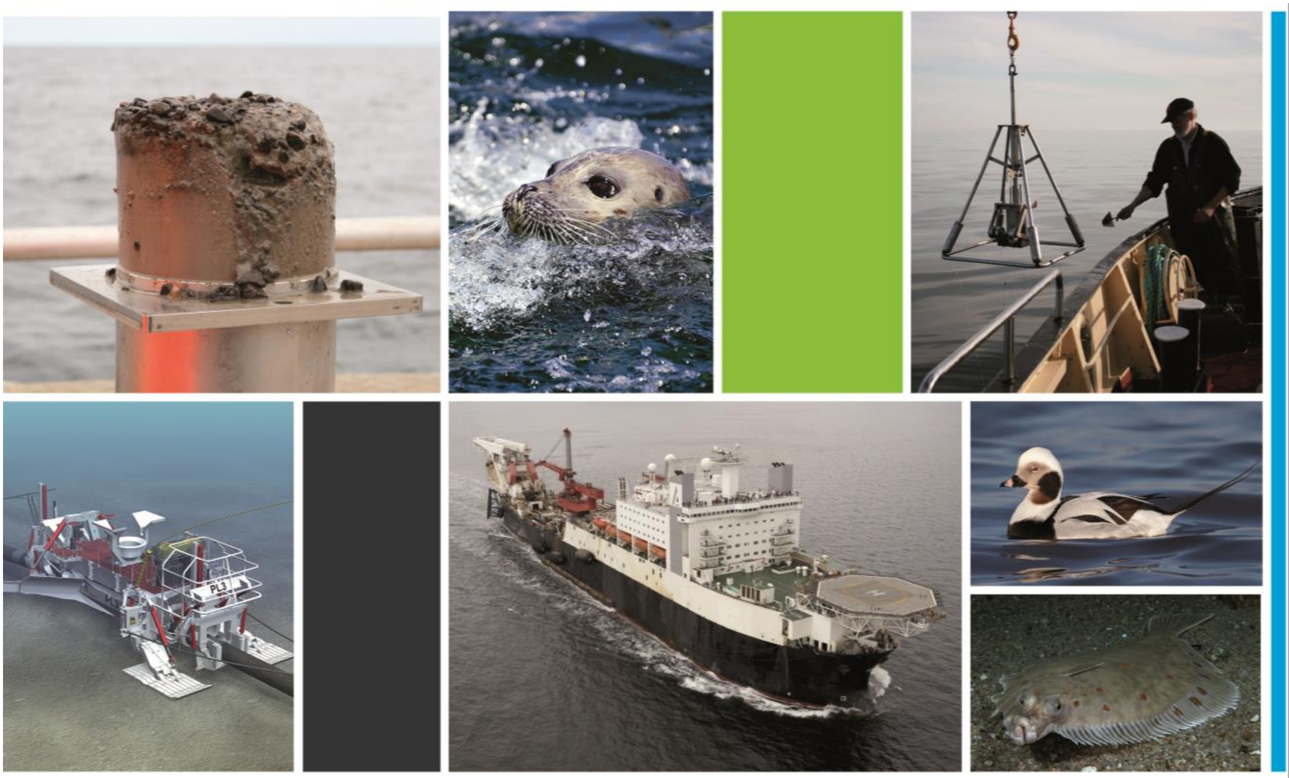
Nord Stream 2 AG

March 2017



NORD STREAM 2
ENVIRONMENTAL IMPACT ASSESSMENT, DENMARK

Document no. W-PE-EIA-PDK-REP-805-010100EN

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NORD STREAM 2
Environmental Impact Assessment, Denmark

This EIA document “Nord Stream 2, Environmental impact assessment, Denmark” has been translated from the English original version to a Danish version “Nord Stream 2, Vurdering af Virkninger på Miljøet, Danmark”. In the event that the translated version and the English version conflict, the English version shall prevail.

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APPENDICES

ABBREVIATIONS

ADCP	Acoustic doppler current profiler
ADF	Admiral Danish Fleet
AFDW	Ash-free dry weight
AIS	Automatic identification system
ALARP	As low as reasonably practicable
As	Arsenic
ASEAN	Association of Southeast Asian Nations
AWTI	Above-water tie-in
BAC	Background assessment criterion
BAT	Best available techniques
BCM	Billion cubic metres
BES	Bad environmental status
BGR	Bundesanstalt für geowissenschaften und rohstoffe
BNetzA	German Bundesnetzagentur
BUCC	Back-up control centre
approximately	Circa
CAPEX	Capital expenditure
CBD	Convention on biological diversity
Cd	Cadmium
CERA	Cambridge Energy Research Associates
cf.	Confer
CFP	Common fisheries policy
CFSR	Climate forecast system reanalysis
CH	Methylidyne
CHEMSEA	Chemical munitions search and assessment
CHO	Cultural heritage object
CITES	Convention on international trade in endangered species of wild fauna and flora
cm	Centimetre(s)
CMS	Conservation of migratory species
CO	Carbon monoxide
Co	Cobalt
CO_2	Carbon dioxide
CO_2	Carbon dioxide
Cr	Chromium
CTDO	Conductivity, temperature, depth and oxygen
Cu	Copper
CWA	Chemical warfare agent(s)
CWC	Concrete-weight-coated / concrete-weight-coating
dB	Decibel(s)
DBT	Dibenzothiophene
DCE	Danish Centre for Environment and Energy
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEA	Danish Energy Agency
DECC	United Kingdom Department of Energy & Climate Change
DIN	Dissolved inorganic nitrogen
DIP	Dissolved inorganic phosphorus
DNV	Det Norske Veritas
DNV GL	Det norske veritas and germanischer lloyd (international certification body and classification society)
DP	Dynamically positioned
DW	Dry weight
EAC	Environmental assessment criteria
EC	European Commission
EEZ	Exclusive economic zone

EGIG	European Gas Pipeline Incident Data Group
EHS	Environmental, health, and safety
EIA	Environmental impact assessment
ENTSOG	European network of transmission system operators for gas
EOD	Explosive ordnance disposal
ER	Eutrophication ratio
ERL	Effect-range low
ES	Route east of NSP (preferred route)
ESMS	Environmental and social management system
EQS	Environmental quality standards
ESPO	Eastern siberia-pacific ocean oil pipeline
EU	European Union
EU 28	European Union Member States
Fe	Iron
FIMR	Finnish Institute of Marine Research
FOGA	Fishermen's information on oil and gas activities
FS	Route west of nsp
FTA	Finnish Transport Agency
FTU	Formazin Turbidity Unit
GES	Good environmental status
GHG	Greenhouse gas
GPS	Global positioning system
g/m^2	Grams per square metre
HAZID	Hazard identification
HC	Hydrocarbon
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HD	Hydrodynamic
HFO	Heavy fuel oil
Hg	Mercury
HSE	United kingdom health and safety executive
HSES	Health, safety, environmental and social
HSS	Heat-shrinkable sleeve
HUB	Helcom underwater biotope and habitat classification system
Hz	Hertz
H_2S	Hydrogen sulphide
IBA	Important bird and biodiversity area
ICES	The International Council for the Exploration of the Sea
IEA	International Energy Agency
IFC	International Finance Corporation
IFO	Intermediate fuel oil
IMO	International Maritime Organization
In	Indium
ISO 14001	International standard on environmental management
IUCN	International union for conservation of nature and natural resources
kg	Kilogram(s)
km	Kilometre(s)
km^2	Square kilometre(s)
KP	Kilometre point
kW-days	Kilowatt days, a way to measure the effectiveness of the fishing effort
kWh	Kilowatt hours
kHz	Kilohertz
LAL	Lower action level
LBK	Lovbekendtgørelse (the danish word for consolidation act)
LC	Least concern
LFFG	Landfall facility germany
LFFR	Landfall facility russia
LFL	Lower flammable limit

LLOQ	Lowest limit of quantitation
LMIU	Lloyd's maritime intelligence unit
LNG	Liquefied natural gas
LOI	Loss of ignition
LTE	Land termination end
m	Metre(s)
m^3	Cubic metre(s)
MAB	Unesco man and the biosphere programme
max.	Maximum
MBES	Multibeam echosounder
MBT	2-mercaptobenzothiazole
MCC	Main control centre
MCDA	Multiple-criteria decision analysis
MDO	Marine diesel oil
MES	Moderate environmental status
MFO	Medium fuel oil
MGO	Marine gas oil
mg/l	Milligrams per litre
mg/m^3	Milligrams per cubic metre
mio. t.	Million tonnes
ml/l	Millilitres per litre
mm	Millimetre(s)
MPA	Marine protected area
MS	Management system
MSFD	Marine strategy framework directive
MWh	Megawatt hours
m/h	Metres per hour
N	Nitrogen
n	Number
NA	Not applicable
NCEP	National centers for environmental protection
NE	North-east
ng/kg	Nanograms per kilogram
Ni	Nickel
NIS	Non-indigenous species
nm	Nautical mile
NOAA	National oceanic and atmospheric administration (US)
NO_X	Nitrogen oxide
NSP	Nord stream 1 pipeline system
NSP2	Nord stream 2 pipeline system
NT	Near threatened
N_{tot}	Average normalized annual input of nitrogen
NTU	Nephelometric turbidity units
OECD	Organisation for Economic Co-operation and Development
OHSAS 18001	International standard on occupational health and safety management
OIES	Oxford Institute for Energy Studies
OSPRP	Oil spill prevention and response plan
P	Phosphorus
PAH	Polyaromatic hydrocarbon
PARLOC	Pipeline and riser loss of containment
Pb	Lead
PCB	Polychlorinated biphenyls
PEC	Predicted environmental concentration
PGA	Peak ground acceleration
PID	Project information document
PIG	Pipeline inspection gauge
PM	Particulate matter
PNEC	Predicted no-effect concentration

