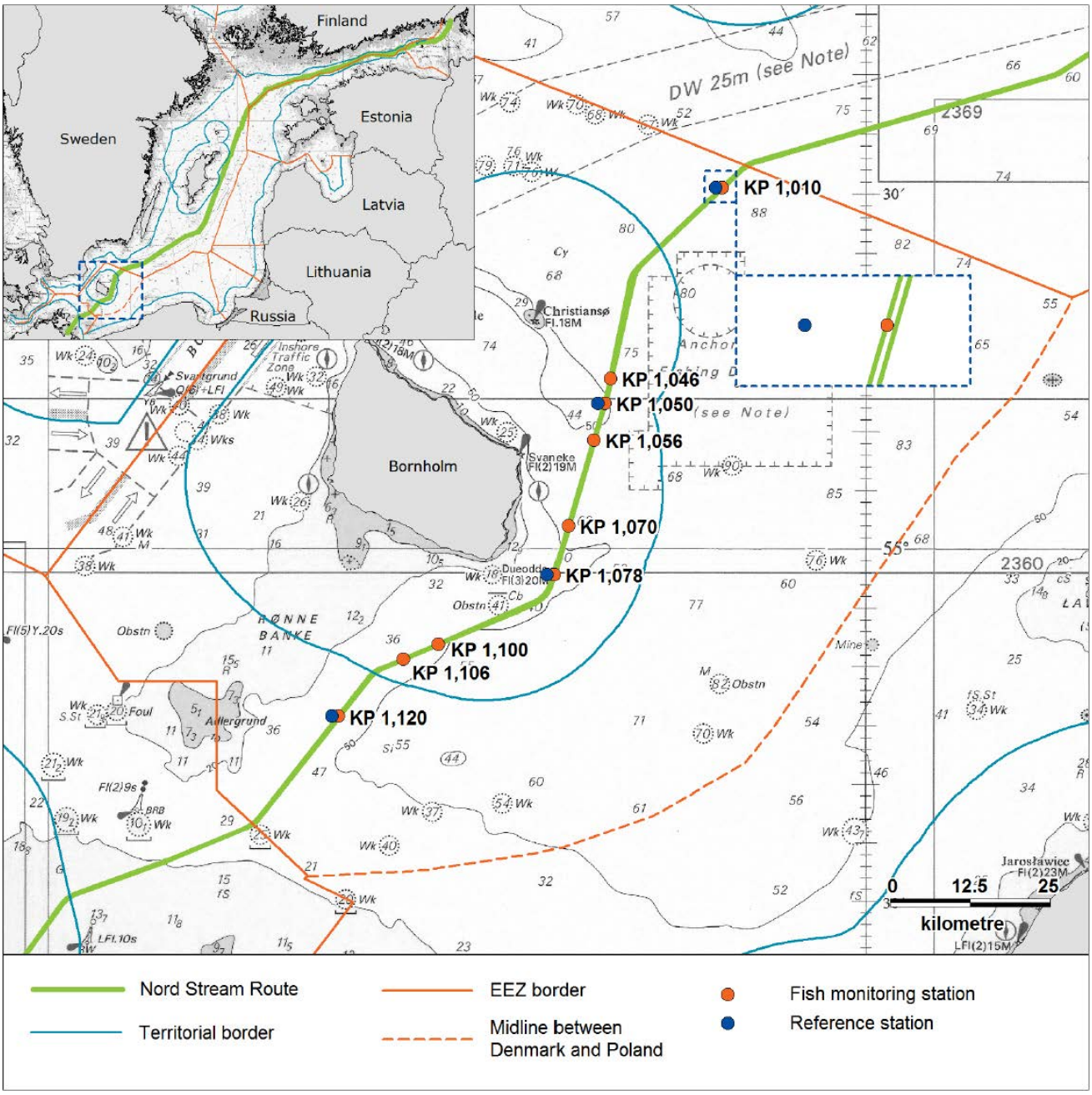


**Figure 4.1** Areas for monitoring of fish along the pipeline in Denmark.

The monitoring of fish at and in the immediate vicinity of the pipelines is focused on demersal fish species, as no effects from the presence of the pipelines on the seabed are expected for pelagic fish species. In addition to survey trawl fishery (TV3-520 trawl) and gill net fishery (gill net type K072), echo-sounder measurements area also carried out.

A summary of the monitoring programme for fish in Denmark is presented in Table 4.2.

**Table 4.2** Summary of the monitoring programme for fish fauna along the pipeline in Denmark.

| Fish in Denmark | |
|---|---|
| **Monitoring of fish fauna along the pipeline** | |
| Purpose | To evaluate and document the qualitative and if possible the quantitative changes in the fish community in the area adjacent to the Nord Stream Pipeline |
| Area to be monitored | At nine locations plus four reference locations along the pipeline inside the Danish sector |
| Activity to be monitored | Two stations at trenched section, two stations at section with pipeline on seabed, five stations at section with intense trawling activity and four reference stations |
| Method to be used | Fish investigations by survey trawl (TV-3 trawl), echosounder measurements and CTDO profiles inside trawled sections |
| Period of monitoring | September 2010-2014. If the preliminary results from the monitoring show that the impact is insignificant or negligible, suggested changes for subsequent monitoring activities are reported to the relevant authorities |
| Results | Documentation of changes in fish fauna along the pipelines compared with seabed without pipelines |

### 4.1.2 Monitoring and results for 2011

In order to avoid the impact of seasonal variations in the results, the goal is to complete the fish survey during the same period each year. The baseline study was conducted in October and November 2010 and the survey in 2011 was conducted during September. The monitoring locations and sampling methods are listed in Table 4.3. The survey at each station included CTDO-measurements, Secchi depth measurements, echo-sounder measurements and fish sampling (trawl or gill net).

**Table 4.3** Locations of fish monitoring areas (locations can be seen in Figure 4.1 ).

| Location | Depth | Sediment | Sampling method | Replicates |
|---|---|---|---|---|
| KP 1010 + Reference | 69 - 78 m | Very soft clay | Bottom trawl | 3 at both stations |
| KP 1046 | 86 - 89 m | Very soft clay | Bottom trawl | 3 |
| KP 1050 + Reference | 44 - 53 m | Coarse sediments | Gill net | 8 at both stations |
| KP 1056 | 62 - 67 m | Sand and fine silt | Bottom trawl | 3 |
| KP 1070 | 53 - 70 m | Very soft clay | Bottom trawl | 3 |
| KP 1078 + Reference | 39 - 44 m | Coarse sediments | Gill net | 8 at both stations |
| KP 1100 | 47 - 53 m | Silt and fine sand | Bottom trawl | 3 |
| KP 1106 | 42 - 45 m | Sand | Bottom trawl | 3 |
| KP 1120 + Reference | 42 - 45 m | Silt and fine sand | Bottom trawl | 3 at both stations |

The structure of the demersal fish assemblage obtained during 2011 within the studied locations was similar compared to the results from the baseline survey from 2010, and was strongly dominated by cod. The focus of the study has been on cod since it is a demersal fish species in the areas, and because the catches of cod were high throughout the entire sampling. The amount of cod was similar between the two surveys. Noticeable, in the three most southern locations, KP1100, KP1106 and KP1120 an evident increase in flat fish (flounder and plaice) was observed in 2011 compared to in 2010. Other demersal fish species, e.g. shorthorn sculpin, four bearded rockling, turbot and lumpfish were only documented sporadically and in low numbers. The dominant species

found during the baseline study and during the first investigation after the pipeline was established, are common in the Baltic Sea fish community.

The northern locations, where the depth ranged from 60 to 90 m (KP1010, KP1046, KP1056 and KP1070), were partly or totally affected of hypoxia. This provides inadequate conditions for assessment of any difference in composition of fish species or quantity of fish in relation to the establishment of the pipeline. In the remaining locations, KP1050, KP1078, KP1100, KP1106 and KP1120, the depth varied between approximately 40 to 50 m and the hydrographical conditions, that might affect the presence of demersal fish, were similar between surveys and no hypoxia was observed. This provides favourable conditions for evaluating temporal differences in the demersal fish community. Potential effects on the fish community or on the presence of fish are therefore more likely caused by natural variations than by the Nord Stream Pipeline. However, lack of individual and independent reference area for KP1100 and KP1106; preclude any conclusions regarding impact from the pipeline and only possible temporal variation can be documented.

To summarize, based on the results from the first survey after establishment of the Nord Stream Pipeline, temporal variations but no impact from the pipeline on fish composition or presence of cod was observed. There was also a temporal variation at the southern locations (KP1100, KP1106 and KP1120) and a tendency towards a reef effect at location KP1120 in regard to the presence of flat fish.

The results in the northern location KP1010 are strongly affected of hypoxia, resulting in low catches of fish and high variation between replicates. Hence, the collected data at location KP 1010 are less reliable for making conclusions regarding a reef effect from the pipeline. The low number of fish makes the results from length distributions and individual weight-length relationships also unreliable.

The assemblages of fish at the southern location 1120 were by far the most diverse, and cod and flat fish dominated the catches. The remaining demersal species were only found sporadically at the stations. Hydrographical conditions, that could have had an effect on the presence of demersal fish, were similar between the two years of surveys and between impact and reference areas and no hypoxia was observed. This provides favourable conditions to detect possible changes in the fish community in the impact area by comparing the fish community at the pipeline with the fish community on the surrounding seabed.

A significant difference in fish composition was observed between years but not between the impact and the reference station, indicating a temporal variation and no effect from the pipeline. Cod dominated the catches both years with more individuals in the impact area. Because there was no difference in biomass and abundance between treatments within year 2011, no effects on cod from the pipeline can be established.

Furthermore, there was no difference in shoals of fish from the echo-sounder investigation.

Somewhat larger individuals were observed during the survey in 2011 in both impact and reference area and individual body-weight at length had increased at the reference stations and decreased at the impact stations between years. An increase in number of plaice was noticed within both treatments (impact and reference) between years at location KP1120, indicating a temporal

variation. However, there was also a difference within year 2011 between impact and reference stations, with an increased number of plaice in the impact area, which could indicate an effect from the pipeline. Nevertheless, plaice is a species that is strongly associated to soft bottoms and a reef effect from the pipeline (artificial hard bottom) is less plausible.

At location KP1050, where the fish survey was conducted with gillnets at depths between 44 and 53 m, similar hydrographical conditions and no hypoxia was observed between the two years investigated. Cod dominated the catches and the remaining demersal species were only found in low numbers. Regarding fish composition there was a difference in both biomass and abundance between years. However, the fish assemblage was similar between impact and reference stations, indicating a temporal variation and no impact from the pipeline. Both abundance, biomass and length distribution of cod were similar between the years investigated. The individual body weight at length was somewhat higher at the impact stations compared with the reference stations within both years, indicating no impact from the pipeline.

At location KP1078, where fishing with gillnets was conducted at depths between 39 and 44 m, no difference in salinity, temperature and oxygen levels that could have an affect the demersal fish assemblage, was observed. There was a difference between years in fish assemblages regarding abundance but no difference between impact and reference stations. An increased number of the dominant species cod was noticed in 2011 compared to in 2010. However, there was no difference between impact and reference stations, indicating a temporal variation and no impact from the pipeline. The pattern in length distribution demonstrates presence of smaller individuals of cod during 2011 compared to 2010, which might explain the difference in abundance but not in biomass. The individual body weight at length was somewhat higher at the impact stations compared to the reference stations within both years. The result shows no impact from the pipeline at location KP1078.

At the locations KP1046, KP1056, KP1070, KP1100 and KP1106, no reference areas have been applied in the fish monitoring programme. Furthermore, there are only three replicates at each location. This complicates the evaluation of the results and potentially effects on the fish community from the pipeline. Due to the low numbers of replicates, as well as lack of reference areas, no multivariate statistics of difference in fish assemblages between years could be applied. However, possible temporal changes in abundance and biomass of the dominated species cod and flat fish were detected through the statistical ANOVA for each location separately. The statistical analyses resulted in no clear trend towards either increasing or decreasing abundance/biomass of cod at these locations. However, flat fish had increase at station KP1100 and KP1106 between the years investigated.

The depth intervals at the northern locations, KP1046, KP1056 and KP1070, are approximately between 60 and 90 m and the bottom water are partly affected by hypoxia. This provides bad conditions to evaluate possible temporal changes in biomass and abundance of fish species. However, at the two locations KP1100 and KP1106, the depth varied between 42 and 53 m and no hypoxia and similar hydrographical conditions in the bottom water was observed between years.

At location KP1046 extremely low levels of oxygen were observed at all stations (between 0.01 and 0.03 ml/l) in 2011, and not surprisingly the biomass and abundance of the dominant species cod had

decreased between years. However, no difference in number of shoals was observed from the echo-sounder investigation, showing presence of fish at approximately 30 m above the bottom, where oxygen levels were high. Hence, the low number of fish at the bottom is consequently a result of low oxygen levels. Due to low numbers of individuals of cod no comparison in length distribution and weight-length relationships between years was possible at KP1046.