POP	Persistent organic pollutant
PPS	Porpoise positive seconds
PSU	Practical salinity unit
PTA	Pig trap area
PTS	Permanent threshold shift
P_{tot}	Average normalized annual input of phosphorus
QA/QC	Quality assurance/quality control
RA	Route alternative
RE	Regionally extinct
RMS	Root mean square
ROV	Remotely operated vehicle
RQ	Risk quotient
SAC	Special area of conservation
SAMBAH	Static acoustic monitoring of the baltic sea harbour porpoise
SAP	Salmon action plan
SCADA	Supervisory control and data acquisition
SCI	Site of community importance
SECA	Sulphur emission control area
SEL	Sound exposure level
Si	Silicon
SMHI	Swedish Meteorological and Hydrological Institute
SOPEP	Shipboard oil pollution emergency plan
SO_X	Sulphur oxides
SO_2	Sulphur dioxide
SPA	Special protection area
SPL	Sound pressure level
SSC	Suspended sediment concentration/suspended solids concentration
SSS	Side-scan sonar
T	Tonne(s)
TANAP	Trans-Anatolian Pipeline
TAP	Trans-Adriatic Pipeline
TAPI	Turkmenistan-Afghanistan-Pakistan-India pipeline
TBT	Tributyltin
tcm	Trillion cubic meter
TDC	Telecommunications company in denmark
TOC	Total organic carbon
TSP	Total suspended particles
TSS	Traffic separation scheme
TTS	Temporary threshold shift
TW	Territorial waters
Twh	Terawatt hours
UGSS	Unified gas supply system
UK	United Kingdom
UN	United Nations
UNECE	United nations economic commission for europe
UNESCO	United nations educational, scientific and cultural organization
US	United States of America
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
UXO	Unexploded ordnance
V	Vanadium
VERIFIN	Finnish institute for verification of the chemical weapons convention
VMS	Vessel monitoring system
VOC	Volatile organic compound
VU	Vulnerable
WHO	World health organization
WWI	World war i
WWII	World war ii

Zn	Zinc
°C	Degrees celsius
μg/l	Micrograms per litre
μmol/l	Micromoles per litre
.	Decimal mark used to separate the integer from the fractional part of a number written in decimal form i.e. 2.5.
,	Thousand separator used in digit grouping i.e. 2,500

DEFINITIONS

Aarhus Convention	Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters.
Affected Communities	Groups of people that may be directly or indirectly impacted (both negatively and positively) by the Project.
Affected Party	The contracting parties (countries) to the Espoo Convention likely to be affected by the transboundary impact of a proposed activity.
Anchor corridor	Offshore corridor within which pipe-lay vessels would be deploying anchors.
Anchor corridor survey	Survey for sections where the pipeline may be installed by anchor lay vessel, to ensure that there is a free corridor for anchoring the lay vessel.
Anoxia	Condition of oxygen depletion in the sea.
Appropriate Assessment	Environmental assessment of impacts required under the Habitats Directive of the European Commission. Appropriate assessment is required when a plan or project is potentially affecting a Natura site.
ASCOBANS	Agreement on the conservation of small cetaceans of the baltic, north east atlantic, irish and north seas
Ballast Water Management Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments.
Bern Convention	Convention on the Conservation of European Wildlife and Natural Habitats.
Cathodic protection (sacrificial anodes)	Anti-corrosion protection provided by sacrificial anodes of a galvanic material installed along the pipelines to ensure the integrity of the pipelines over their operational lifetime.
CBD	Convention on Biological Diversity
Chance find	Potential cultural heritage, biodiversity component, or munition object encountered unexpectedly during project implementation.
Chemical warfare agent	Hazardous chemical substances contained in chemical munitions.
CMS	Convention on the Conservation of Migratory Species of Wild Animals
Commissioning	The filling of the pipelines with natural gas.
Contractor	Any company providing services to Nord Stream 2 AG.
Cultural heritage	A unique and non-renewable resource that possesses cultural, scientific, spiritual or religious value and includes moveable or immoveable objects, sites structures, groups of structures, natural features, or landscapes that have archaeological, paleontological, historical, cultural, artistic, and religious values, as well as unique natural environmental features that embody cultural values.
Decommissioning	Activities carried out when the pipeline is no longer in operation. The activities take into account long term safety aspects and aim at minimizing the environmental impacts.
Descriptor	A high level parameter characterizing the state of the marine environment
Detailed geophysical survey	Survey of a 130 m wide corridor along each pipeline route utilising side-scan sonar, sub-bottom profilers, swath bathymetry and magnetometer.
ES route	NSP2 route alternative that runs east of the existing NSP route.
EU Birds Directive	The Birds Directive aims to conserve all wild birds in the EU by setting out rules for their protection, management and control
EU EI Directive	Environmental Information Directive ensures compliance with the requirements under the Aarhus Convention
EU EIA Directive	Requires that projects which are likely to have significant effect to the environment are assessed on the basis of an Environmental Impact Assessment
EU Habitats Directive	Ensures the conservation of a wide range of rare, threatened or endemic animal and plant species. The EU Habitats Directive also protects habitats.
EU MSFD	The Marine Strategy Frameword Directive aims to achieve "good environmental status" ("GES") of the EU marine waters by 2020
EU MSP	The Maritime Spatial Planning Directive creates a common framework for maritime spatial planning in Europe

EU PP Directive	Public Participation Directive ensures compliance with the requirements under the Aarhus Convention
EU WFD	The Water Framework Directive has a number of objectives, such as preventing and reducing pollution, promoting sustainable water usage, environmental protection, improving aquatic ecosystems and mitigating the effects of floods and droughts
Espoo convention	Convention on Environmental Impact Assessment in a Transboundary Context.
Exclusion zone	Area surrounding a cultural heritage, biodiversity component, or munition object within which no activities shall be performed and no equipment shall be deployed.
Exclusive economic zone	An exclusive economic zone (EEZ) is a sea zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights regarding the exploration and use of marine resources, including energy production from water and wind.
Freespan	A section of the pipeline raised above the seabed due to an uneven seabed or the pipeline span between rock berms made by rock dumping.
FS route	NSP2 route alternative that runs west of the existing NSP route.
Geotechnical survey	Cone penometer and Vibrocorer methods that provide a detailed understanding of the geological conditions and engineering soil strengths along the planned route. The geotechnical survey assists in optimising the pipeline route and detailed design including the required seabed intervention works to ensure long-term integrity of the pipeline system.
Good environmental status	The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive (Marine Strategy Framework Directive, Article 3).
Halocline	Level of maximum vertical salinity gradient.
HELCOM	Helsinki convention, the baltic marine environment protection commission.
HELCOM Marine Protected Area	Valuable marine and coastal habitat in the Baltic Sea that has been designated as protected.
HSES	Health, Safety, Environmental and Social. "Safety" incudes security aspects for personnel, assets and project affected communities.
HSES Plan	A written description of the system of HSES management for the contracted work describing how the significant HSES risks associated with that work will be controlled to an acceptable level and how, where appropriate, interface topics shall be managed.
LIFE+	EU funding instrument for environmental and climate related actions.
London convention	Convention promotes the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter
Management standard	ISO management system standards provide a model to follow when setting up and operating a management system. The benefits of an effective management system include: more efficient use of resources; improved risk management, and increased customer satisfaction as services and products consistently deliver what they promise.
MARPOL 73/78	The international convention for the prevention of pollution from ships
MARPOL 73/78 SA	A MARPOL 73/78 Special Area means a sea area where for recognized technical reasons in relation to its oceanographical and ecological condition and to the particular character of its traffic the adoption of special mandatory methods for the prevention of sea pollution by oil is required.
Mattress	Rock material tied together by a steel grid laid on the seabed to raise the pipeline above the seabed. Typically used at crossings of cables and other pipelines.
Mitigation measure	Measures implemented to avoid, minimise or compensate for a social, economic or environmental impact.
Munitions clearance	Removal of unexploded munitions found on the seabed in the construction area.
Munitions screening survey	Detailed gradiometer survey carried out to identify unexploded ordnance (UXO) or chemical warfare munitions that could endanger the pipeline or personnel during the installation and operating life of the pipeline system.
Natura 2000	EU-wide network of nature protection areas established under the 1992 Habitats Directive.
Nord Stream 2 AG	Project company established for the planning, construction and subsequent operation of the Nord Stream 2 Pipeline.
OSPAR	Oslo-paris convention, the current legal instrument guiding international cooperation on the protection of the marine environment of the north-east atlantic
PIG	Pipeline Inspection Guages are pressure driven through the pipeline to clean and/or to investigate the condition of the pipeline.
Pig trap area (PTA)	Pig trap areas are permanent above ground facilities located at the upstream and downstream limits of the NSP2 pipeline and used during the life of the pipeline to perform intelligent pigging operations, monitoring and control functions and certain maintenance operations.

Pigging	Pigging in the context of pipelines refers to the practice of using devices known as "pigs" to perform various maintenance operations. This is done without stopping the flow of the product in the pipeline.
Pipe-lay	The activities associated with the installation of a pipeline on the seabed.
Pipe-lay survey	Survey to be performed just prior to the commencement of construction to confirm the previous geophysical survey and to ensure that no new obstacles are found on the seabed. ROV bathymetric and visual inspection survey will be undertaken for theoretical pipeline touchdown points on the seabed.
Post-lay trenching	The burying of a pipeline in a trench on the seabed after the pipeline has been laid on the seabed.
Pre-commissioning	Activities carried out before gas filling of the pipeline to confirm the pipeline integrity.
Project	All activities associated with the planning, construction, operation and decommissioning of the Nord Stream 2 pipeline system.
Pycnocline	A level of maximum vertical density gradient, caused by vertical salinity (halocline) and/or temperature (thermocline) gradients.
RA route	NSP2 direct route alternative that runs through an area where anchoring and fishing are discouraged.
Ramsar Convention	Convention on Wetlands of International Importance.
Reconnaissance survey	Survey providing information on the preliminary pipeline route, including geological and anthropogenic features, the surveys typically cover a 1.5 km wide corridor and are performed by various techniques including side-scan sonar, sub-bottom profilers, swath bathymetry and magnetometers.
Rock placement	Use of unconsolidated rock fragments graded in size to locally reshape the seabed, thereby providing support and cover for sections of the pipeline to ensure its long-term integrity. The rock material is placed on the seabed by a fall-pipe.
ROV	Remotely operated underwater vehicle which is tethered and operated by a crew aboard a vessel.
Safety zone	An area surrounding a cultural heritage, biodiversity component, or munition object within which no activities shall be performed and no equipment shall be deployed.
SEA Directive	Strategic environmental assessment directive
Seabed intervention works	Works aiming at ensuring the long term pipeline integrity and including rock placement and trenching
Stakeholders	Stakeholders are defined as persons, groups or communities external to the core operations of the Project who may be affected by the Project or have interest in it. This may include individuals, businesses, communities, local government authorities, local nongovernmental and other institutions, and other interested or affected parties.
Supplier	Any company supplying goods or materials to Nord Stream 2 AG.
Territorial waters	Territorial waters or a territorial sea as defined by the 1982 United Nations Convention on the Law of the Sea, is a belt of coastal waters extending at most 12 nautical miles (22.2 km; 13.8 mi) from the baseline (usually the mean low-water mark) of a coastal state.
Thermocline	Level of maximum vertical temperature gradient.
Tie-ins	The connection of two pipeline sections. Tie-ins can be made on the seabed (called hyperbaric weld tie-ins) or by lifting the pipeline sections to be connected above water (called above water tie-ins).
Trenching	Burial of the pipeline in the seabed.
UNCLOS	United nations convention on the law of the sea
Weight-coated pipes	Pipe joints coated with concrete to increase weight.

1 INTRODUCTION

Nord Stream 2 is a planned twin pipeline system that can transport natural gas from the world's largest reserves in Northern Russia to supply homes and businesses across Europe. Nord Stream 2 will build capacity into the supply system to add flexibility and safeguard Europe's long-term energy security.

Supported by leading international energy companies, the project builds on the success and experience of Nord Stream, twin pipelines through the Baltic Sea put into operations in 2011 and 2012. The new pipelines will increase capacity along the Baltic Sea route from Russia to Germany.

The route through the Baltic Sea is the most direct connection between the gas reserves in Russia and markets in the European Union. The pipelines will cross the territorial waters and/or exclusive economic zones of Russia, Finland, Sweden, Denmark, and Germany.

The Nord Stream 2 is subject to national legislation in each of the countries through which it crosses. In accordance with the requirements of country-specific national legislation, national permit applications for construction and operation and documentation for the Environmental Impact Assessment (EIA) will be submitted in all five countries. In addition, international consultation will be undertaken according to the Espoo Convention all countries possibly affected by the Nord Stream 2 the opportunity to review the transboundary impacts that the pipelines could potentially have on the environment.

In Denmark, an environmental impact assessment (EIA) is an integrated part of the permitting procedure for a pipeline, and must be prepared in accordance with the Danish Administrative Order (14/19/2015) on Offshore Environmental Impact Assessment (EIA).

This Environmental Impact Assessment has been prepared specifically for the Danish Sector of the Nord Stream 2 Pipeline. The EIA provides information on the current environment in the project area and the different existing and planned interests. It describes how the route corridor for the pipelines has been chosen, and the anticipated environmental impacts from the construction and operation of the pipeline system.

2 BACKGROUND

2.1 The Nord Stream 2 Pipeline Project

Nord Stream 2 is a pipeline system through the Baltic Sea planned to deliver natural gas from vast reserves in Russia directly to the European Union (EU) gas market. The pipeline system will contribute to the EU's security of supply by filling the growing gas import gap and by covering demand and supply risks expected by 2020.

The twin 1,200-kilometre subsea pipelines will have the capacity to supply about 55 billion cubic metres of gas per year in an economic, environmentally safe and reliable way. The privately funded €8 billion infrastructure project will enhance the ability of the EU to acquire gas, a clean and low carbon fuel necessary to meet its ambitious environmental and decarbonisation objectives.

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

The Nord Stream 2 Pipeline Project envisages construction and subsequent operation of twin subsea natural gas pipelines with an internal diameter of 1,153 millimetres (48 inches). Each pipeline will require approximately 100,000 24-tonne concrete-weight-coated (CWC) steel pipes laid on the seabed. Pipe-laying will be done by specialised vessels handling the entire welding, quality control and pipe-laying process. Both pipelines are scheduled to be laid during 2018 and 2019, in order to facilitate testing and commissioning of the system at the end of 2019.

The route will stretch from Russia's Baltic coast near Ust-Luga, west of St Petersburg to the landfall in Germany, near Greifswald. The Nord Stream 2 routing is largely parallel to Nord Stream. Landfall facilities in both Russia and Germany will be separate from Nord Stream.

Nord Stream 2 – like Nord Stream – transports gas supplied via the new northern gas corridor in Russia from the fields on the Yamal peninsula, in particular the supergiant field of Bovanenkovo. The production capacity of the Yamal peninsula fields are in the build-up phase, while producing fields from the previously developed Urengoy area that feed into the central gas corridor have reached or passed their plateau production. The northern corridor and Nord Stream 2 are efficient, modern state-of-the-art systems, with an operating pressure of 120 bar onshore and an inlet pressure of 220 bar to the offshore system.

The Nord Stream 2 Pipeline will be designed, constructed and operated according to the internationally recognised certification DNV-OS-F101 which sets the standards for offshore pipelines. Nord Stream 2 AG has engaged DNV GL, the world's leading ship and offshore classification company, as its main verification and certification contractor. DNV GL will verify all phases of the project.

The downstream transport of gas supplied by Nord Stream 2 to the European gas hubs will be secured by upgraded capacity (NEL pipeline) and newly planned capacity (EUGAL pipeline), developed simultaneously by separate transmission system operators (TSO). Thus, the new downstream infrastructure will be delivering gas to Germany and north-western Europe as well as to central and south-eastern Europe via the gas hub in Baumgarten, Austria, complementing the southern corridor. This will strengthen the EU's gas infrastructure, hubs and markets and will complement the existing infrastructure.

The new state-of-the-art gas supply infrastructure will be privately funded. The project budget (CAPEX) is around 8 billion euros, with 30% shareholder funded and 70% from external financing sources.

2.2 Project History

The Nord Stream 2 Pipeline will be implemented based on the positive experience of construction and operation of the existing Nord Stream Pipeline.

The Nord Stream Pipeline project, upon its completion, was hailed as a milestone in the long-standing energy partnership between Russia and the EU, contributing to the achievement of a common goal – a secure, reliable and sustainable reinforcement of Europe's energy security.

Nord Stream's first line was put into operation in 2011 and the second line came on stream in 2012. The entire project was completed on schedule and on budget, and received many accolades for high environmental and HSE standards, green logistics, open dialogue and public consultation.

In May 2012, at the request of its shareholders, Nord Stream AG conducted a feasibility study of two potential additional pipelines. The study included technical solutions, route alternatives, environmental impact assessments and financing options.

The feasibility study confirmed that extending Nord Stream with one or two additional lines was possible.

In its feasibility study, Nord Stream AG developed three main route corridor options to be investigated further based on reconnaissance level surveys, environmental impact assessments and stakeholder feedback, in order to come to an optimized route proposal.

In 2012, Nord Stream AG submitted requests for survey permits in the relevant countries. The aim was to further research the route corridor options and to find the optimal routing for the pipelines with minimum length and environmental impact.

In April 2013, Nord Stream AG published the Project Information Document (PID) on the extension project, a key milestone in enabling planning for future environmental impact assessments. The PID highlighted the proposed project in the context of the international notification process according to the Espoo Convention, enabling potentially affected parties to determine their role in the future environmental and social impact assessments and associated permitting processes, in accordance with their country-specific laws and regulations.

In preparation for further development of an extension project, Nord Stream discussed the programme proposals for the national environmental impact studies in the five countries (Russia, Finland, Sweden, Denmark, and German) whose Exclusive Economic Zones (EEZ) or territorial waters the proposed route would cross. –Initial consultations were also conducted with the authorities and stakeholders in other Baltic Sea countries.

The permitting, survey and engineering work initiated by Nord Stream AG was taken over by a dedicated project company, Nord Stream 2 AG, which was established in July 2015.

2.3 The Project Company

Nord Stream 2 AG is a project company established for planning, construction and subsequent operation of the Nord Stream 2 Pipeline. The company is based in Zug, Switzerland and owned by Public Joint Stock Company (PJSC) Gazprom. PJSC Gazprom is the largest supplier of natural gas in the world, accounting for approximately 15 percent of world gas production.

At its headquarters Nord Stream 2 AG has a strong team of over 200 professionals of over 20 nationalities, covering survey, environment, HSE, engineering, construction, quality control, procurement, project management and administrative roles.