At location KP1056 hypoxia was observed in 2011. However, the levels were close to 2 ml/l and no decrease in presence of cod or of shoals of fish between years were observed. The majority of the shoals of fish were observed at approximately 5 m above the bottom (at 60 m depth), where the oxygen levels were approximately 4 ml/l. The individuals of cod caught in the survey in 2011 were larger but had less individual body-weight at length.

At location KP1070 hypoxia was noticed at one of the stations in 2011. Furthermore, to be able to trawl in the immediate vicinity of the pipeline, the location KP1070 had to be trawled at different depths. In one of the stations this caused higher oxygen levels compared to remaining stations and hence, large catches of cod. Because of the high variations between replicates no difference in biomass and abundance of cod could be observed. The shallower haul also resulted in smaller individuals of cod with smaller individual body-weight at length. Furthermore, a relatively high number of whiting was noticed at the shallower station.

At location KP1100 no hypoxia was observed and the salinity and temperature were similar between years. Cod dominated the catches and flat fish increased in biomass and abundance between the years investigated. The individuals of cod were somewhat larger with smaller body-weight at length in the survey in 2011 compared to in 2010.

At location KP1106 no difference in the hydrographical conditions was observed between the years investigated. The abundance of plaice had increased in 2011 compared to in 2010, but the catches of the dominant species cod were similar. The length distribution of cod demonstrates smaller individuals with smaller individual body-weight at length during the survey in 2011 compared to in 2010.

The monitoring of fish in Danish waters along the Nord Stream Pipeline has only information from one year before the pipeline was established, which make it difficult to evaluate the natural variation in the data. Therefore, it is sometimes difficult to evaluate the cause to an observed difference in this study and to draw any long-term conclusion regarding impacts from the pipeline on the fish community. Nevertheless, it can be verified that the number of fish along the pipeline has not decreased in year 2011 compared to the baseline study in 2010.

The survey is planned to be repeated once a year also in 2012-2014 to further evaluate the impact of the presence of the pipeline.

## 4.2 Monitoring of benthic fauna

### 4.2.1 Monitoring programme, purpose and period of monitoring

The monitoring programme for benthic fauna to be undertaken once every year is described in /10/, /13/ and /17/. Monitoring of infauna will be carried out before and after establishment of the Nord

Stream Pipeline on the seabed, while monitoring of epifauna will start after the first pipeline has been installed on the seabed. Monitoring of the benthic fauna includes:

- Infauna investigations: Once per year in June/July from 2010-2013
- Epifauna investigations: Once per year in September/October from 2011-2014

The purpose of the monitoring programme for benthic fauna is:

- To evaluate and document re-colonization and recovery of the infauna changes around the pipelines after their installation
- To evaluate and document the establishment and growth of epifauna on the pipelines.

**Infauna**

The monitoring areas for benthic infauna are shown in Figure 4.2. The benthic infauna stations are located in areas where trenching is planned, and where the most pronounced effects from sediment dispersion and re-sedimentation due to trenching can be expected. The three planned benthic infauna transects (B10, B11, B29) are located perpendicular to the Nord Stream Pipeline. There are 15 stations at each transect. At each station three Van Veen grab samples are collected along with one core sample for analysis of physical and chemical properties of the seabed sediment.

A summary of the monitoring programme for infauna in Denmark is presented in Table 4.4.

**Table 4.4** Summary of the monitoring programme for infauna in Denmark.

| Benthic fauna in Denmark | |
|---|---|
| **Monitoring of infauna** | |
| Purpose | To evaluate and document effects on and recovery of the infauna |
| Area to be monitored | Three transects where post-lay trenching is carried out |
| Activity to be monitored | Trenching |
| Method to be used | Infauna investigations by Van Veen grab sampler. Sediment analyses: grain size, dry matter, loss of ignition, total organic carbon at all stations. Water measurements: CTDO profiles at all stations. Visual inspections by video mounted on ROV at all stations |
| Period of monitoring | June/July 2010-2013 |
| Results | Description of re-colonisation/recovery of infauna |

**Epifauna**

Inspection of colonisation and growth of epifauna on the pipelines is undertaken by visual inspections of the pipeline structures in areas with relatively shallow depths. Visual inspections are performed at nine locations as shown in Figure 4.3, in which the growth of benthic epifauna is described and evaluated.

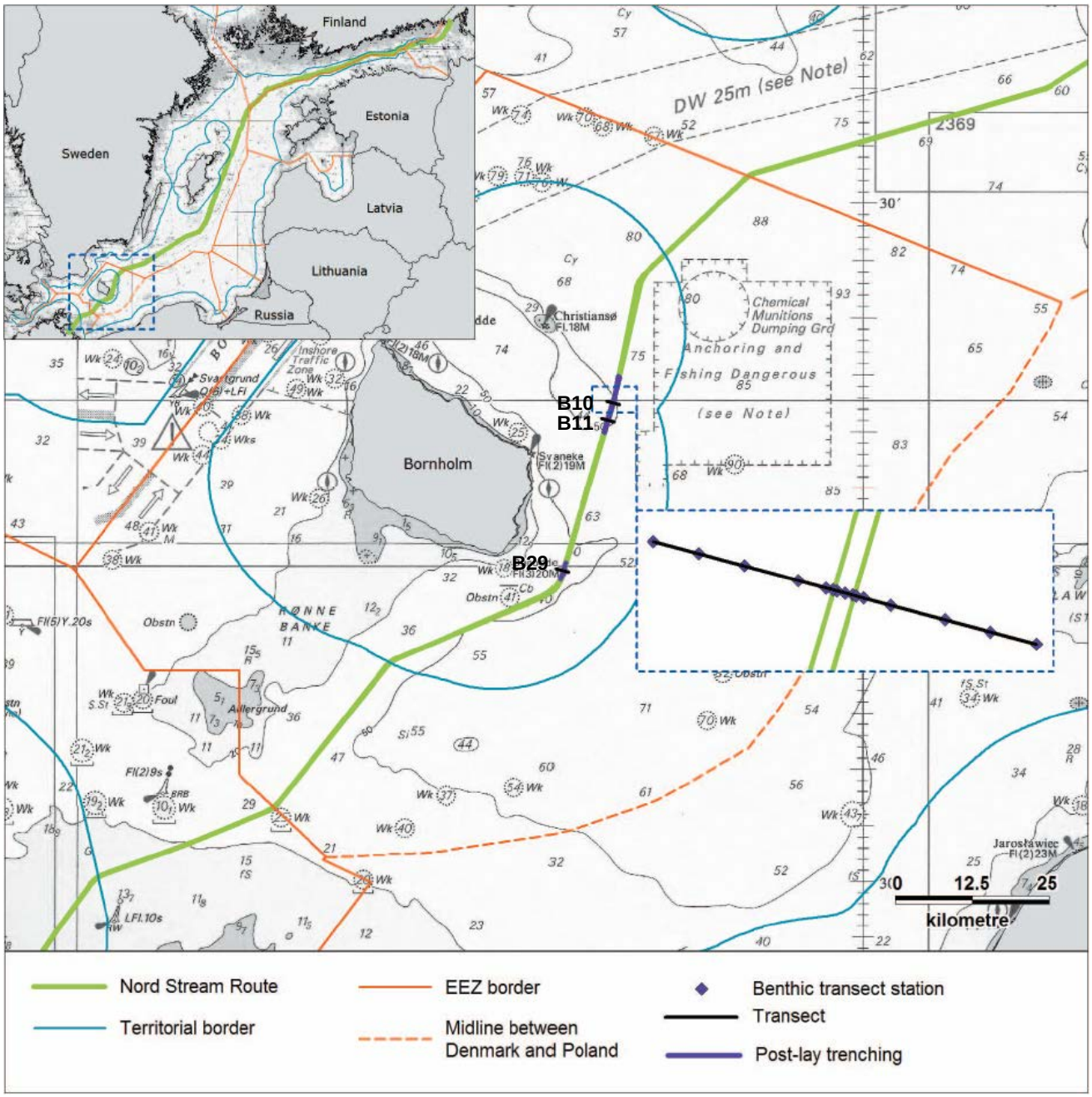


**Figure 4.2** Monitoring stations for infauna in Denmark. Sampling along transect B29 proved to be impossible due to a hard and stony seabed.

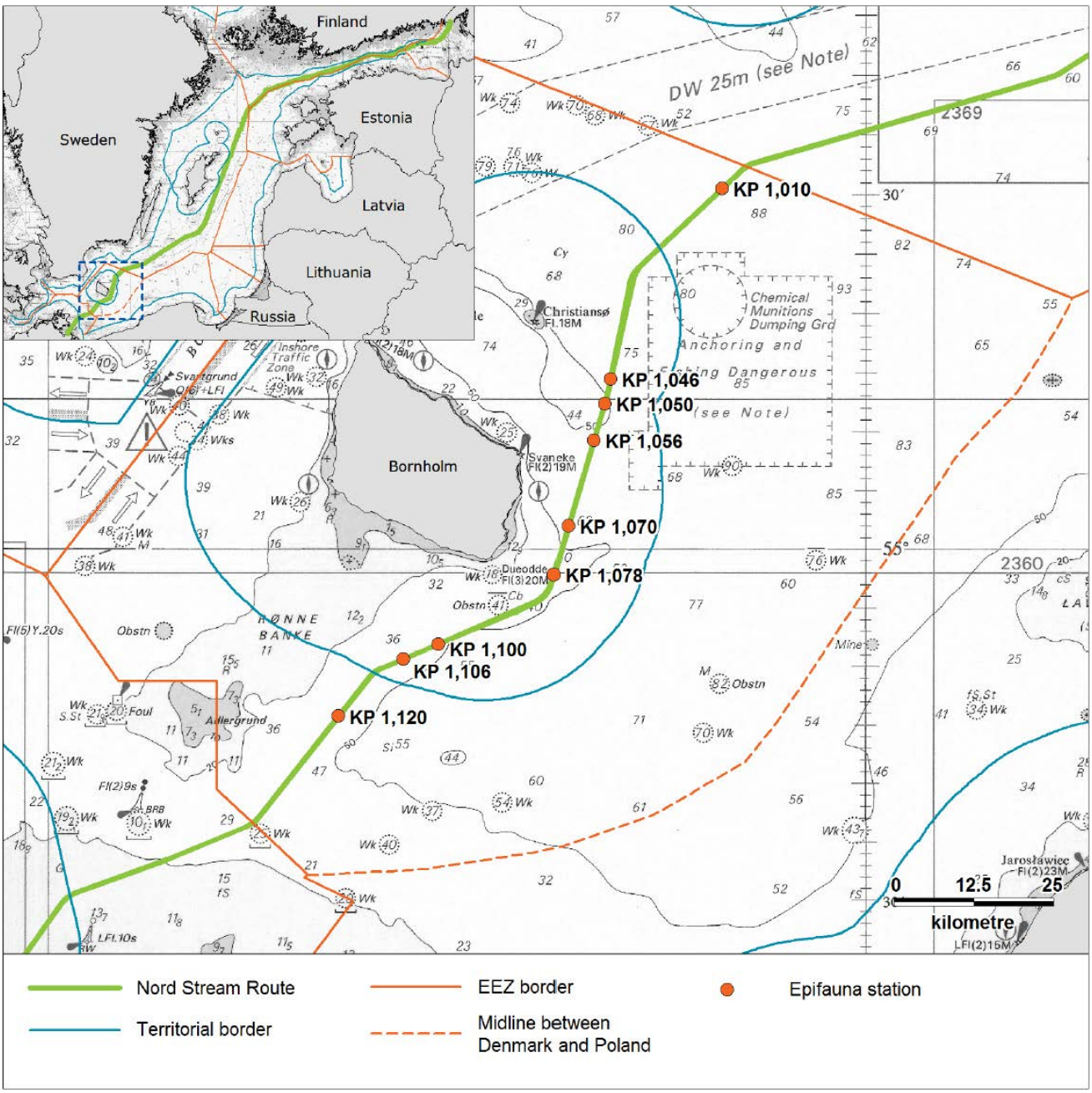


**Figure 4.3** Areas for monitoring of benthic epifauna in Danish waters.

A summary of the monitoring programme for epifauna in Denmark is presented in Table 4.5.

**Table 4.5** Summary of the monitoring programme for establishment and growth of epifauna on pipelines in Denmark.

| Benthic flora and fauna in Denmark | |
|---|---|
| **Monitoring of establishment and growth of epifauna on the pipelines** | |
| Purpose | To evaluate and document the establishment and growth of epifauna on the pipelines |
| Area to be monitored | At nine stations along the pipeline inside the Danish sector |
| Activity to be monitored | Two stations at trenched sections, one section where the pipeline is on the seabed and six stations in areas where intense bottom trawling takes place |
| Method to be used | Monitoring along the pipeline by a video mounted on ROV |
| Period of monitoring | Summer 2011-2014 |
| Results | Description of establishment and growth of epifauna on pipelines |

### 4.2.2 Monitoring and results for 2011

**Infauna**

The field survey in 2011 was carried out in the period 7-17 June 2011. The sampling programme illustrated in detail in /18/ is described in brief below. The programme include two transect (B10 and B11) each having 15 stations. The survey at each station included:

- An underwater video record of the seabed
- Measurement of conductivity (salinity), temperature, depth and oxygen (CTDO-measurements)
- Sediment sampling for analysis of selected physical and chemical variables
- Three van Veen grab samples for analysis of the benthic fauna.