Based on its stringent procurement policy and international tenders, Nord Stream 2 contracts leading companies to supply materials and services. Europipe GmbH, Mülheim/Germany, United Metallurgical Company JSC (OMK), Moscow/Russia and Chelyabinsk Pipe-Rolling Plant JSC (Chelpipe) and Chelyabinsk/Russia were chosen to deliver approximately 2,500 km of large-diameter pipes with a total weight of roughly 2.2 million tonnes. The first pipe deliveries started at the end of September 2016. Wasco Coatings Europe BV was contracted for concrete weight coating, pipe storage and logistics and will operate an existing weight coating plant in Kotka, Finland, a second plant in Mukran Germany, as well as storage yards located around the Baltic Sea for storing the pipes, including Hanko, Finland and Karlshamn, Sweden. The pipe-lay contract has been awarded to Allseas, who will undertake offshore pipe-lay works for both lines in 2018 and 2019.

As with Nord Stream AG, Nord Stream 2 AG adheres to high standards, with regard to technology, environment, labour conditions, safety, corporate governance and public consultation.

Nord Stream AG, the operator of the existing Nord Stream Pipeline, has been absolutely committed to safety and environmentally-friendly solutions from the very start of the project – through the planning, construction and now the operational phases. In addition to a state-of-art technical design, Nord Stream demonstrated in a very transparent way its competence in the sustainable management of the environmental and social aspects associated with the implementation of a pipeline project. The implementation of an Environmental and Social Management System enabled Nord Stream to monitor its contractors and closely follow up on all commitments and obligations. This ensures good management of construction and operational activities in an environmentally and socially responsible manner, as well as transparent and comprehensive reporting to authorities and stakeholders.

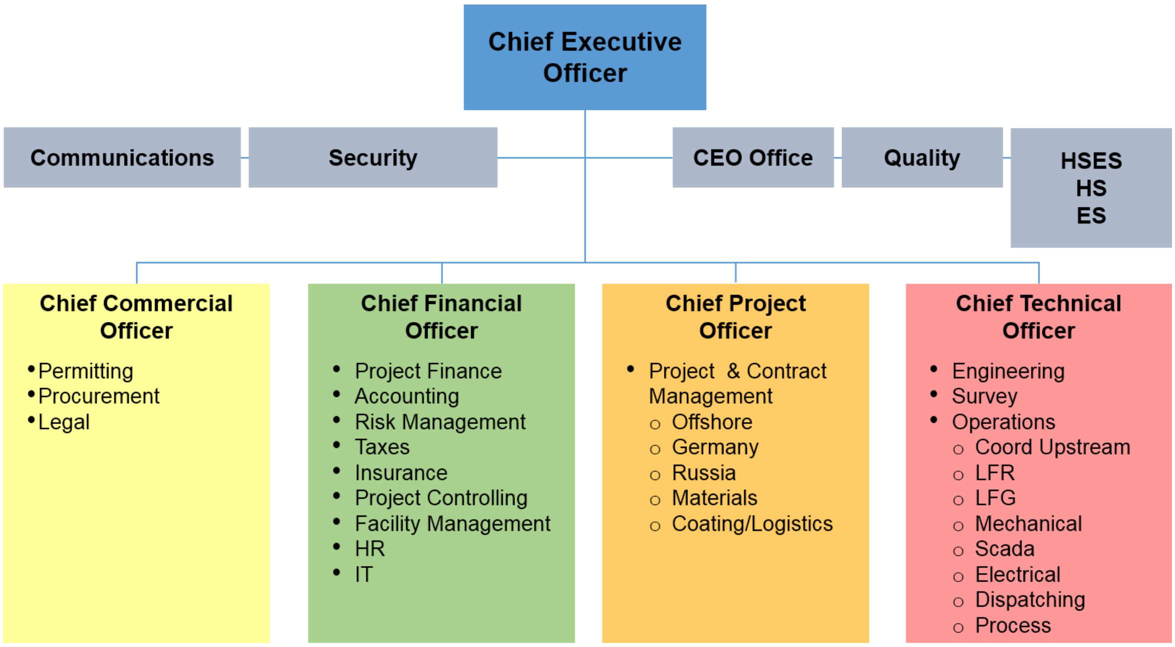
Following this approach, quality assurance by suppliers, contractors of Nord Stream 2 AG and the company itself will exceed the standards normally applied to other offshore pipelines and will guarantee the highest possible standard of operational safety. Nord Stream 2 AG is also committed to complying with the Environmental and Social standards of the International Finance Corporation.

Following completion of the project phase, the results from Nord Stream's Environmental and Social Monitoring Programmes demonstrate that pipeline construction did not cause any unforeseen environmental impact in the Baltic Sea and confirms the positive trend in environmental recovery after construction. So far, all monitoring results have confirmed that construction-related impacts were minor, local and predominantly short-term. Also transboundary effects have been verified as being insignificant. The data in the environmental surveys and monitoring programmes has been transferred to the 'Data and Information Fund' and can be reviewed and used for scientific purposes.

The results of previous surveys and the experience gained during the construction and operation will help to ensure that the Nord Stream 2 Pipeline will meet the same stringent environmental standards and can be built without any lasting adverse effects on the environment.

In line with the company's commitment to transparency and open dialogue, Nord Stream 2 has a dedicated website where extensive project related information can be reviewed and inquiries can be addressed: www.nord-stream2.com.

2.4 Competencies within the organisation



3 PROJECT JUSTIFICATION

This section describes the occasion and reasons for the Nord Stream 2 project and proves why this project is required to secure the supply of gas to the European Union and its Member States. Nord Stream 2 AG has commissioned Prognos AG to prepare a study on the European gas balance, forecasting future gas demand and possible sources for demand coverage. In view of the above, Prognos AG, which advises decision-makers from politics, business and society in Europe providing objective analyses and forecasts, completed the study "Current Status and Perspectives of the European Gas Balance" in January 2017[1].

The study area of this chapter is thus the European Union, consisting of 28 Member States (*EU 28*) – consistently including the United Kingdom (UK). A possible withdrawal of UK from *EU 28* ("Brexit") would have no significant impact on the natural gas flows between UK and other *EU 28* Member States as well as Norway, as UK's natural gas import requirements, and the *EU 28* total imports, would not change[2]. The geographic area will be extended within the following analysis, when required from an *EU 28* perspective i.e. non *EU 28* Member States are able to or have decided to cover their gas import requirements exclusively from the *EU 28*[3]. In the following this is discussed in detail.

It would not be appropriate to focus solely on those areas which are directly supplied by pipeline. The EU internal gas market is significantly influenced by the global LNG market.

Thus, an overall European gas balance has to be analysed in order to assess the extent of supply security. Ignoring the interdependencies with supply and the available sources, the complexity of the markets would not be treated appropriately and thus the requirements of a sound forecast would not be met. It is particularly important to consider the relevant geographic area when comparing the results presented below with other studies, as some studies focus on OECD Europe instead of *EU 28*. The main difference between OECD Europe and *EU 28* is that OECD Europe considers Norway (a large net exporter of natural gas) and Turkey (a large importer of natural gas). Further, the *EU 28* Member States Romania, Bulgaria, Croatia, Latvia and Lithuania are not part of OECD Europe. This leads to considerable differences in the respective quantitative balances.

The time horizon for projections in this document, is usually 2020 until 2050 (depending on specific analyses). In view of the long forecasting period and the complexity of the subject – which is characterised by significant uncertainties – Prognos has analysed in detail numerous studies on future gas demand in its study[4].

Figures in this document are rounded to the first or no decimal, potentially leading to slight deviations in shown totals.

The Nord Stream 2 pipeline project is essential for the secure, cost-effective and sustainable supply of natural gas to the general public for the following reasons.

Prognos differentiates between so-called target and reference scenarios. Target scenarios generally aim at an all-electric world fuelled by solar and wind-based power generation and show strongly declining fossil fuel demand trajectories to achieve politically set climate protection targets detached from the likelihood of achieving them (see Figure 3-1). Given their methodological approach they are not suitable for setting a reliable basis in order to forecast future supply

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[1] Prognos AG, Status und Perspektiven der europäischen Gasbilanz (2017).

[2] Prognos AG, Status und Perspektiven der europäischen Gasbilanz (2017), p. 5.

[3] Prognos AG, Status und Perspektiven der europäischen Gasbilanz (2017), p. 29.

[4] Please refer to Prognos, Status und Perspektiven der europäischen Gasbilanz (2017), p. 56ff.

needs. Reference scenarios, on the other hand, take into account the risk of not complying with ambitious targets.

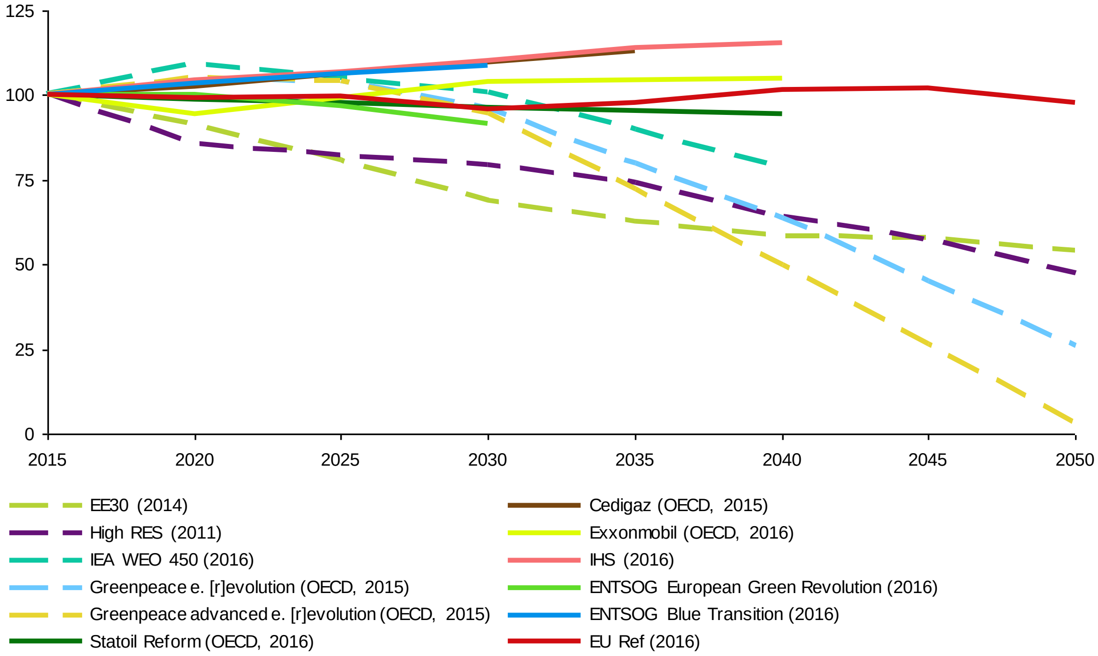

Figure 3-1 Natural gas demand scenarios for EU 28 and OECD Europe [indexed with 2015 = 100]

In order to ensure the security of energy supply of the *EU 28* with natural gas, particularly in the event of not fulfilling such objectives, it is necessary to base the medium- to long-term planning on reference scenarios. Prognos therefore bases its analysis on the *EU Reference Scenario* (2016), also taking into account recent developments. Prognos, as subject matter experts, consider the *EU Reference Scenario* as a good starting point to analyse *EU 28* energy demand and production, as its projections are based on present best practices (from a technological and legal perspective) and it is highly transparent. However, Prognos concluded that the *EU Reference Scenario* need to be adjusted where more up-to-date official production outlooks are available and extended to include projections for imports from the EU internal gas market by Switzerland and Ukraine to *EU 28* figures, in order to get a complete picture of future gas import requirements (*EU 28*).

Considering Switzerland and Ukraine, which are expected to import approximately 20 bcm/a of natural gas from the EU internal gas market as of 2020, demand of *EU 28* is projected to show an almost stable development from 494 bcm in 2020 to 477 bcm in 2030 and 487 bcm in 2050. At the same time however, *EU 28* domestic production is projected to decline by 55% between 2015 and 2050 (see Figure 3-2).

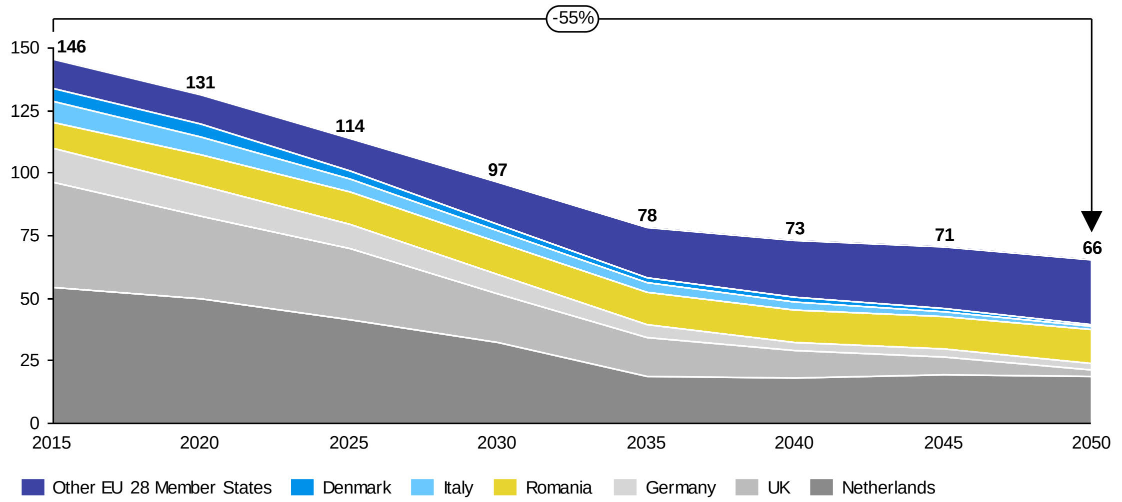

Figure 3-2: EU 28 natural gas production projections according to Prognos based on EU Reference Scenario 2016 [bcm]

According to Prognos, natural gas production is expected to decrease even further than projected due to recent decisions by the Dutch government to reinforce limitations on the natural gas production from the Groningen field, as well as lower projections for natural gas production in Germany and the UK.

After adjustments, *EU 28* domestic production is projected to decline from 118 bcm in 2020 to 83 bcm in 2030 and 61 bcm in 2050 (see Figure 3-3).

In combination, the stable development of demand and the strong decline in production results in a constantly increasing natural gas import requirement of *EU 28,* developing from 376 bcm in 2020 to 394 bcm in 2030 and 427 bcm in 2050 (see Figure 3-3), with the result that additional gas supplies will be necessary to ensure the sustainable supply security of *EU 28*.

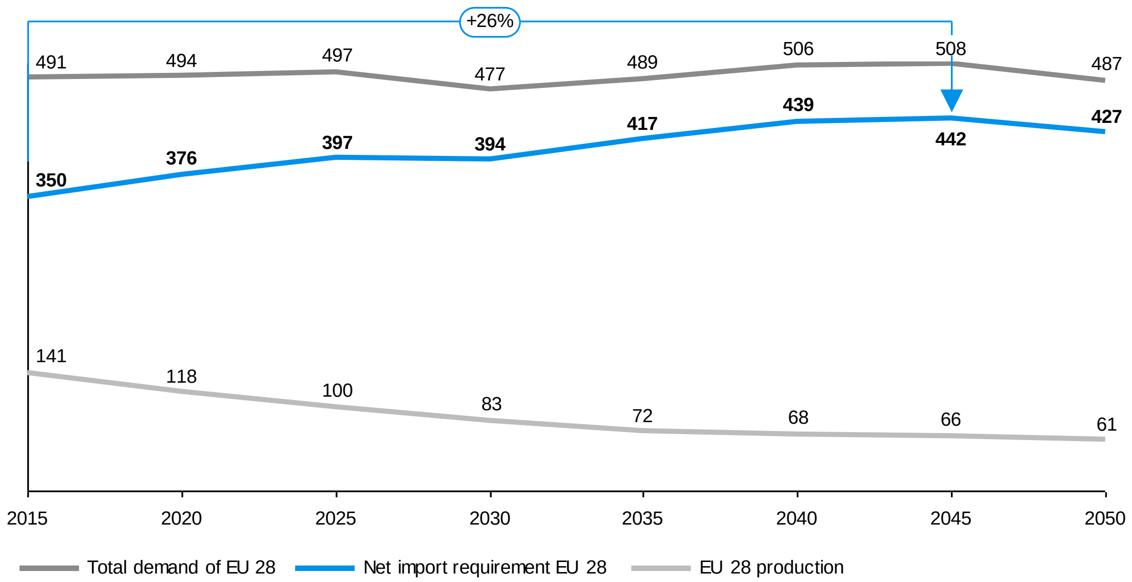

Figure 3-3: Natural gas demand, production and import requirement of EU 28 [bcm]

According to Prognos, without Nord Stream 2, it cannot be ensured that this natural gas import requirement will be covered (securing energy supply) if these gaps cannot be filled with pipeline gas. The global LNG market is subject to drastic fluctuations, so that LNG cannot be assumed reliably cover any potential demand gaps. Therefore, the realization of the project is necessary in order to eliminate uncertainties of supply and to facilitate a competitive situation with the aim of providing gas at low costs.

Pipeline gas: To cover the import requirement, pipeline gas and natural gas imported as LNG are available to *EU 28*. With regard to pipeline gas, however, all existing suppliers to the EU internal gas market with the exception of Russia (Norway, Algeria and Libya) are projected to supply decreasing volumes due to restrictions in future production and/or increases in domestic consumption (see Figure 3-4 and Figure 3-5).