The water depth along transect B10 and transect B11 are rather shallow and pronounced stratifications in salinity, temperature and oxygen were not developed in 2011. The oxygen concentrations were high close to the bottom and above critical levels for the benthic fauna. The spatial changes in 2011 and temporal changes since 2010, in salinity, temperature and oxygen close to the bottom, were limited.

The sediment consisted of thin layers (1-7 cm) of coarse sand and gravel on top of clay. The surface of the sediment was oxidized with no smell of hydrogen sulphide, except at station B10.32. Since 2010 the content of organic matter (loss on ignition and total organic carbon) has increased at transect B10. The median grain size of the sediment and the silt/clay content was unchanged at transect B10. No changes were observed in the variables measured in the sediment at transect B11 since 2010.

The number of species (about 20) and the species composition is characteristic for this low saline part of the Baltic Sea. The benthic community was dominated by the same species along transect B10 and transect B11. However, the structure of the benthic community was significantly different at transect B10 and B11 due to differences in abundance and biomass of the dominant species. The main differences were a dominance of the bivalve *Astarte borealis* along the deeper transect B10 and a dominance of the bivalve *Macoma balthica* and the polychaete *Pygospio elegans* along the more shallow transect B11. Other characteristic species were the polychaete *Scoloplos armiger*, the common mussel *Myilus edulis*, the crustacean *Diastylis rathkei* and the Ripulid *Halicryptus*

*spinulosus*. Since 2010 the abundance of the polychaete *Bylgides sarsi* and the crustacean *Diastylis lucifera* has declined at transect B10 and B11. However, the average abundance and biomass of the benthic fauna has increased since 2010. The increases are most pronounced at transect B10.

Analysis of the structure of the benthic fauna 10 m, 50 m and >50 m from Line 1 revealed no spatial or temporal changes along transect B 10.

At transect B 11 the structure of the benthic community 10 m and 50 m from the pipeline was different from the benthic fauna >50 m from Line 1. However, the abundance of the benthic fauna was higher at 10 m and 50 m stations than at stations > 50 m from the pipeline. In addition, the predominance close to the pipeline of the polychaete *Pygosio elegans*, which is likely to be sensitive to burial, lead to the conclusion that the spatial and temporal changes at transect B 11 are result of natural changes since 2010 and not caused by trenching of Line 1 in 2011.

In the Danish EIA it was calculated that trenching will affect an area with concentrations of suspended sediment > 10 mg/l of 5.9 – 8.9 $km^2$, with an average duration of concentrations > 10 mg/l lasting around three hours. The majority of the sediment is expected to settle within close vicinity of the pipelines, resulting in very minor net sedimentation > 1 mm within a few hundred metres of the pipelines. All in all it was concluded that the intensity of effects on benthic fauna would be minor, the scale of effects to be local, and the duration of the effects to be short-medium term.

The survey at transect B10 and B11, where post-lay trenching was carried out between the baseline survey in 2010 and the first impact survey in 2011, showed no effects of trenching which correspond well to the evaluation in the Danish EIA.

To monitor long-term effects and potential cumulative effects from construction of Line 2 the survey for benthos is planned to be repeated in 2012 and 2013.

**Epifauna**

The monitoring was undertaken in July 2011. Visual inspection of the seabed by video cameras mounted on an ROV was performed at a stretch of 250 m at each of the nine monitoring stations. The ROV was equipped with port and starboard boom arm colour cameras, together with a centrally mounted colour camera to enable the top and sides of the pipe to be viewed in one continuous pass. The camera angles were adjusted to provide a representative overview of the coverage percentage and pattern of the fauna communities. The quality of the footage recorded made it possible to determine which type of fauna community was present on the pipeline.

The video recordings and still photos from the nine analysed locations in Danish waters did not reveal any establishment of sessile epifauna on the pipeline. Only one mobile species, the crustacean *Saduria entomon*, could be identified to be present on the pipeline.

In the Danish EIA it was estimated that the establishment of the pipelines and rock berms will introduce new types of sub-littoral structures, which increase the habitat heterogeneity which, depending on the depth, might result in epifauna colonisation. The size, diversity and density of organisms associated with an artificial reef are conditional on the number and size of niches. The growth of sessile invertebrates and macro algae on the reef further contributes to an increase in the heterogeneity of the ecosystem. The presence of the artificial structures will in time likely lead to

colonisation by epibenthic organisms that may not have inhabited the area previously. The structures of the pipelines may also provide substrates that are more usable to mobile fauna than the previous 'pre-pipeline' seabed. The establishment of fouling communities on the hard substrates will increase the available food to fish, which again will lead to an increase in the available food to marine mammals and birds.

Colonisation of the artificial substrates will take place through a combination of migration from the surrounding seabed and settling of larvae and juveniles. The recruitment will be governed by the residual currents carrying the larvae and juveniles to the foundation and by the location of the pipelines with respect to factors such as depth and distance from recruitment source.

It was concluded that it is likely that the biodiversity and productivity will increase in some places along the pipelines, although slowly, from the situation before establishment of the pipeline due to an increase in habitat heterogeneity.

The results from survey in 2011 did, as expected, not reveal any establishment of sessile epifauna on the pipeline. Only one mobile species, the crustacean *Saduria entomon*, could be identified on and at the pipeline. An explanation for no sessile species being present at the pipeline might be the relatively short time period between establishment of the pipeline in November/December 2010 and the survey. Trenching in the analysed areas took place in February/March 2011, and the video recordings were performed in July 2011.

The monitoring for epifauna growth on the pipeline is planned to be repeated in 2012-2014.

## 4.3 Monitoring of water quality

### 4.3.1 Monitoring programme, purpose and period of monitoring

The purpose of the water quality programme in Denmark is to monitor the sediment plume during trenching, in order to validate the assumptions for the Environmental Impact Assessment for the Danish part of the pipeline /11/.

The monitoring programme is detailed in ref. /2/. The parameters measured as part of the monitoring programme is shown in Table 4.6.

**Table 4.6** Monitoring programme for mobilised sediments.

| Monitoring of spilled sediment | | | | | |
|---|---|---|---|---|---|
| **Activity** | **Parameter** | **Unit** | **Method** | **Location** | **Timing** |
| Trenching | Concentration of suspended sediment | mg/l | Water sampling, turbidity meter. CTD-probe[1] ADCP[2] | At transects along trenching sections of the pipeline route | 3-4 days during trenching |
| | Turbidity | NTU | | | |
| | Water temperature | $^0$C | | | |
| | Salinity | ‰ | | | |
| | Current velocity | m/s | | | |
| | Current direction | degrees | | | |
| 1: Conductivity, Temperature and Depth. 2: Acoustic Doppler Current Profiler. | | | | | |

### 4.3.2 Vessel-based monitoring of the sediment plume during trenching

Vessel based monitoring was carried out on three sections near Bornholm in Danish water (Ref. /13/); see also Figure 4.4:

- Test trenching 100 m to the west of Line 1 at KP 1047.000 – KP 1046.300
- Along Section 1 (1079.930 – KP 1077.452)
- Along Section 2 (1054.630 – 1046.080).

Monitoring during trenching in Danish waters took place on 7 February 2011 (trial trenching), on 9 February 2011 (trenching of Section 1), and on 13 February 2011 (trenching of the first part of Section 2). Due to rough weather conditions, it was not possible to carry out monitoring when trenching the last part of Section 2 on 14 February 2011.

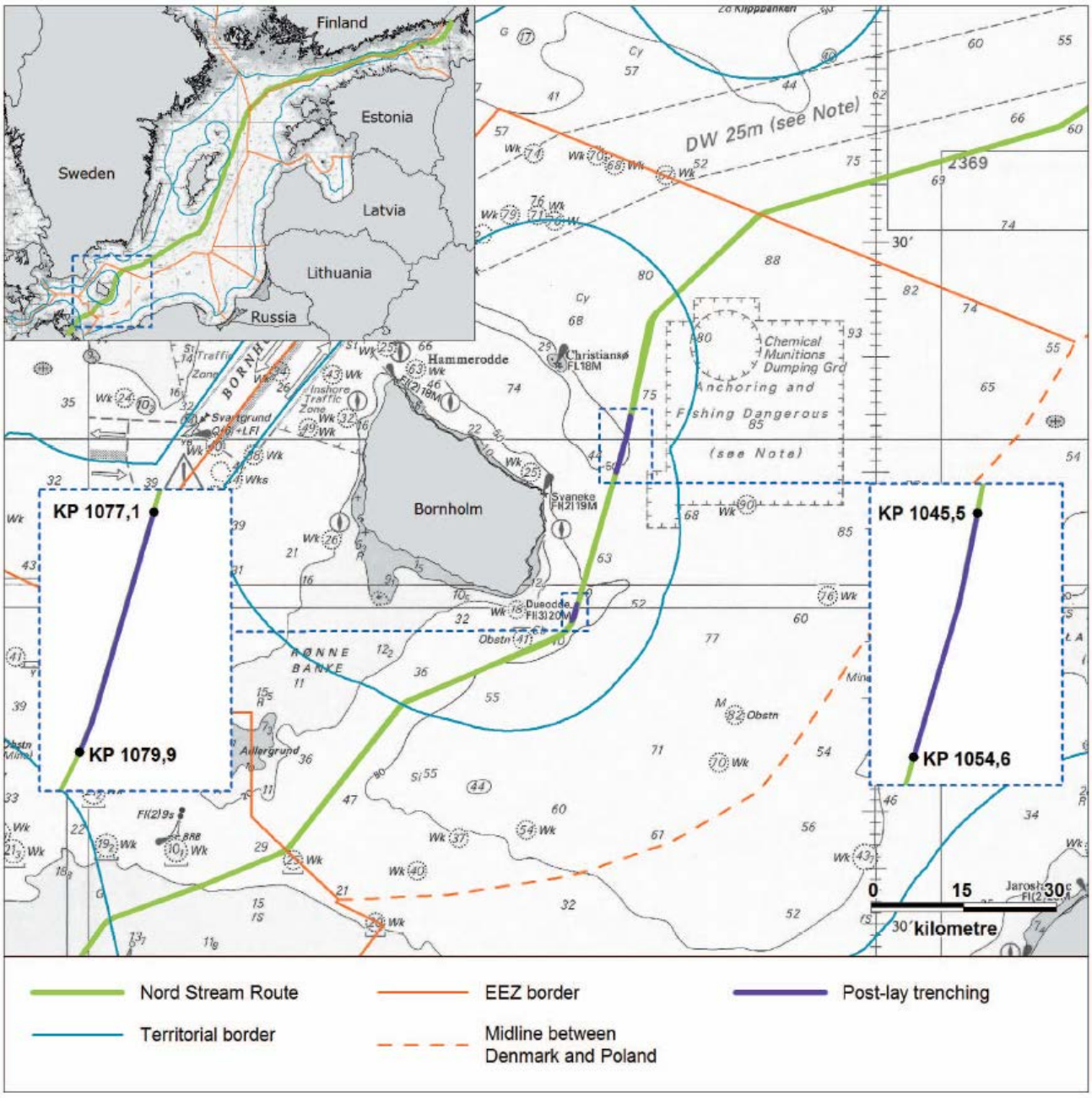


**Figure 4.4** Overview of planned trenching near Bornholm in the Danish Territorial Waters. Vessel-based monitoring of sediment spill is focused on these two stretches, which are located from KP 1045.5 to KP 1054.6 and from KP 1077.1 to 1079.9 /2/.

Before the ploughing for the Nord Stream project took place, no experience with regards to sediment spill rate from ploughing existed in the literature. Based on analysis of sediment spill rates from other seabed interventions activity types, and taking into consideration the relatively modest disturbance

of the seabed, which ploughing represents, a sediment spill rate from ploughing of 2 % of the handled seabed materials was assumed. Based on experience, an average ploughing speed of 300 m/h was assumed. The average nominal trenching volume was estimated to be 6.2 $m^3$/m, and using the porosity of the materials found from seabed samples, the above assumptions lead to an estimated sediment spill rate of 16 kg/s during trenching /11/.

The measurements were carried out outside the specified safety zones for the construction works[2], which was agreed with the vessel operator. During trenching works, profiles of turbidity, salinity, water temperature and currents were measured from a vessel. The profiles were measured downstream of the trenching activities, aiming at measuring the maximum sediment concentrations. Reference measurements were carried out upstream of the trenching works in order to establish the natural background sediment concentration. A DCP backscatter signals were used to locate the position of the sediment plume, allowing for the profile measurements to be carried out at the optimal positions. Turbidity was measured by an OBS sensor mounted on a cable. A CTD sensor was mounted on the same cable to measure water temperature, conductivity (salinity) and depth. To enable conversion of the results of the turbidity measurements to concentrations of suspended sediments, water samples were taken frequently at the same depths at which the turbidity meters were located.