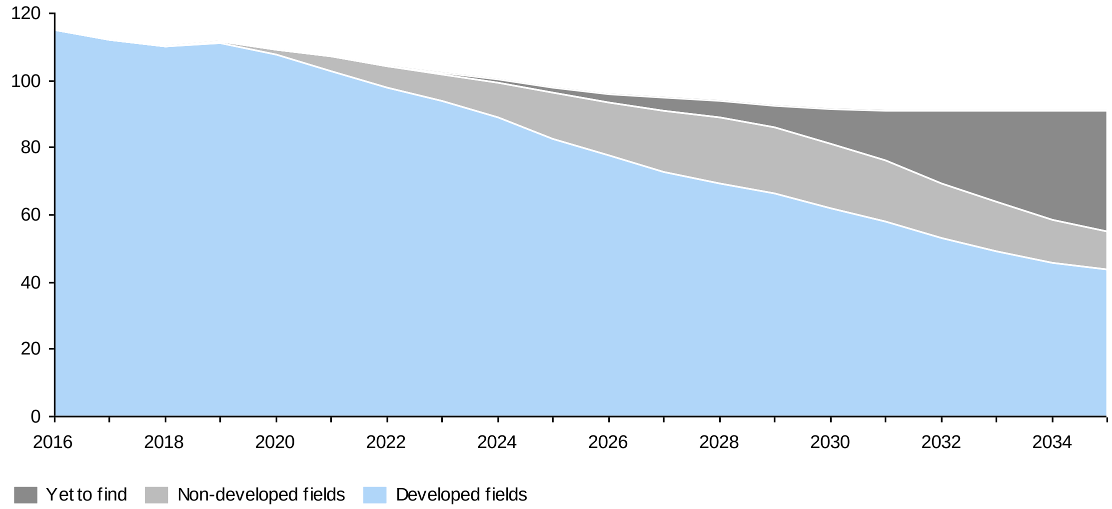

Figure 3-4: Natural gas production forecast for Norway [bcm]

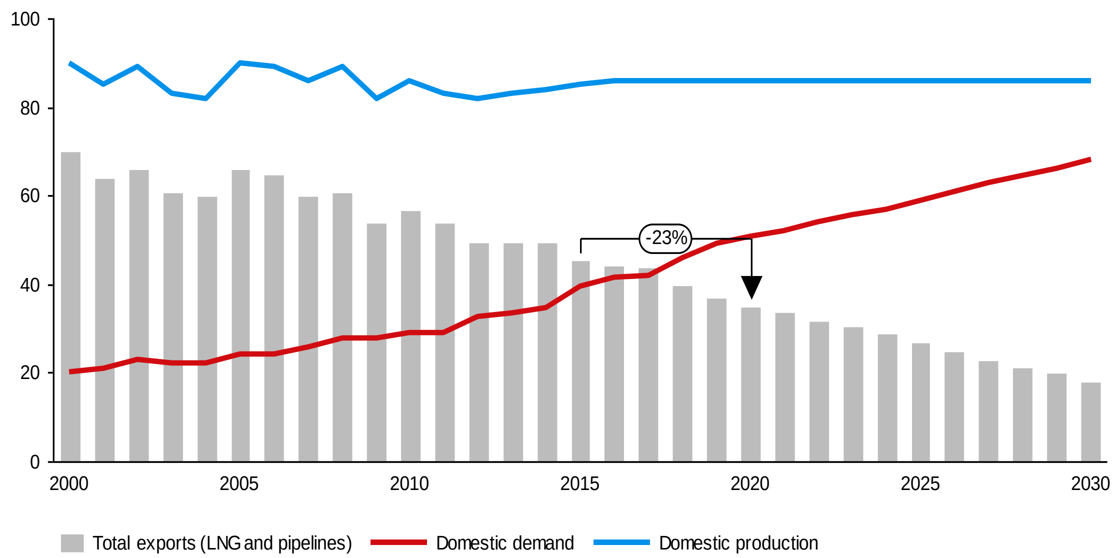

Figure 3-5: Natural gas balance forecast for Algeria [bcm]

Russia, in contrast, holds the largest proven natural gas reserves worldwide and has extensive production capacity to satisfy both domestic demand and export demands of *EU 28* and other countries (see Figure 3-6).

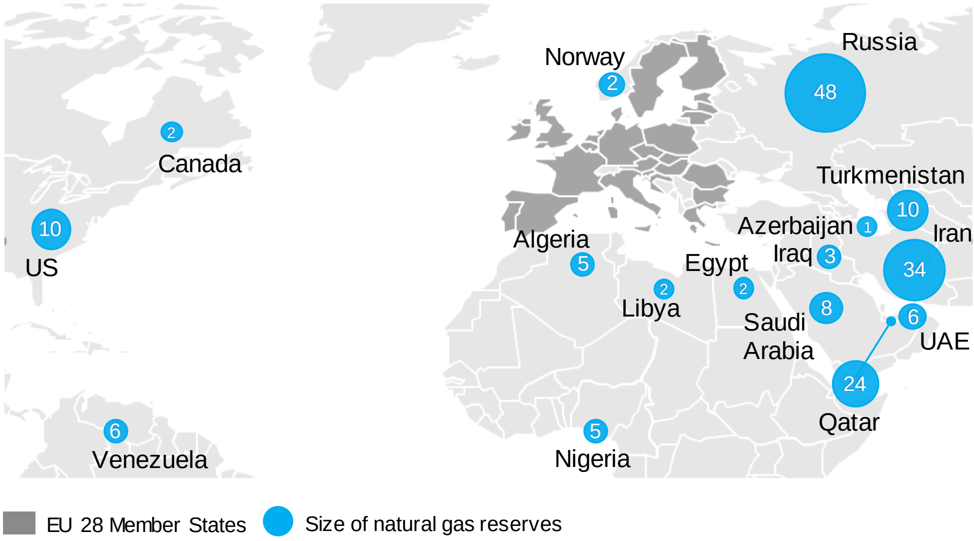

Figure 3-6: Distribution of global natural gas reserves [tcm]

With regard to the transportation of produced gas to the EU internal gas market, Nord Stream (1) and Yamal-Europe as well as Russian gas transports to the Baltic States (Estonia, Latvia, Lithuania) and Finland are reliably available. However, for the Central corridor through the Ukraine, further transport capacity of only 30 bcm/a can be considered as sustainably available. This transport capacity is only available if the required refurbishment, which is funded by EBRD (Europäische Bank für Wiederaufbau)/ EIB (Europäische Investitionsbank) emergency loans, is actually pursued. However, in order to ensure this transport capacity in the long term, substantial maintenance and refurbishment measures are required in the future, which has not been the case at least in recent years. In fact, the planned investment programme has been consistently under-fulfilled by the operator.

The inadequate condition of the system has resulted in an incident rate about 10-times higher than the European average. A situation likely to exacerbate, as pipelines enter the fourth and sometimes fifth decade of operation in 2020. Furthermore, the depleting Nadym Pur Taz region is substituted by gas production from the more north-western located Yamal region. The Nord Stream corridor running from the Yamal region to the EU internal gas market is not only technically more advanced, but also about one-third shorter than the Central corridor. This leads to a significantly lower gas consumption of the compressors for the transport and thus to a higher efficiency and profitability of the transport system. As a result, the respective demand gaps cannot be reliably covered by pipeline gas ensuring future gas supply.

With regard to pipeline gas potentially supplied from new source countries (Azerbaijan, Turkmenistan, Israel, Iraq and Iran) to the EU internal gas market, is clearly limited. Apart from additional volumes from Azerbaijan transported via the new TAP/TANAP pipeline project – currently under construction with a maximum capacity of 10 bcm/a – no additional pipeline gas coming to the EU internal gas market is conceivable. As a result, no additional import volumes are expected from these suppliers in the foreseeable future.

LNG: The global LNG market generally represents a possible supply source to import considerable additional volumes of natural gas to cover the future *EU 28* import requirement. However, due to its nature as a cyclical industry (see Figure 3-7) LNG cannot ensure to cover natural gas demand. Therefore, reliable medium and long term forecasts of the LNG market are hardly feasible.

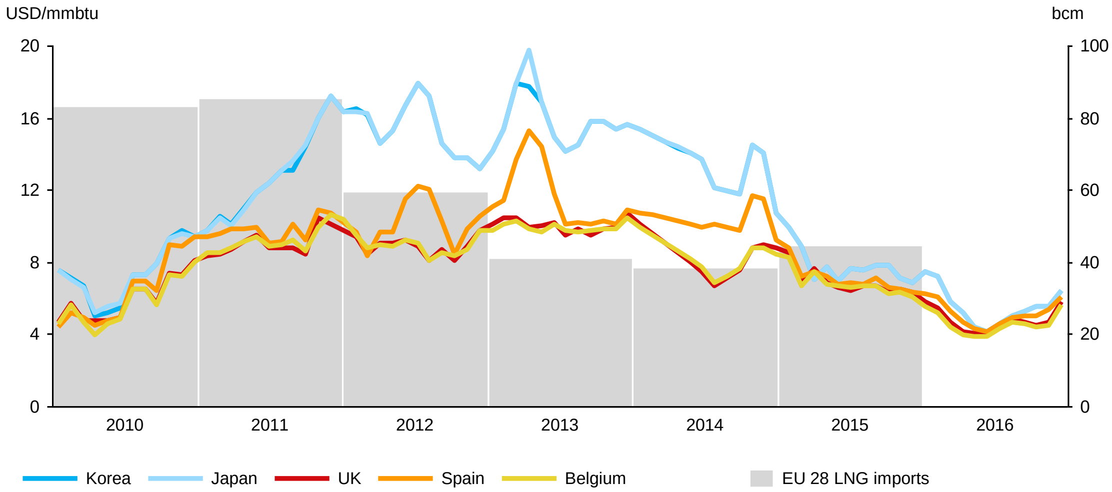

Figure 3-7: Development of regional landed LNG prices [USD/mmbtu] and EU 28 LNG imports [bcm]

In addition, Prognos[5] and various other available studies[6] are assuming that the LNG demand will exceed the supply in the early 2020s, so that sufficient quantities for Europe are not guaranteed, resulting in an increased price competition. Natural gas imported as LNG into the EU internal gas market therefore is not a reliable supply option. Based on available LNG scenarios, LNG imports with an average of 67 bcm in 2020 and up to 95 bcm in 2030 are expected and considered in the following.

As a result, there would be an import gap without the implementation of the Nord Stream 2 project. This import gap will increase from 30 bcm in 2020 to 59 bcm in 2030 and 110 bcm in 2050 (see Figure 3-8). The construction of the Nord Stream 2 pipeline can close this import gap from 2020 onwards. This will increase Russia's sustainable transport capacity towards the EU internal gas market and thus avoid the additional reliance on volatile LNG. With its designed annual capacity of 55 bcm per year[7], the Nord Stream 2 pipeline will contribute to the closure of the import gap from 2020 onwards, thus guaranteeing the security of supply with natural gas.