**Table 4.7** Summary of the monitoring programme for the sediment plume during trenching in Denmark.

| Water quality in Denmark | |
|---|---|
| **Monitoring of the sediment plume during construction** | |
| Purpose | To evaluate and document the sediment plume during trenching |
| Area to be monitored | Sections to be trenched in Danish waters |
| Activity to be monitored | Post-lay trenching |
| Method to be used | Vessel-based monitoring of turbidity (OBSs) and current (ADCPs) and water samples for calibration of turbidity measurements |
| Period of monitoring | During trenching in Danish waters in the first part of February 2011 |
| Results | Description of distribution of sediment plumes during trenching |

### 4.3.3 Monitoring and results 2011

A comparison between the measured concentrations with the expected concentrations, taking into account the current velocities and the distance from the spill source, has led to the conclusion that the actual spill rate was approximately 7 kg/s. This is significantly less than the 16 kg/s that was adopted in the modelling for the Danish EIA /11/.

The results of the monitoring programme therefore showed that the assumptions for and the results of the sediment spill modelling carried out as part of the EIA prior to the construction works are conservative (i.e. on the safe side); the sediment spill rate, and the increase in sediment concentrations were smaller than was assumed.

[2] During monitoring as close as 200 m to the side of the plough and 100-200 m behind the plough, but in front of the vessel survey vessels must adhere to the 1nm safety zone

## 4.4 Monitoring of hydrographic conditions in the Bornholm Basin 2010 – 2011

### 4.4.1 Monitoring programme, purpose and period of monitoring

The purpose of the hydrographic monitoring programme in Danish and Swedish waters is to establish documentation for the theoretical analysis of the possible blocking of the water inflow to the Baltic Sea caused by the presence of the Nord Stream Pipeline as reported in /15/.

The saltwater inflows from the Kattegat are sporadic and ecologically important. Concern has been raised in relation to the influence of the pipelines on the inflowing of high-salinity bottom water through the Bornholm Basin. In response, Nord Stream carried out an extensive study to address the issue, /4/. The study concluded that the impact of the pipelines on the inflow of high-saline bottom water in the Baltic Proper will be negligible.

During the public consultation process for the Nord Stream Pipeline, questions were raised as to whether existing knowledge and data would be sufficient for an exhaustive description of the problem. Consequently, Nord Stream decided to accomplish a hydrographic monitoring programme in agreement with the relevant authorities.

The purpose of the hydrographic monitoring programme is to investigate the influence of the pipelines on the inflowing, high-saline deepwater in the Bornholm Basin. It was assessed that it is impossible to directly monitor the effect due to the presence of the pipelines. This is due to the natural variability being several orders of magnitude higher than a possible local effect. The scope, therefore, is focused on verifying the hypothesis of the previous investigations by SMHI in their consulting report /4/.

Hydrographic measurements in 2010 have been carried out and new measurements are planned for 2013 in order to verify the influence on blocking and mixing caused by the presence of the pipeline described in /4/. The measurements aim to describe the bottom currents, interfacial friction and dissipation of inflow waters. Oceanographic measurements (velocity, temperature, salinity) were carried out initially during a period of 9 months (including approximately one month down period) at KP 1036 northeast of Bornholm at a water depth of approximately 90 m. The location was selected in mutual understanding with SMHI and the fishermen's organisation on Bornholm. In autumn 2010 the measuring station was moved to KP 966 in order to also obtain measurements from the halocline level at shallower water depths (approximately 68 m). The two locations of the monitoring station are presented in Figure 4.5.

In addition to the fixed station, a total of six line transects of current measurements have been carried out by ADCP. Four transects along the pipeline route between KP 1030 and KP 1070 were done while a fifth transect was prolonged towards KP 966. An additional transect covered a broader area of the Bornholm Basin.

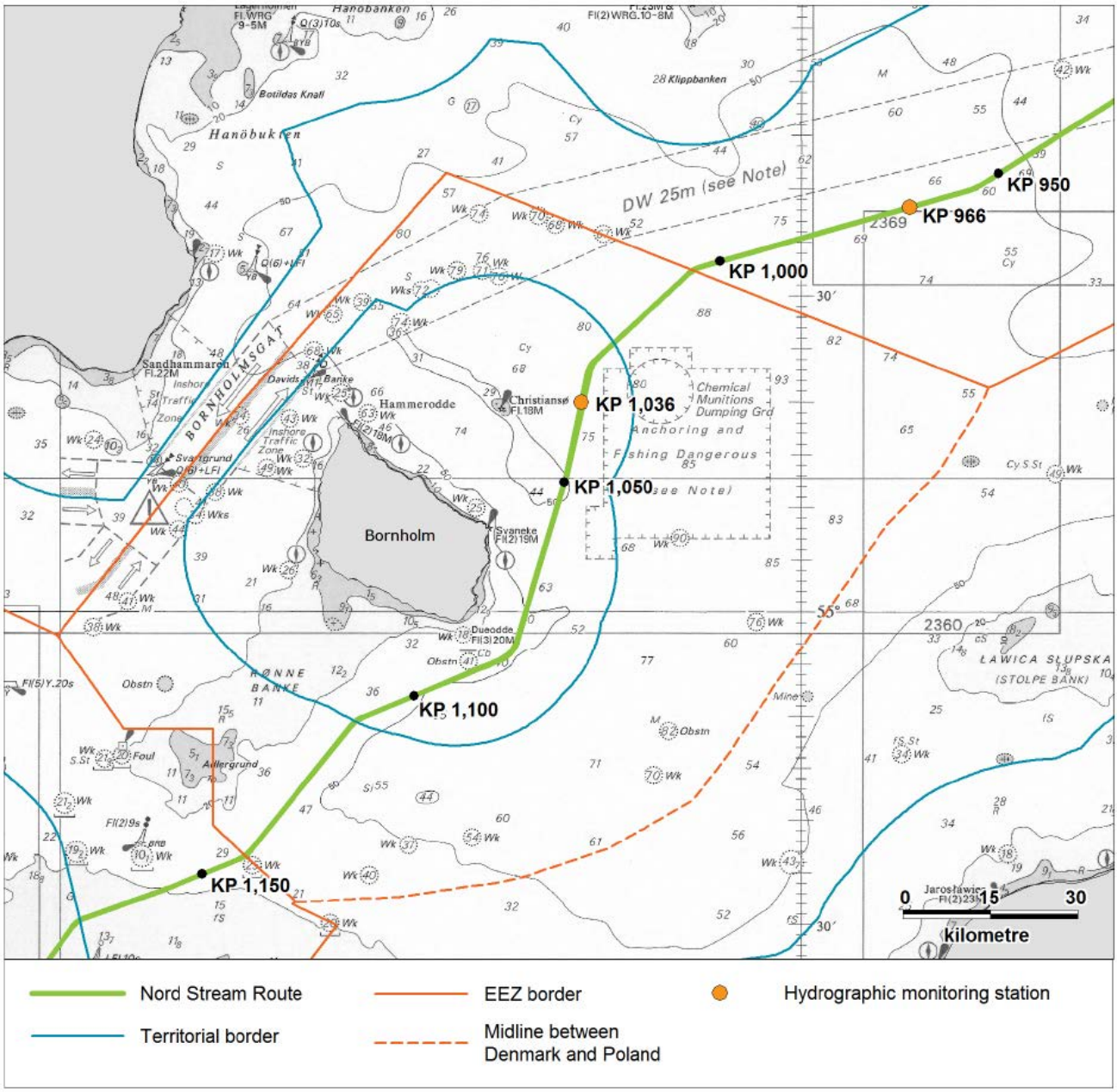


**Figure 4.5** Location of hydrographic monitoring station in Denmark and Sweden. The station was originally deployed near KP 1036. In autumn 2010 it was moved to shallower water at KP 966.

**Table 4.8** Summary of the hydrographic monitoring programme in Denmark and Sweden.

| Hydrography in Denmark/Sweden | |
|---|---|
| **Monitoring of water inflow** | |
| Purpose | Description of bottom currents, interfacial friction and dissipation of inflow waters. Evaluation of changes caused by the Nord Stream pipelines |
| Area to be monitored | Transects at the pipeline route between in the Bornholm Basin. The measuring station was positioned at KP 1036 in Danish water and at KP 966 in Swedish water |
| Activity to be monitored | Presence of the pipelines on the seabed |
| Method to be used | ADCP, CTD (fixed station). Ship mounted ADCP (line transects) and ship based CTD profiling |
| Period of monitoring | Continuous measurement for one year (2010) at the fixed stations before construction and after the pipelines have entered into operation (2013) |
| Results | Documentation of effects from the pipeline on inflowing saline/oxygenated bottom water from the Danish straits |

### 4.4.2 Monitoring and results 2010 - 2011

**Fixed monitoring station**

The fixed monitoring station was installed at KP 1036 on 21 January 2010. The station was retrieved from this location on 11 October 2010. The station was trawled up on 7 March 2010 and redeployed on 8 April 2010. No data was consequently compiled during this period. The equipment was moved to a new position at KP 966 on 5 November 2010 and retrieved 11 January 2011. The monitoring activity is summarised in Table 4.9.

**Table 4.9** Monitoring activity and data availability for the fixed stations at KP1036 and KP966 of the 2010 hydrographic monitoring campaign.

| | KP 1036 | KP 966 |
|---|---|---|
| Operation period | 22-01-2010 to 11-10-2010 | 05-11-2010 to 11-01-2011 |
| General remark | Trawled up: 01-03-2010. Redeployed: 08-04-2010.<br>(No data) | |
| Salinity/Temperature SeaBird MicroCAT SBE 37-SM<br>(fixed CTD) | Full data coverage | No data from 13 m and 40 m.<br>Otherwise full data coverage |
| Current meter<br>Nortek AWAC Wav 5599<br>(Upward looking) | Full data coverage | Full data coverage |
| Current meter<br>Nortek Aquadopp AQP 1826<br>(Downward looking) | Battery failure /no data:<br>01-05-2010 to 15-06-2010,<br>22-08-2010 to 31-08-2010,<br>14-09-2010 to 11-10-2010<br><br>Cell 0-1 m + cell 11-12 m; data deleted due to side lope or blanking:<br>22-01-2010 to 11-10-2010<br><br>Cell 1-2 m + cell 9-10 m +<br>cell 10-11 m; data deleted due to noise:<br>16-16-2011 to 11-10-2010 | Battery failure /no data:<br>04-01-2011 to 11-01-2011<br><br>Cell 1-2 m + cell 9-10 m cell 10-11 m deleted due to noise :<br>05-11-2010 to 11-01-2011 |

Unfortunately data from the ADCP instrument (Aquadopp) from 12 m depth to the bottom is missing in the following three periods: 1 May 2010 – 16 June 2010, 22 August 2010 – 31 August 2010 and 14 September 2010 – 11 October 2010. In the first case it seems to be due to unstable power supply since internal cabling has been changed in the subsequent service. In the second case data is classified as “unvalidated”, and in the latter case, it is due to battery failure, which is surprising since data loss occurred less than two weeks after the last service inspection.

In the ADCP data from the mooring, some depths have excessive noise levels and have been disregarded. This is mostly due to known effects, such as reflection from the bottom, blanking distance from the instrument and disturbances from sharp interfaces (the density interface above the mixed bottom layer).

Salinity and temperature data from the mooring and from CTD profiles are in general of a very high quality.

**Line transects**

Line transects for monitoring currents with ADCP have been carried out. The line transects have been carried out as summarised in Table 4.9. Transects T1-T4 were carried out at the pipeline route over a 40 km distance between KP 1030 to KP 1070. Transect T6 was prolonged towards KP 966. Transect T5 covered a broader area of the Bornholm Basin. The monitoring activity is summarised in Table 4.10.

**Table 4.10** Monitoring activity and data availability for line transects of the 2010 hydrographic monitoring campaign.

| Date | Transect ID | Length | Data |
|---|---|---|---|
| 16.02.2010 | T1 | 40 | Yes, but noisy |
| 17.03.2010 | T2 | 40 | Yes |
| 16.06.2010 | T3 | 40 | Yes |
| 01.09.2010 | T4 | 40 | Yes |
| 10.11.2010 | T5 | 140 | Yes |
| 14-15.04.2011 | T6 | 134 | Yes |

Transect T1 is of lower quality, in part due to cold water and low particle content, a known problem for acoustic instruments.

An overview of fixed stations, CTD positions and conducted transects area shown together with the pipeline route on Figure 4.6.

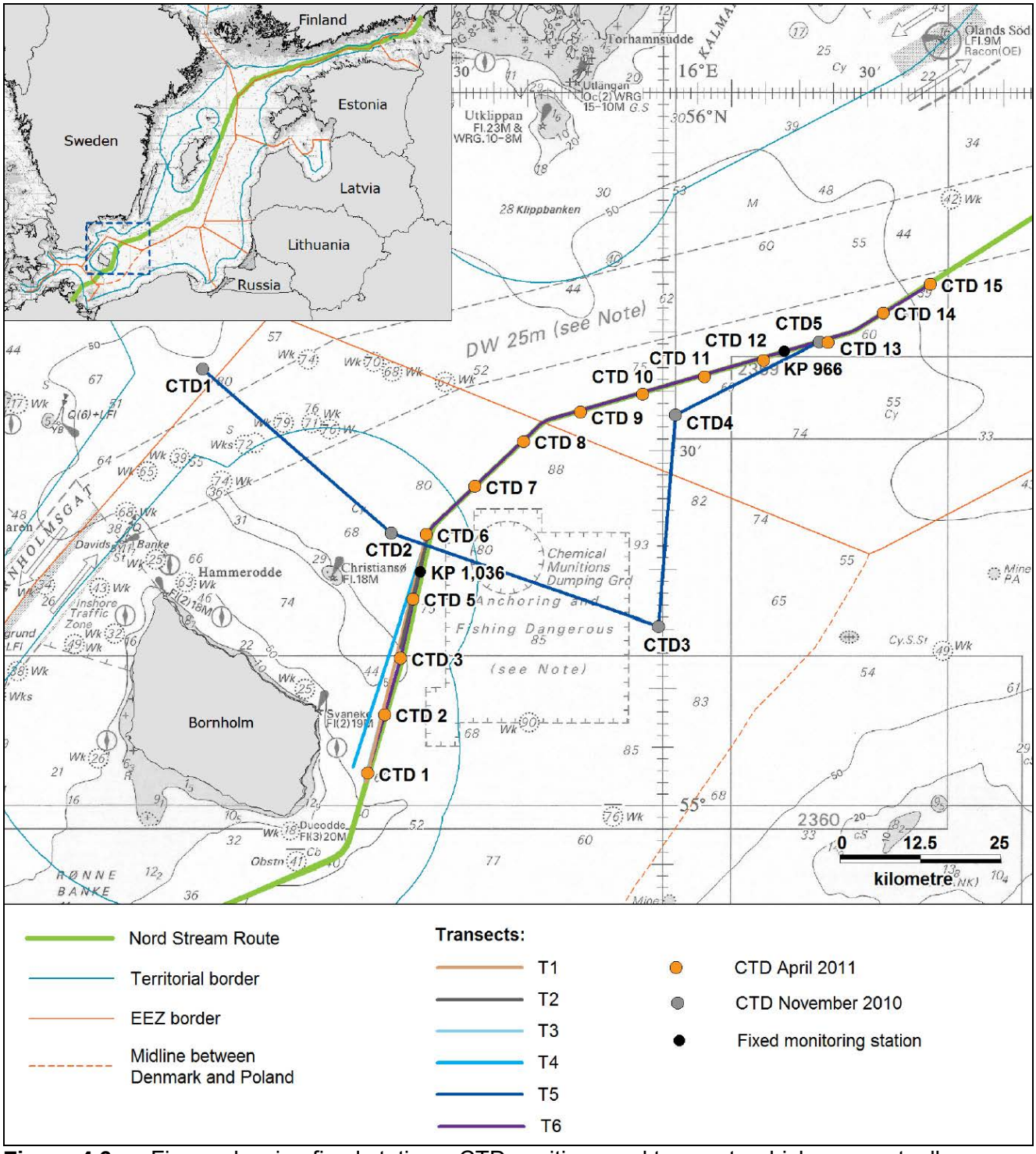


**Figure 4.6** Figure showing fixed stations, CTD positions and transects which were actually conducted during the monitoring campaign in the Bornholm Basin.

**Monitoring results**

The current speeds in a 10 m thick layer above the bottom at KP 1036 were generally less than 0.1 m/s. Only during a few, about one-day-long events in January and February did current speeds approach 0.3 m/s. At KP 966 there were frequent events with maximum current speed in the interval 0.25-0.35 m/s. Neither of these events can directly be correlated to inflow of dense bottom water. In periods between these events, current speeds are typically less than 0.1 m/s. At both locations, stronger currents in the bottom layer seem to be due to internal waves with a 180° phase shift of current direction in the halocline. The higher frequency of stronger bottom currents at KP 966 as compared to KP 1036 is probably due to the shallower water at KP 966 and maybe also stronger winds in November and December.

At KP 1036 there are a number of short events, typically half-day-long, with rather strong and vertically narrow currents in the halocline (about 35 – 50 m above the seabed, see Figure 4.7. This current signature might be due to inflow of new deep water, through Bornholm Channel that is interleaved in the halocline. The about 3.5 km wide current with maximum speed 0.5 m/s, observed between 35 and 55 m depth rather close to Bornholm on the transect taken 31st of August, might be of similar origin. This interleaved current will not interfere with the presence of pipelines at the seabed.

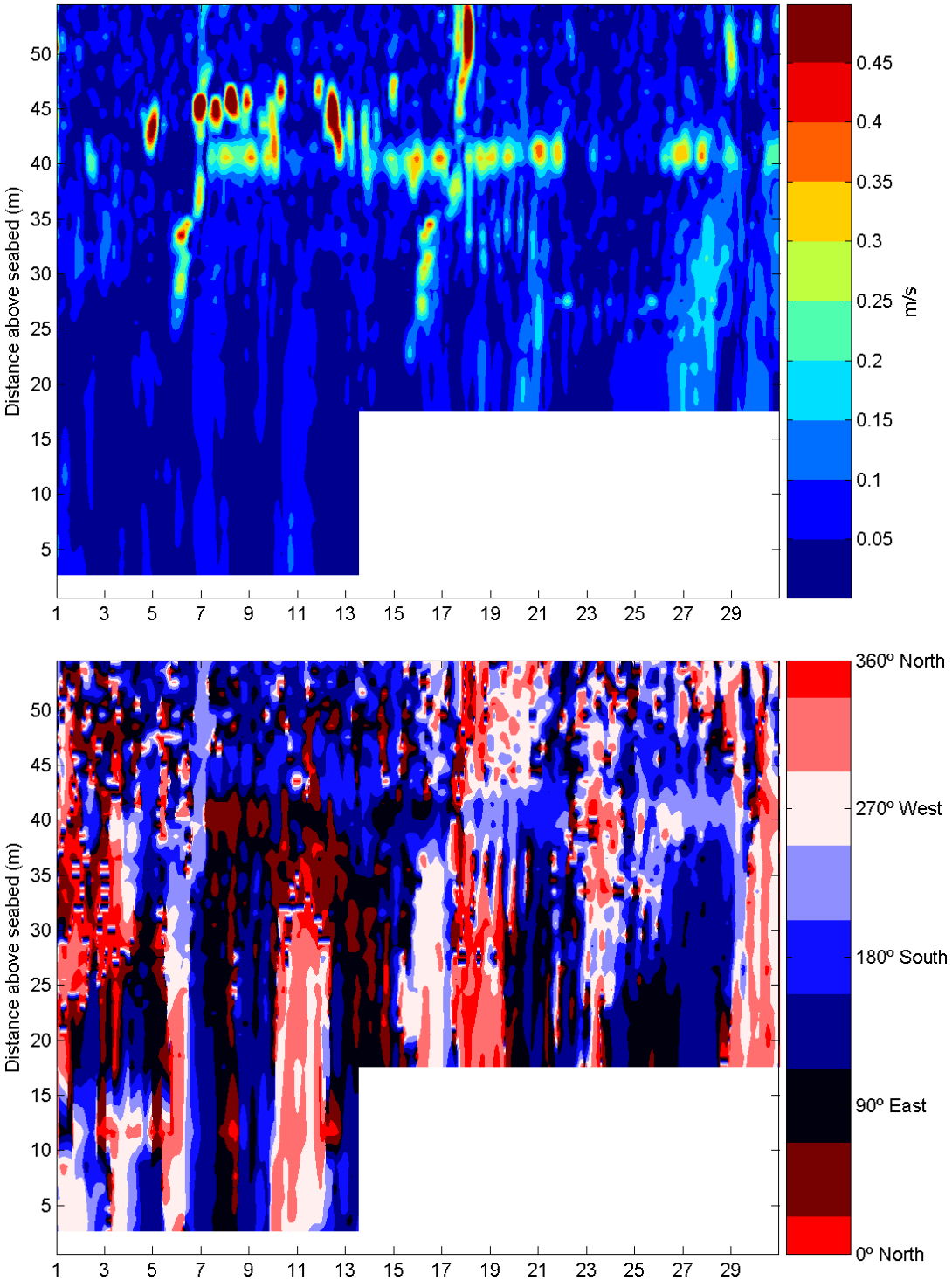


**Figure 4.7** Monitoring results from station KP 1036. The graphics shows current speed (upper) and current direction (lower) for the month September 2010 (x-axis =days). Blank areas: Missing high-quality data from these levels/periods, /19/.

According to /19/ there were inflows of new deepwater in August and September and this fits well with the increased frequency of flow pulses in the halocline in August and September. However, because temperature and salinity were observed only up to 40 m above the seabed, it is not possible to determine the temperature and salinity signature of these current events. Similar currents confined to the halocline were not observed at KP 966, maybe due to lack of inflow of new deepwater during the relatively short period of observations at that position.

It is assumed that the transport of new deepwater across the pipelines by band-like currents on the western side and by the baroclinic flank current on the eastern side are equally large. The mean baroclinic geostrophic flank current might then be 10 km wide and have a speed of 0.15 m/s when crossing the pipelines. The current should be located east of KP 966. In periods of inflow of new deepwater through Bornholm Channel, the pycnocline rises and the flow in the flank current should increase. It should be stressed that the conceptual model of the flow of new deepwater through the Bornholm Basin by the flank current is supported by the corresponding flow through the Arkona Basin which has been verified by observations, but there are still no observations of the flank current in the Bornholm Basin.

The existence of well-mixed layers close to the bottom was investigated for both moorings. The reason for this was that the drag coefficient C of the pipelines depends on the densimetric Froude number of the dense bottom current as explained in /4/. However, since there were no dense bottom currents at the moorings, the observed mixed layers were not used to compute the drag coefficient of the pipelines in dense bottom currents.

As a basic assumption for /4/ it has been assumed that height of the pipeline above the seabed is 1.0 m. However, some stretches of the pipelines in Bornholm Basin are trenched. The non-trenched part of the pipelines will sink into the seabed. Detailed 'As-laid' and 'as-trenched' surveys have been carried out. The surveys show that the top of the pipeline is 0.65 m above seabed as an average through the Bornholm Basin (KP 920 – KP 1 080). The pipeline might still sink deeper into the seafloor and reduce height further. A more realistic but still conservative value of the height is changed from 1.0 m to 0.7 m.

As mentioned above, the flank current has been reduced from 0.3 m/s to 0.15 m/s.

The reduction of current speed and pipeline height will reduce the mixing effect of the pipelines from 0-1% to 0-0.2%. This estimate is based on the same value of the drag coefficient C of the pipelines as used in /4/ as no additional information has been gained.

This conclusion differs from that in /4/. The present conclusion is based on an improved understanding and quantification of currents in the Bornholm Basin as compared to that available when /4/ was written.

# 5 Socio-economic monitoring within the Danish territorial water and EEZ

## 5.1 Monitoring of cultural heritage

### 5.1.1 Monitoring programme, purpose and period of monitoring

The purpose of the cultural heritage monitoring programme in Denmark is to verify that construction in the vicinity of wrecks of cultural heritage significance has proceeded as planned.

**Verification that the construction has proceeded as planned**
In collaboration with the Danish authorities, Nord Stream has agreed on an environmental monitoring programme for Denmark. As a part of the programme, monitoring of the two wrecks located closest to the Nord Stream Pipelines has been included (see Figure 5.1).

The wrecks have been designated as:

- S-DK1-2-36-4472 – Wooden wreck, collapsed. The debris area is approximately 28 m long. The wreck is situated closest to the northwest pipeline.
- S-S33-3802 – Iron wreck, approximately 42 m long. The wreck is situated closest to the southeast pipeline.

The wreck monitoring is carried out as visual inspection using an ROV before and after pipeline installation. The inspections serve to evaluate whether damage has occurred to the wrecks during pipeline installation and whether the presence of the pipelines causes enhanced erosion around the wrecks.

Wreck monitoring after installation of the first pipeline and prior to Line 2 installation was conducted in January 2011. Post-lay wreck monitoring for the Line 2 installation is planned to be carried out in July 2012. Monitoring will be carried out again in 2014 and 2016 to check that no erosion has taken place around the wrecks as a result of the pipelines being present on the seabed. Erosion patterns may be altered slightly due to local changes in the current in the areas where the pipelines are placed directly on the seabed. If no erosion can be detected after three inspections, the inspections will be suspended.

In Denmark, the detailed surveys that Nord Stream conducted prior to installation have led to the discovery of a number of wrecks and cultural heritage sites east and south of Bornholm. On behalf of the Heritage Agency of Denmark, the Viking Ship Museum assessed these cultural heritage sites and it was agreed that protection zones of 200 m should be established around 27 cultural heritage locations during pipeline installation in Danish waters for the first pipeline.

Prior to installation of Line 2 in 2011, it was agreed between Nord Stream and the Viking Ship Museum/Heritage Agency of Denmark to investigate the positions of protected wreck sites, in order for the Viking Ship Museum to perform an assessment of the wreck locations. The investigations were commenced in July 2011, where Marin Mätteknik AB performed a survey of the wreck locations. The survey included a ROV-based multibeam survey and ROV video inspection. The result of the investigations and assessment was that 10 exclusion zones were removed and a few were reduced in size from a 200 m radius to a 100 m radius.

It has been a greed that if other cultural heritage objects are identified during the pipe-laying and anchor-handling operations, the Heritage Agency of Denmark will be notified immediately.