In view of the broad range and the complexity of possible forecasts, it cannot be excluded that other studies generate different results. However, these won't be able to prove that the EU's security of supply can be guaranteed in the future without the implementation of Nord Stream 2. On the contrary, there are additional risk factors which can currently lead to an increased threat to the security of supply. The Nord Stream 2 pipeline can help to ensure security of supply, particularly in terms of potential transit, supply and demand risks.

[5] Prognos, Status und Perspektiven der europäischen Gasbilanz, p. 69.

[6] See for example Royal Dutch Shell plc., LNG Outlook (2017), p. 13; The Boston Consulting Group, A Challenging Supply-Demand Outlook for LNG Producers (2016), p. 8.

[7] In Figure 3-8 a typical utilisation rate of 90% is applied to the designed annual capacity of Nord Stream 2 (55 bcm/a), which leads to average annual volumes of 50 bcm.

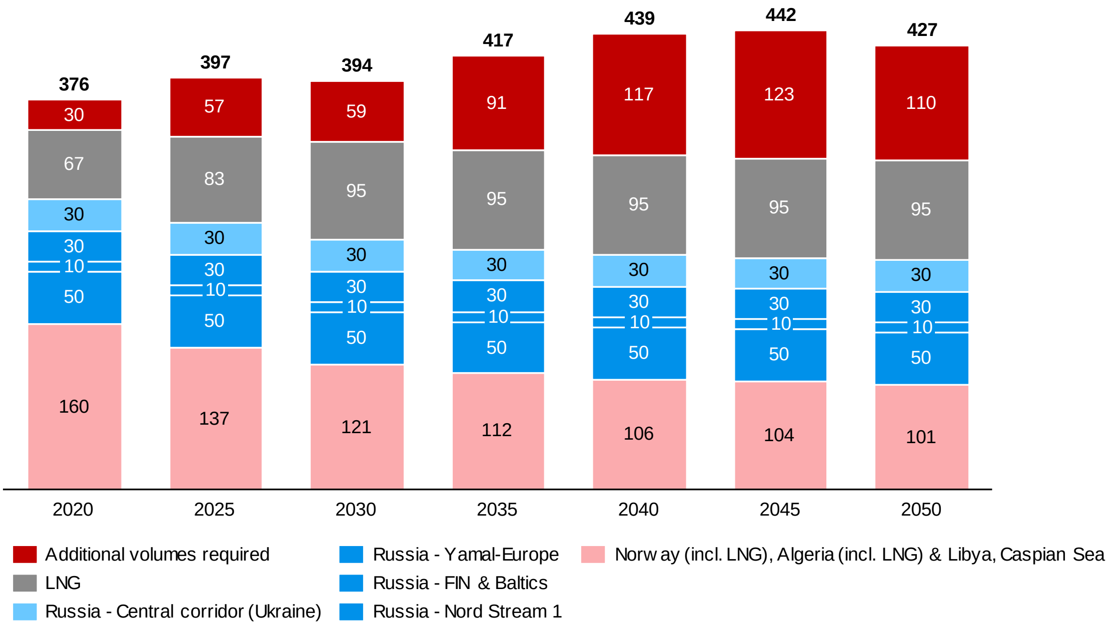

Figure 3-8: EU 28 import gap forecast with average LNG and 30 bcm/a Ukraine transit (Reference Case) [bcm], figures for Russian supplies in the bar chart are arranged in the same order as used in the legend

The most prominent risk factors are a complete halt of transit through Ukraine on commercial or legal grounds (see Figure 3-9) or low levels of LNG supply due to a tightening global LNG market (see Figure 3-10). Furthermore, demand or supply-side risks could be higher than assumed by Prognos, such as a complete stop of production from the Groningen field or a halt of exports from North Africa, which would endanger the security of gas supply of *EU 28* (see Figure 3-11).

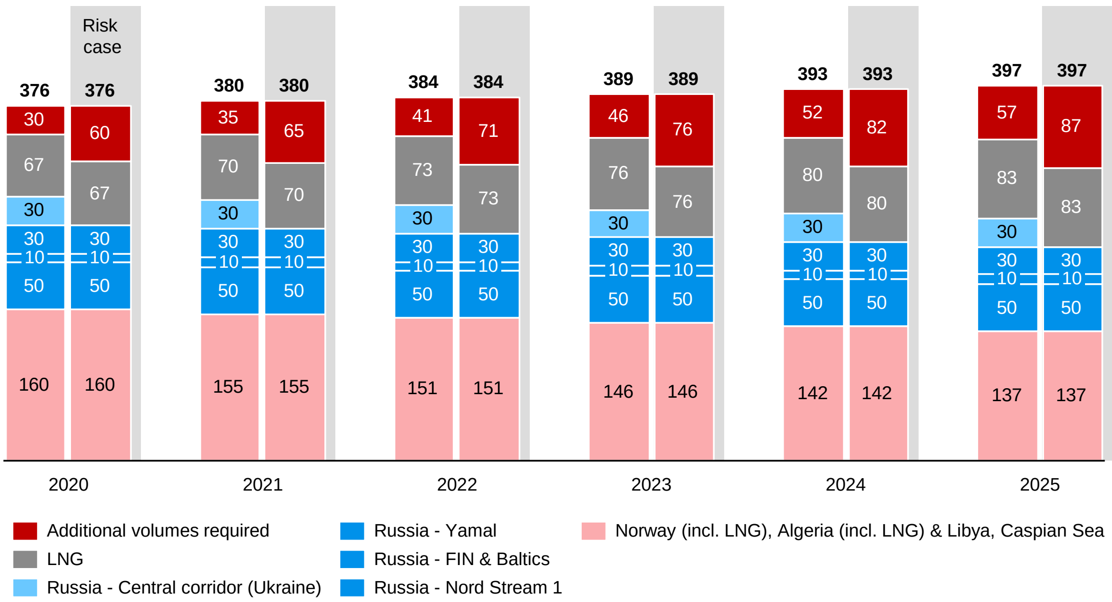

Figure 3-9: Risk case 1 for EU 28: 0 bcm/a Ukraine transit [bcm]

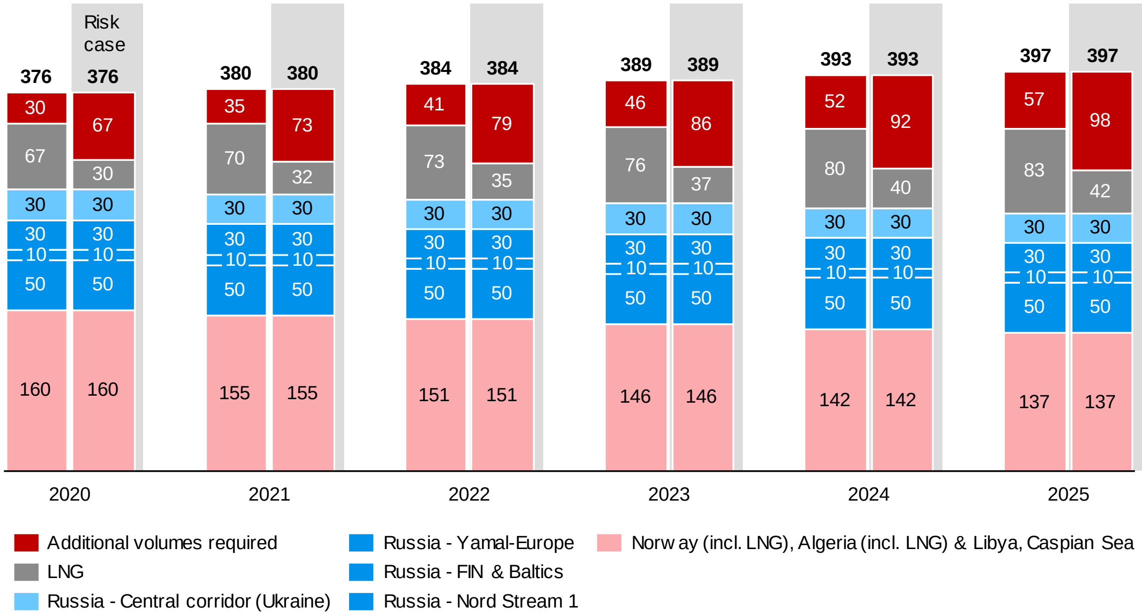

Figure 3-10: Risk case 2 for EU 28: Minimum LNG import by EU 28 [bcm]