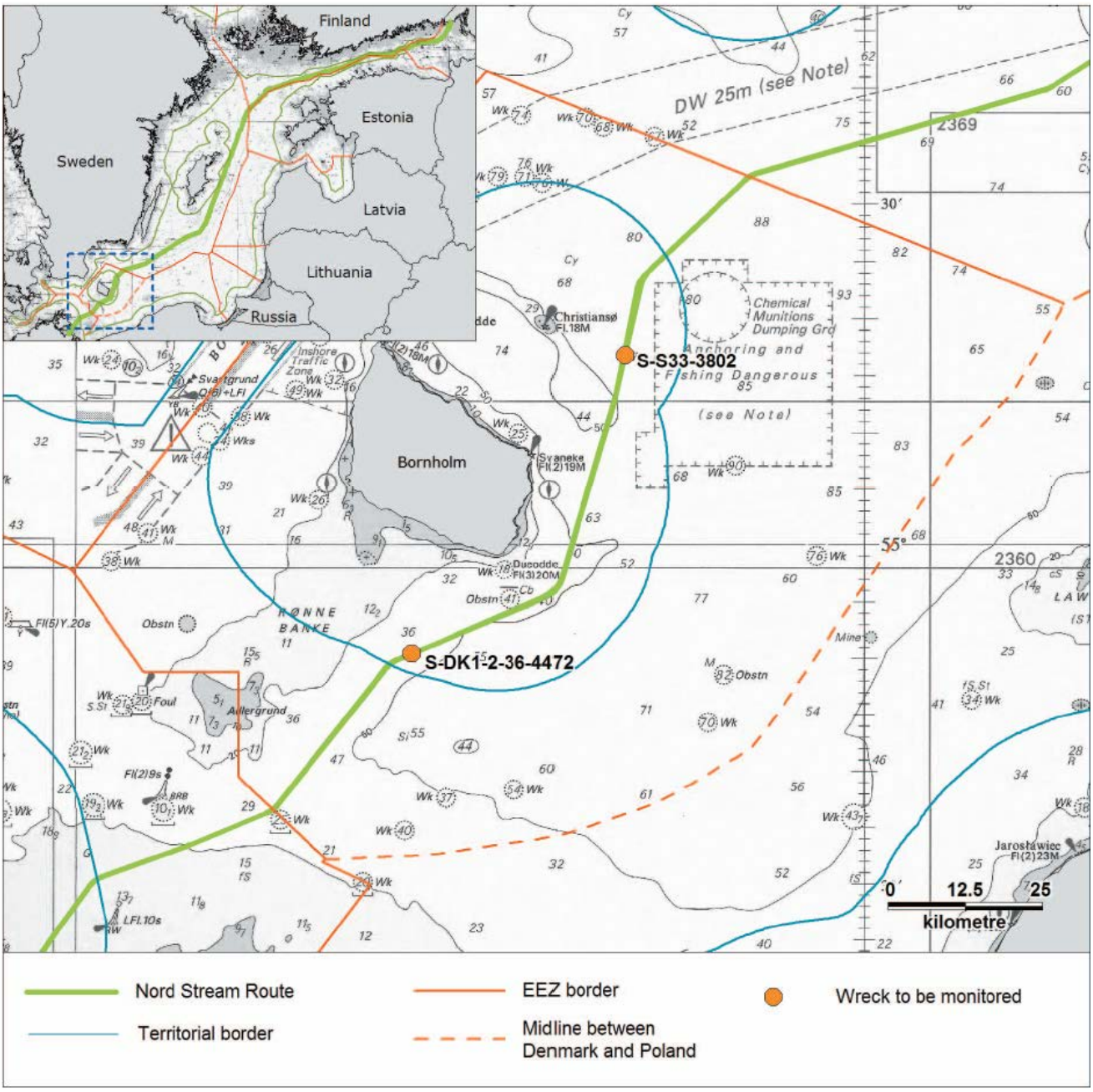


**Figure 5.1** Cultural heritage monitored in Denmark.

**Table 5.1** Summary of the monitoring programme for cultural heritage in Denmark.

| Cultural heritage in Denmark | |
|---|---|
| **Monitoring of cultural heritage objects** | |
| Purpose | To evaluate and document that the identified wrecks have not been damaged, and that the presence of the pipelines does not cause enhanced erosion around the wrecks |
| Area to be monitored | Selected wrecks of cultural heritage |
| Activity to be monitored | Construction of the pipeline |
| Method to be used | Visual inspection by ROV |
| Period of monitoring | Inspections carried out before and after completion of the pipelines. Further inspections carried out in 2014 and in 2016. If no erosion is detected after three inspections, the inspections will be suspended |
| Results | Video recordings |

### 5.1.2 Monitoring and results for 2011

During 2011 monitoring of cultural heritage has been conducted in connection with installation of the second Nord Stream Pipeline in Danish waters.

The monitoring has included pre-lay visual monitoring of the two wrecks:

- Wooden wreck, ID no.: S-DK 1-2-36-4472
- Iron wreck, ID no.: S-S33-3802

Prior to installation of Line 2 a survey was conducted of protected wreck sites identified in Danish waters. The results of the investigations were that 10 of the original 27 exclusion zones were removed and some of the remaining exclusion zones were reduced from a 200 m radius to a 100 m radius.

In compliance with the Danish permit requirements /5/ all safety zone restrictions around cultural heritage locations were established and respected during installation of Line 2.

The post-lay monitoring of wrecks for Line 2 is planned to be conducted in summer 2012, and hence no results are available at present time (spring 2012). Comparison of the wreck condition before and after Line 2 installation will be made after the post-lay monitoring and will be presented in the monitoring report for 2012.

Wreck monitoring will be carried out again in 2014 and 2016 to check that no erosion has taken place around the wrecks as a result of the pipelines being present on the seabed.

## 5.2 Monitoring of munitions

### 5.2.1 Monitoring programme, purpose and period of monitoring

The purpose of the chemical munitions monitoring programme in Denmark is to validate the integrity of chemical munitions objects identified before the start of construction.

The Nord Stream Pipeline passes close to the chemical dumpsite east of Bornholm in Denmark and there has therefore been a special focus on this area related to the EIA process. Five chemical munitions objects were identified in Danish waters during munitions screening surveys. During the pre-lay survey Nord Stream did for Line 2 in autumn 2011 and a survey carried out for wreck inspections in summer 2011, two additional chemical munitions objects were found in Danish waters. Figure 5.2 shows a map with the location of the seven chemical munitions in Denmark. The integrity of the seven munitions objects is documented before and upon completion of the construction works by visual inspection of the objects.

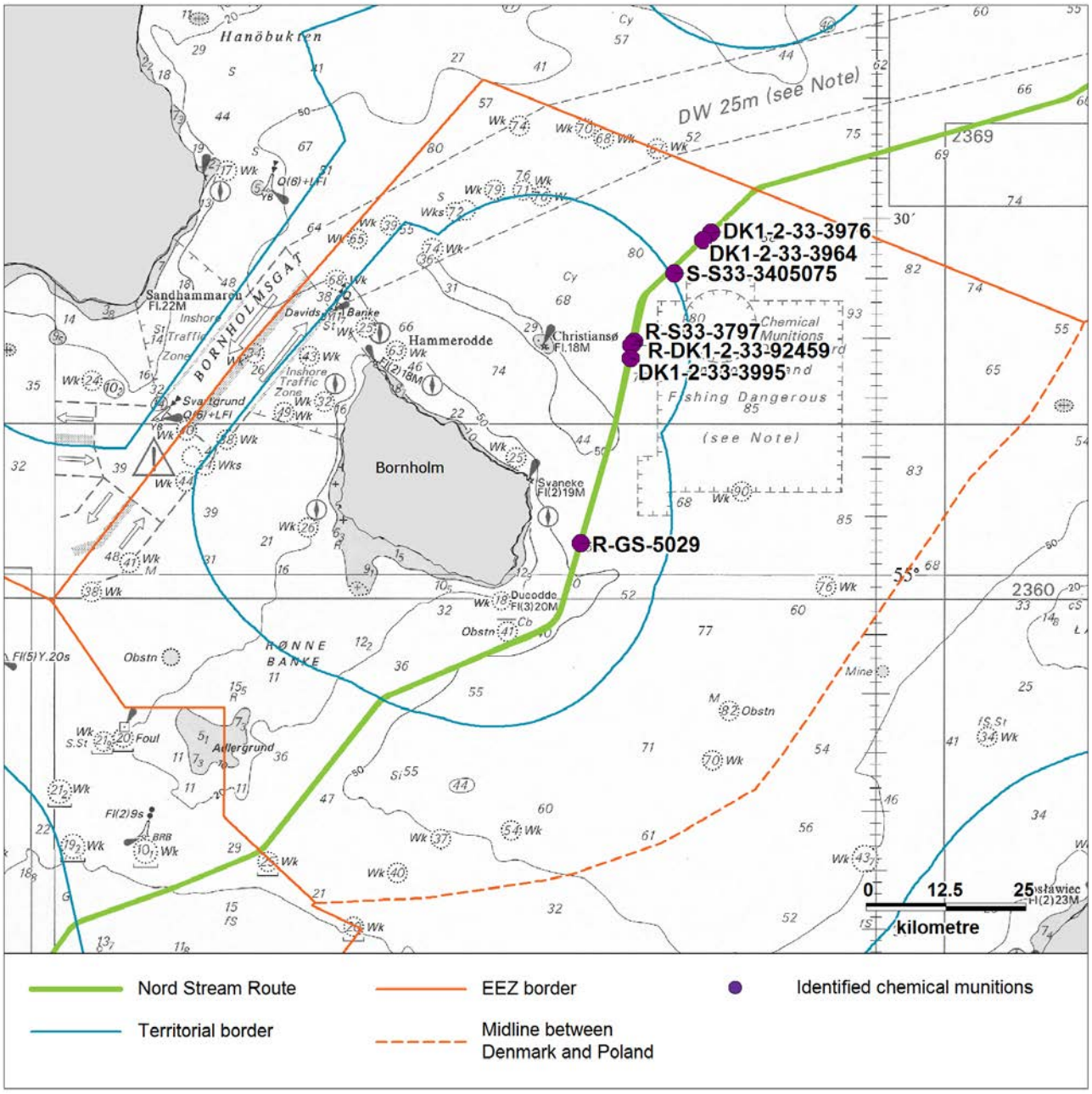


**Figure 5.2** Chemical munitions identified in Denmark along the Nord Stream Pipeline route.

A summary of the monitoring programme for validation of the integrity of the seven chemical munitions objects identified in Denmark is presented in Table 5.2.

**Table 5.2** Summary of the monitoring programme for chemical munitions in Denmark.

| Chemical munitions in Denmark | |
|---|---|
| **Documenting integrity of identified munitions objects** | |
| Purpose | To evaluate and document the integrity of seven identified munitions objects |
| Area to be monitored | Chemical munitions objects |
| Activity to be monitored | Effects from pipe-laying |
| Method to be used | Video inspection |
| Period of monitoring | Before and after construction: 2010, 2011 and 2012 |
| Results | A video recording of the munitions objects |

### 5.2.2 Monitoring and results for 2011

During 2011, monitoring of munitions has been conducted in connection with installation of the second Nord Stream Pipeline in Danish waters.

The monitoring has included pre-lay visual inspection of five chemical munitions objects assessed to be German chemical KC250 mustard bomb:

- DK1-2-33-3976 – assessed as German chemical KC250 mustard gas bomb
- DK1-2-33-3964 – assessed as fuse from chemical bomb
- R-S33-3797 – assessed as German chemical KC250 mustard gas bomb
- R-DK1-2-33-92459 – assessed as German chemical KC250 mustard gas bomb
- DK1-2-33-3995 – assessed as bomb tail from chemical mustard gas bomb.

In addition, two chemical munitions objects were found in Danish waters during 2011. They were found during the pre-lay survey which Nord Stream carried out for Line 2 in autumn 2011 and during a survey carried out for wreck inspections in summer 2011. The objects have been reported to the Admiral Danish Fleet and will be included in the remaining monitoring work Nord Stream is carrying out in Denmark.

In compliance with the Danish permit requirements /5/, safety precautions and emergency plans for handling of chemical munitions have been followed during installation of Line 2 in Danish waters. The Admiral Danish Fleet have been onboard the lay vessel and anchor handling tugs during the entire installation operation in Danish waters from 15th October to 22nd November 2011, and onboard the plough support vessel in February 2011. The scope of their assistance comprised the following:

- Cable crossings: anchors and anchor wires are brought to deck during crossing, and pose a risk of being smeared with chemical warfare agents, since they have been in contact with the seabed. ADF assisted in detection of chemical warfare agents on anchors and wires.

- Recovery of pipe head: in case of rough weather, the pipe is lowered from the lay barge to the seabed and brought up again when weather conditions permit installing operations to continue. The pipe head poses a risk of being smeared with chemical warfare agents, from contact with the seabed. ADF assisted in detection of chemical warfare agents on the pipe head.

- Ploughing: when the plough is salvaged after ploughing operation, there is a risk it could be smeared with chemical warfare agents. ADF assisted in detection of chemical warfare agents on the plough and washing down of the plough. After completion of trenching operations, DEMA (Danish Emergency Management Agency) carried out thorough plough cleaning at a location close to Rønne harbour.

From the detection and cleaning work the Admiral Danish Fleet and DEMA performed, no chemical warfare agents were found.

The post lay monitoring of munitions in Denmark for Line 2 is planned to be conducted in summer 2012, and hence no results are available at present time (spring 2012). Comparison of the munitions conditions before and after Line 2 installation will be made after the post-lay monitoring and will be presented in the monitoring report for 2012.

## 5.3 Monitoring of Chemical Warfare Agents (CWA) in the sediment

### 5.3.1 Monitoring programme

The purpose of the CWA monitoring programme in Denmark is to document changes of levels of chemical warfare agents in the sediment due to project activities resulting in the disturbance of contaminated sediment originating from disposed chemical munitions.

With the monitoring programme, Nord Stream shall document any changes in the level of chemical warfare agents in the sediment due to project activities resulting in the disturbance of contaminated sediments originating from dumped chemical munitions. Hence, before and after pipe-laying, seabed sampling, laboratory analyses and environmental assessments are conducted.

Figure 5.3 shows the locations for seabed sampling. Sampling is conducted at 29 stations along the midline of the pipelines. At six of these stations, a transect consisting of 15 stations is planned to be sampled /13/. The sampling programme is aligned with the baseline investigations conducted in 2008. Sampling and analysis for CWAs is conducted in June/July 2010 before installation of the first pipeline, in June/July of 2011 after installation of the first pipeline, and in June/July 2012 after installation of the second pipeline.

A summary of the CWA monitoring programme in Denmark is presented in Table 5.3.

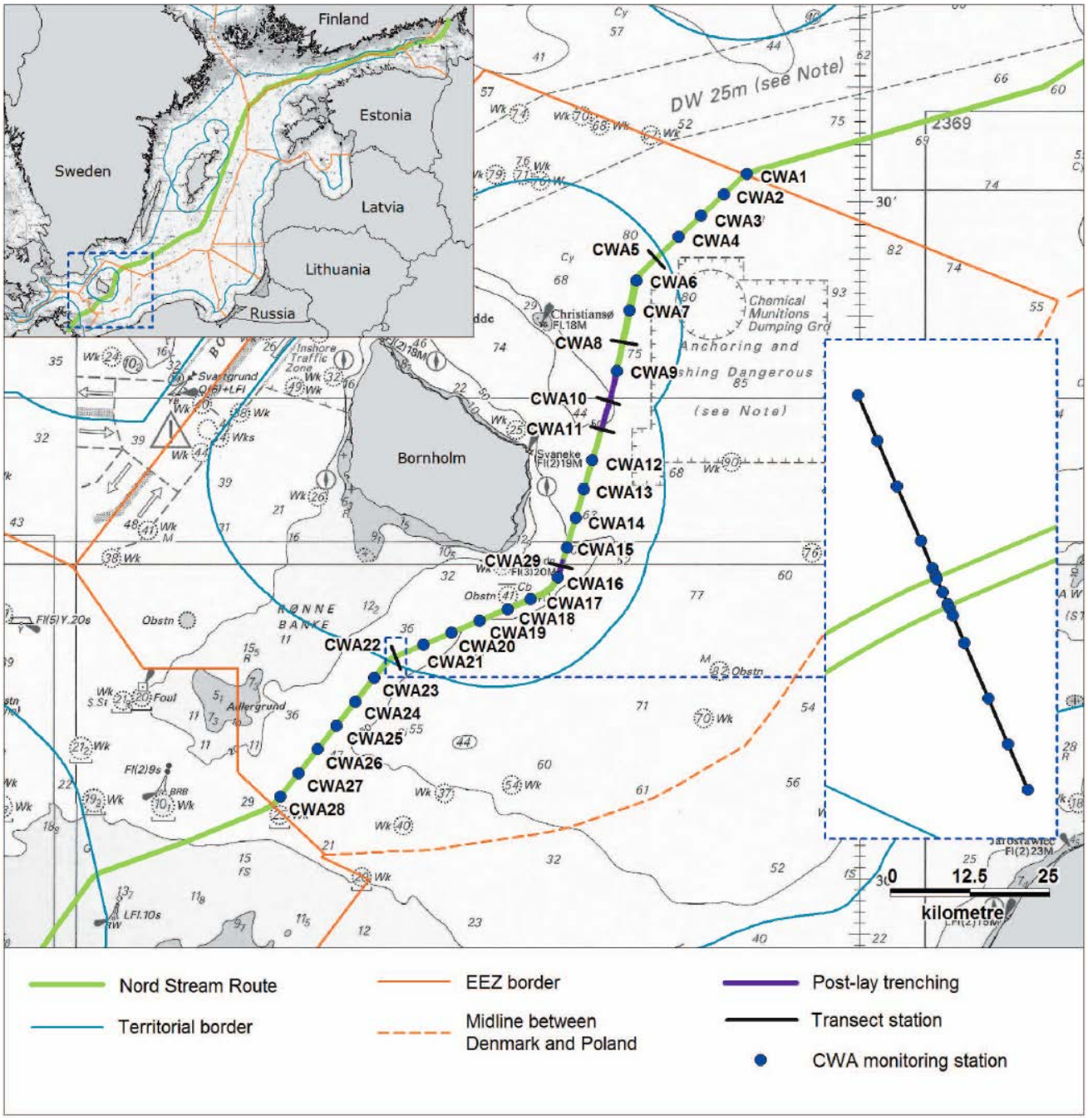


**Figure 5.3** Sediment sampling stations for chemical warfare agents comprising 29 stations along the midline of the pipelines. Six stations are transects stations with 15 stations in each /13/. Sampling of transect CWA 29 proved to be impossible in 2010 due to hard and stony seabed why sampling at CWA 29 the following years have been excluded.

**Table 5.3** Summary of the monitoring programme for concentrations of chemical warfare agents in the seabed sediment in Denmark.

| Seabed sediment in Denmark | |
|---|---|
| **Monitoring of chemical warfare agents** | |
| Purpose | To evaluate and document the changes in concentrations of chemical warfare agents in the seabed sediment |
| Area to be monitored | 29 pipeline route sampling locations and six transect sampling locations |
| Activity to be monitored | Construction of the pipeline |
| Method to be used | Seabed sampling (with subsequent laboratory analysis) |
| Period of monitoring | Before and after construction: 2010, 2011 and 2012. Baseline investigations conducted in 2008 |
| Results | Changes in the concentration of chemical warfare agents in the seabed |

### 5.3.2 Monitoring and results for 2011

The survey in 2011 was confined to 23 stations distributed over the total length of the pipelines and five transects each with 15 sampling each with 15 sampling stations covering an additional 90 stations. The actual sampling programme ended up covering 98 sample stations.

In all of the samples analysed in 2011 no intact warfare agents, i.e. sulphur mustard (H), Thiodiglycol (TDG), Triphenylarsine (TPA), α-chloroacetophenone (CN), Tabun (GA), Lewisite I (L1) were found.

The only findings in 2011 was CWA residues in form of degradation products from Adamsite (DM), Phenyldichloroarsine (PDCA), Clark I, Trichloroarsine (TCA) and a degradation product from Lewisite (L2[ox]).

Re-suspension of CWA-contaminated sediment during pipeline installation will cause an added risk corresponding to a risk quotient (RQ) of 0.0027 at station CWA 10.45 and of 0.0026 at station CWA 11.60 where we have the highest risk towards the fish community /20/. This added risk at the two stations is approximately 380 times lower than RQ=1, where effects on the fish community can be expected.

The RQ from the prevailing quasi steady-state CWA residues concentrations in the pore water of up to 0.17, compared with the RQ value of 0.025 in 2010, indicates no significant additional risk from pipe laying activities.

The 2010 sampling effort detected two CWA related compounds (L2[ox] and PDCA) with a total CWA related exposure of 0.8 µg/L, resulting in a negligible total CWA risk estimate towards the fish community of 0.026 at sampling station CWA 5.1 and CWA 5.14. It was not possible to compare the predicted risk to biota since there were no biota data for the two locations in 2010. In 2011 only one compound was found at the CWA 5 transect, i.e. Adamsite (DM[ox]) (0.03 µg/L with a resulting RQ of 0.001 at CWA 5.11. Thereby the risk of effects to the fish community is only 1/1000 at CWA 11.

The calculated maximum summed risk quotients in 2011 of 0.17 and 0.15 are located at sampling stations CWA 10.45 and CWA 11.60, respectively. Both sampling stations are nearest the dumpsite

for CWA in their respective east-west transects. The CWA 10.45 RQ is dominated by Lewisite II (L2[ox]) and Phenyldichloroarsine (PDCA[ox]) with RQs of 0.078 and 0.056, respectively. The CWA 11.60 RQ is dominated by Phenyldichloroarsine (PDCA[ox]) with RQ of 0.146. The highest added risk from the installation of the pipelines due to sediment disturbance (laying; trenching; sweeping) is calculated to be 0.003 (0.078 µg/L/29 µg/L) at CWA 10.45, where 0.078 µg/L is the added bulk water concentration derived from the measured sediment concentrations. This added risk is less than 1 % of the background steady state CWA related risk in the area.

The implications of altered level of quantification (LOQs) on comparability of measured sediment concentrations between 2010 and 2011 was examined by identifying findings in 2011 that would not have been identified in 2010 given the higher LOQs. Only one finding of DPA [ox] of 8.2 µg/kg DM at CWA 10.32 would not have been found in the previous sampling round. The 2010 and 2011 data sets are therefore directly comparable with respect to detection frequencies and concentration levels.

No conclusions can be made regarding increasing concentration gradients along transects towards the former CWA dumpsite. Although the highest concentrations are found nearest the dumpsite along two transects, the general variability between sampling stations does not correlate with the distance from the dumpsite. This is in accordance with the conclusions in ref. /21/; that there is significant variation even between samples taken within a small area. This could also explain the low detection frequency of the 2010 samples compared to the 2011 samples.

The conclusions relative to exposure for both 2010 and 2011 is:

- That no parent CWA was found.
- That the exposure concentrations are predicted not to represent a risk towards the fish community; compared to the 2008 data and 2010 data.
- That biota is not governed by CWA exposures but rather other background parameters (such as dissolved oxygen, total organic content, depth, sediment characteristics.
- The detection frequencies are comparable (2 % and 10 %) noting the patchiness of detections and hence sample variability.

Comparing the sampling rounds (2008; 2010 and 2011) would suggest that the detection frequencies and levels of CWA residues are comparable between the years, and that the potential CWA-related risks towards the fish and benthic communities are also comparable and low.

The survey in 2012 is planned to take place in June/July. Procedures that were used for the field investigations and the laboratory analysis in the 2011 survey is planned to be used also for the final 2012 survey. So no changes to the monitoring programme are foreseen in 2012.

## 5.4 Monitoring of maritime traffic

### 5.4.1 Monitoring programme, purpose and period of monitoring

The purpose of Nord Stream's control and monitoring in relation to maritime traffic is to minimise the risk of collisions or other accidents involving commercial ship traffic and/or vessels performing construction activities for the project. A number of activities have been, or are being, performed in

order to achieve this goal. Mitigation and risk reducing measures have been analyzed and discussed in risk assessments and have been included and implemented in ship traffic management procedures (or plans). Safety zones of varying sizes are established around all vessels performing underwater construction work. Vessels within the construction spread, or additional vessels, can serve as guard vessels during certain construction activities or in particularly sensitive areas such as shipping lanes. Information on upcoming and ongoing construction activities is provided to the relevant authorities.

The ship traffic management procedures are developed by the contractors before the start of the construction activities to ensure the safety of both third party shipping and the vessels involved in the construction works. These procedures include e.g. normal and emergency communication lines and flowcharts, safety measures and responsibilities, required safety zones and vessel management systems (such as Automatic Identification System (AIS) for identification and locating of vessels).

Safety zones of varying sizes are established in agreement with the Danish authorities around all vessels performing underwater construction work. No other vessels are allowed to enter this zone without permission from the working vessel's captain. In line with the watch keeping procedures the traffic is regularly monitored visually and by radar. The track and speed of any vessel approaching the safety zone is monitored and any vessel on course to enter the safety zone is contacted and requested to change course. Vessels within the construction spread (or additional vessels) can also act as guard vessels during certain construction activities or in particularly sensitive areas such as shipping lanes. In case radio contact with a vessel is not established, the guard vessels are able to intervene and potentially intercept an approaching vessel.

When operating in Danish waters a daily report is transmitted from the vessels of all construction activities. These reports include e.g. the vessel name, call sign, present position and plan for the next 24 hours. Before and during construction the locations of the construction vessels are announced in 'Notices to Mariners' by the Danish Maritime Safety Administration in order to increase the awareness of project generated ship traffic.

Prior to the commencement of construction activities Nord Stream has informed the fishing associations about the planned activities and safety zones of various construction works. Throughout the construction period regular information is made available (e.g. weekly newsletter) addressing construction vessels, work scopes and potential safety concerns.

The control and monitoring of marine traffic is of high importance during the whole construction phase of the project.

### 5.4.2 Monitoring and results for 2011

Safety measures have been successfully implemented, and there have been no accidents or significant incidents with third party vessels in 2011.

## 6 Comparison of monitoring results from 2011 with assessment in the Danish EIA

A comparison of the monitoring results at the specific monitoring locations with the description of the existing environmental conditions (baseline) in the Danish Environmental Impact Assessment (EIA) shows that the findings from monitoring of benthic fauna, fish along the pipeline and monitoring of chemical warfare agent (CWA) in 2011 are in accordance with the description and assessment of these parameters in the Danish EIA. The results from monitoring of these parameters after Line 1 was established showed no significant changes compared with the results from baseline monitoring in 2010.

The comparison of the monitoring results with the assessment of effects and impacts in the Danish EIA is only possible for monitoring programmes that have been fully finalised. For the period 2010 - 2011 this includes environmental monitoring in connection with:

- Cable crossings for Line 1 and Line 2 (finalised in 2010)
- Water quality for Line 1
- Hydrographic conditions in the Bornholm Basin for Line 1
- Cultural heritage for Line 1
- Munitions for Line 1
- Maritime traffic for Line 1
- National and international monitoring stations close to/relatively close to the Nord Stream Pipeline for Line 1 and Line 2 (finalised in 2010).

Monitoring in relation to cable crossings for Line 1 was finalised in 2010 and effects on the seabed were as assessed in the EIA evaluated to be local and insignificant.

Based on the results from monitoring of water quality for Line 1 in 2010 – 2011 it was concluded that sediment dispersion from the trenching works was restricted to the very close vicinity of the construction area, and with 22 mg/l as the the highest concentration measured. Furthermore, it has been shown that the assumptions regarding sediment spill and sediment spreading in the Danish EIA were conservative (i.e. on the safe side). Sediment spill was measured to be approximately 7 kg/s compared to 16 kg/s that was adopted in the modelling for the Danish EIA.

The results from monitoring hydrography conditions in the Bornholm Basin showed that the mixing between inflowing saline and oxygenated water and overlying water masses caused by the pipelines on the seabed in the Bornholm Basin will be approximately five times less, from 0-1% to 0-0.2%, than estimated and presented in the Danish EIA.

Results from the pre-lay monitoring wreck inspections in October 2010 and the post-lay monitoring in November 2010 and January 2011, showed that no protected wrecks have been affected during installation of Line 1.

The results from monitoring of munitions for Line 1 were that no disturbance of the chemical munitions objects had taken place during pipeline installation.

As assessed in the EIA the effects on the maritime traffic in 2011 were local, short term and insignificant.

Monitoring in relation to national and international monitoring stations was finalised in 2010 and showed that there would be no impacts on any of these stations from construction and operation of the Nord Stream Pipeline.

## 7 Conclusion and recommendations

Based on the results from the Nord Stream monitoring for 2011 it is concluded that effects and impacts on the marine environment have been limited to the immediate vicinity of the pipelines. This is in accordance with assessments in the Danish EIA. Furthermore, impacts have been assessed to be local and of minor to insignificant effect.

The monitoring of benthic infauna at the two transects showed that the benthic community was dominated by the same species as in 2010. Since 2010 the abundance of the polychaete *Bylgides sarsi* and the crustacean *Diastylis lucifera* has declined at the transects. However, the average abundance and biomass of the benthic fauna has increased since 2010. Furthermore, it is concluded that the recorded temporal changes in benthic fauna since 2010 and the spatial differences in 2011 are results of natural changes in the composition and structure of the benthic community.

The monitoring of benthic epifauna on the pipeline was undertaken 1 – 5 months after pipelay. Based on the relatively short colonisation period the monitoring results match the expectations, namely that no sessile epifauna have had time to colonise the pipeline yet.

The results from monitoring of fish along the pipeline showed no difference in the structure of the demersal assemblage between the 2011 survey and the baseline survey in 2010. The focus of the study has been on cod since it is a demersal fish species in the areas, and because the catches of cod were high throughout the entire sampling. To summarize, the results from the first survey, after establishment of Line 1, showed temporal variations, but no impact from the pipeline on fish composition or presence of cod was observed.

The results from monitoring of CWA showed that degradation products of CWA were found in 10 samples. The concentration was however very low and the risk of impacts on the fish community, was as for 2008 and 2010, calculated to be insignificant.

The results of the water quality monitoring during construction of Line 1 in Danish waters confirmed that the assumptions regarding sediment spill and sediment spreading for the EIA for the Danish part of the pipeline were conservative (i.e. on the safe side). The measured sediment spill rate were measured to be around 7 kg/s, approximately one third of the sediment spill rate assumed in the numerical modelling of sediment spreading that made the basis for the Danish EIA.

The results from monitoring of hydrographic effects in the Bornholm Basin showed that the effects caused will at most be 20% of the worst case estimations presented in /4/, and even these were well

below any level of effect that could be measurable as being a result of the pipelines being established on the seabed.

Wreck monitoring after installation of the first pipeline and prior to Line 2 installation was conducted in January 2011. The results have documented that cultural heritage sites under protection were not damaged or disturbed during the construction of Line 1.

Detailed munitions surveys have led to the discovery of five chemical munitions objects relatively close to the Nord Stream route for Line 1. The Admiral Danish Fleet have assessed these objects and it has been agreed with the Admiral Danish Fleet that the chemical munitions are to be left on the seabed and not disturbed during installation of the Nord Stream Pipeline. Installation of Line 1 was completed without disturbance of the five munitions objects.

Separate reports have been elaborated for the 2011 annual reporting for the following issues:

- Monitoring of fish along the pipeline, Denmark 2011
- Monitoring of benthic fauna, Denmark 2011
- Monitoring of water quality, Denmark 2011
- Hydrographic monitoring in the Bornholm Basin 2010-2011
- Monitoring of CWA, Denmark 2012.
- Monitoring of munitions, Denmark 2011
- Monitoring of cultural heritage, Denmark 2011.

The annual monitoring report for 2012: “Environmental monitoring in Danish waters 2012” will include the same issues as included in the 2010 and 2011 reports, except monitoring of hydrographic conditions in the Bornholm Basin, which was completed in 2011.

The 2011 monitoring surveys have been undertaken as planned, and procedures used in the 2011 survey will be updated for the 2012 survey based on findings and recommendations. Based on the execution and the results from monitoring in 2011, it is evaluated that there will be no need for further changes of the monitoring programmes for 2012.

## 8 References

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/5/ Energistyrelsen, **2009**, "Permit to section of the Nord Stream natural gas pipelines in Danish sea area. File no. 1110/8609-0002".

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/7/ H.Sandersson and P.Fauser, **2012**, "Analysis of fish community risk due to exposure to Chemical Warfare Agents (CWAs) from perturbed sediment along and between the two gas pipelines east of Bornholm. Scientific Report from DCE - Danish Centre for Environment and Energy, 2012".

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/9/ Ramboll O&G / Nord Stream AG, **2010**, "Monitoring Stations in Danish Waters. G-PE-EMS-MON-100-05160000-C".

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/11/ Ramboll O&G / Nord Stream, **2010**, "Scope of Work for Monitoring of Mobilised Sediments during Construction in Danish Water. G-PE-EMS-MON-100-05120000 Rev. C".

/12/ Ramboll O&G / Nord Stream, **2010**, "Scope of Work for Visual Monitoring of Munitions and Cultural Heritage in Danish Waters. G-PE-PERREP-100-05130000 Rev. C".

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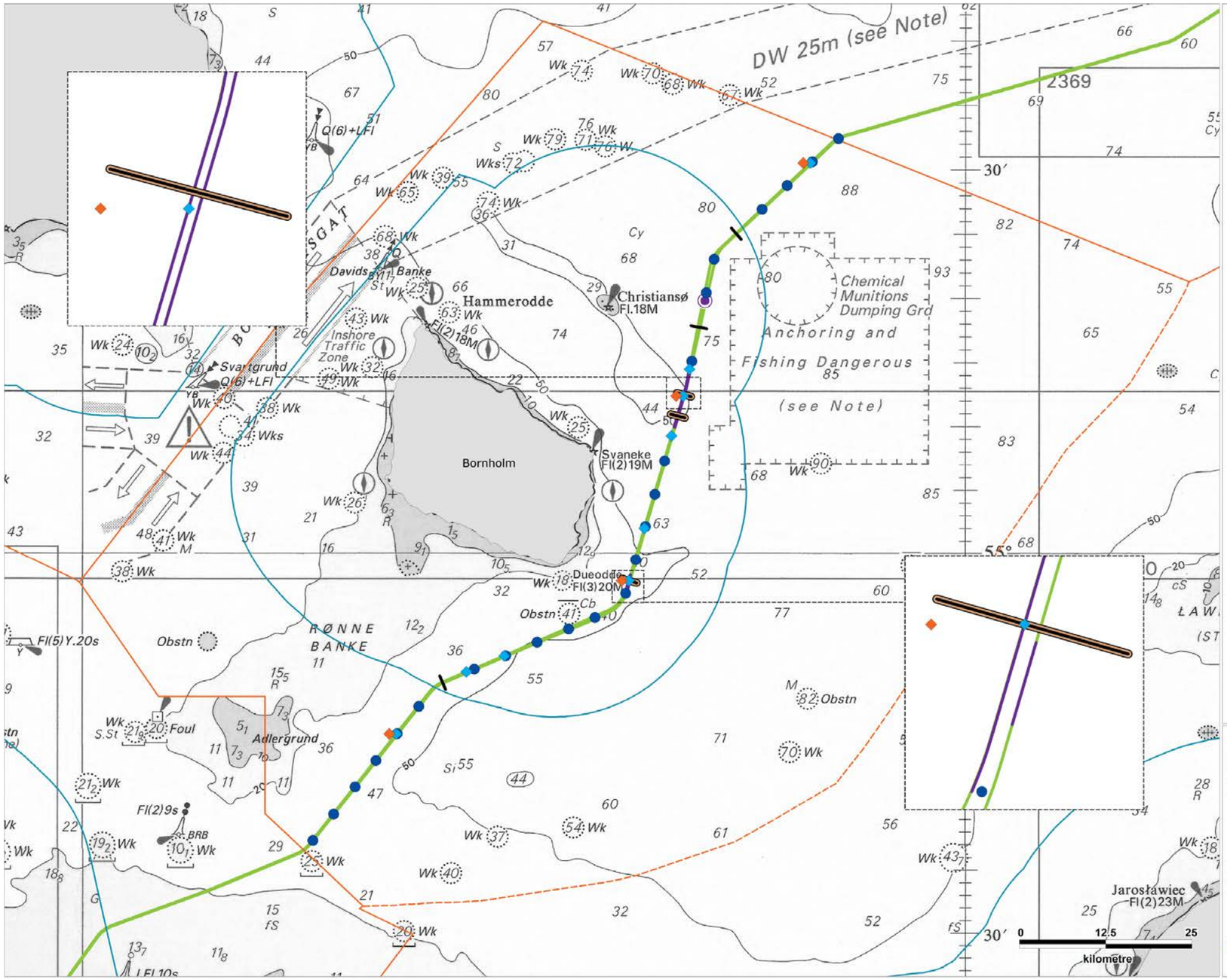
/21/ Finnish Institute for Verification of the Chemical weapons Convention (Verifin), **2011**, "Final Report on Chemical Analysis of Sea-Dumped Chemical Warfare Agents in Sediment Samples, 2011 Report. 2. november 2011. VER-MS-0245.".

## 9 Revision record

| Rev. | Date | Description | Prepared | Checked | Approved | Checked | Approved |
|---|---|---|---|---|---|---|---|
| | | | Ramboll | | | Nord Stream | |
| 02 | 2012-03-13 | Issue for comments | JLA | JCA | NES | SAN | NAN |
| 03 | 2012-03-24 | Issue for comments | JLA | JCA | NES | SAN | NAN |
| 04 | 2012-03-29 | Issue for comments | JLA | JCA | NES | SAN | NAN |
| 05 | 2012-04-04 | Issue for comments | JLA | JCA | NES | SAN | NAN |
| A | 2012-04-10 | Issue for Use / Construction | JLA | JCA | NES | SAN | NAN |

# APPENDIX A

Map of Nord Stream monitoring stations in the Danish EEZ




**Legend :**

- Nord Stream Route
- Territorial border
- EEZ border
- Midline between Denmark and Poland

**Water monitoring:**

- Trenching

**Sediment sampling:**

- CWA monitoring station
- Transect

**Monitoring of fish and epifauna:**

- Fish monitoring station/ Epifauna monitoring station
- Reference station

**Monitoring of infauna:**

- Benthic transect

**Monitoring of the hydrography:**

- Hydrographic monitoring station

General references:
- Pipeline rev. C.16.5 (May 2009).
- Limits of Exclusive Economic Zones and Territorial Waters: IBRU January 2010.
- Background sea charts are "Not to be used for navigation".
- Background sea chart, © Crown Copyright. Reproduced by permission of the Controller of Her Majesty's Stationery Office and the UK Hydrographic Office (www.ukho.gov.uk).

Edition: a
Date: 11-04-2011
Prep: MRIH
Control: JLA
Case no.: 7774001

## Map MON-02

## Monitoring stations in Danish waters

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