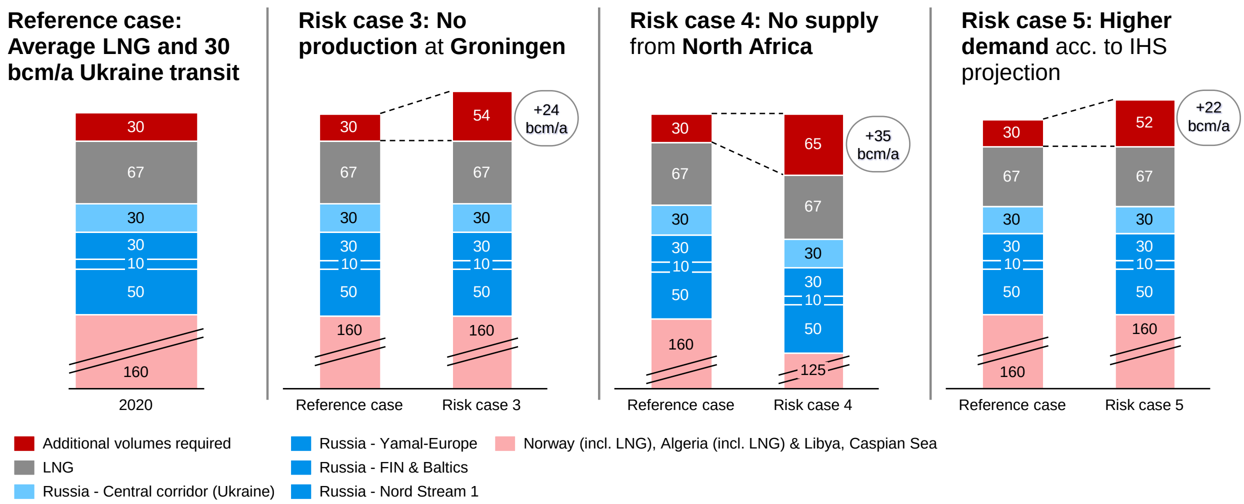

Figure 3-11: Other relevant risk cases for EU 28: No supply from Groningen (NL), North Africa or higher demand for natural gas [bcm]

In addition, Nord Stream 2 will increase competitive pressure on natural gas supplied to the EU internal gas market from different countries, resulting in lower gas market prices for end consumers and therefore contributing to the affordability of energy supply. Furthermore, Nord Stream 2 will trigger further integration of the EU internal gas market through additional downstream pipeline infrastructure.

Finally, the proposed project contributes to an environmental friendly supply of energy. This applies to natural gas as a fossil fuel and its general importance in the energy mix, but also to the project itself.

Natural gas, is a fuel with various applications in the heating, power generation, industry and transport sector of the *EU 28* (see Figure 3-12). Being the fossil fuel with the least greenhouse gas (GHG) and other emissions resulting from combustion (e.g. particulate matter) – especially in comparison with coal and oil – natural gas can serve as both a transitional energy source, enabling a build-out of renewables as well as a back-up energy source guaranteeing overall security of energy supply. Thus, natural gas as an intermediary has the potential to accompany and promote the transition to a low-carbon economy and will continue to play an important role in the *EU 28* energy supply in coming decades. Through the continued use of natural gas, ambitious targets set by the *Paris Agreement* of 2016 on climate change can be reached without jeopardizing the overall security of energy supply.

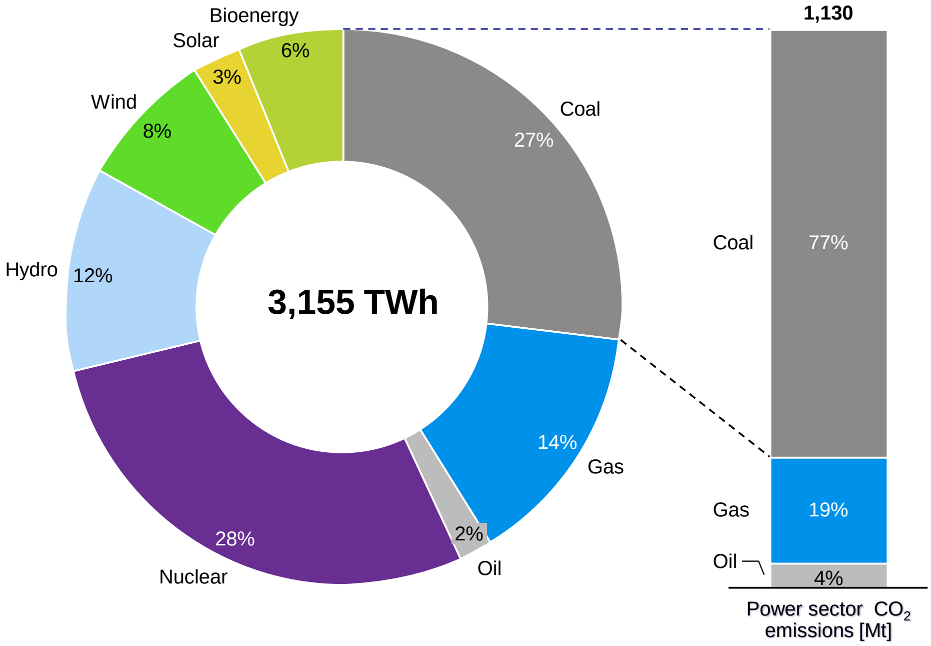

Figure 3-12: Electricity mix 2014 in EU 28 by energy source [TWh, %] and corresponding CO_2 emissions [Mt, %]

Also, from an environmental perspective Nord Stream 2 – combining state-of-the-art technical design with a much shorter route from the relevant production fields in Russia to the EU internal gas market (see Figure 3-13) – has significant advantages in terms of environmental and climate impacts.

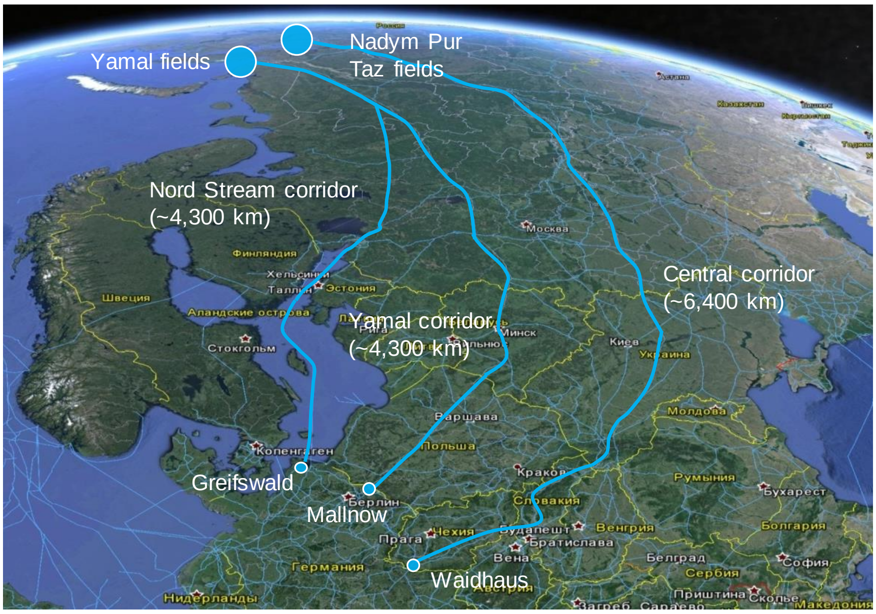

Figure 3-13: Overview of Russian gas fields and pipelines to the EU [schematic]

This applies to both Russian gas supplied to *EU 28* via Yamal-Europe and the Central corridor as well as compared to important LNG supply options (Algeria, Australia, Qatar and US). Among the potential sources of gas supply able to significantly contribute to closing the *EU 28* import gap, Russian gas supplied via the Nord Stream corridor has the lowest carbon footprint. Compared to natural gas reaching the EU gas market via the Nord Stream corridor, the CO_2 footprint of alternative Russian pipeline gas routes is at least 46%, and that of LNG alternatives at least 131% greater (see Figure 3-14).

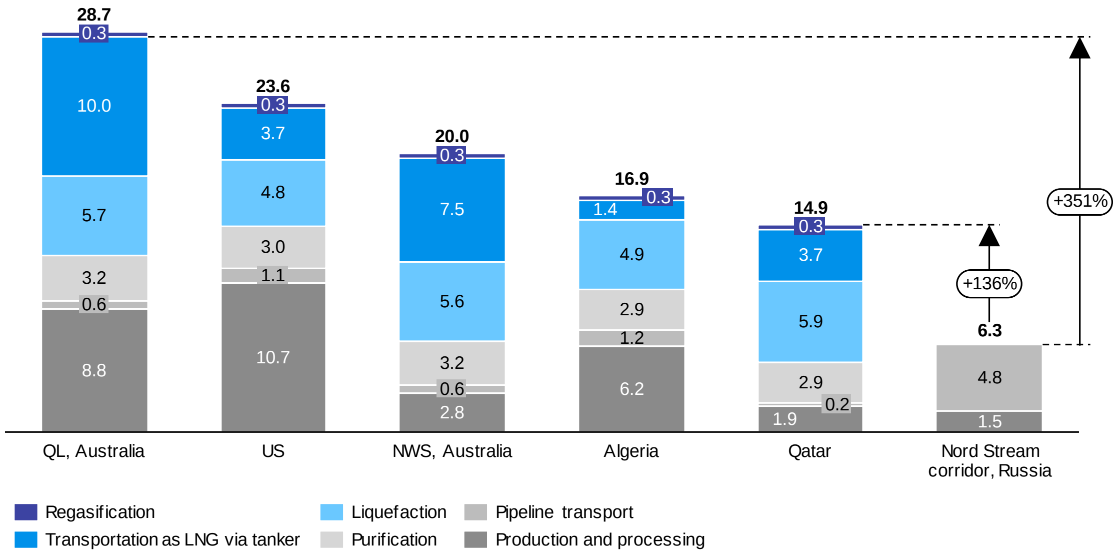

Figure 3-14: Carbon footprint of Russian pipeline gas coming to EU 28 via the Nord Stream corridor and from different sources via LNG [gCO_2e/MJ]

Natural gas is poised to remain a backbone of *EU 28* energy supply, outpacing coal and oil and leading to lower GHG emissions. With a mostly stable natural gas demand, but rapidly decreasing gas production in *EU 28*, alternative gas supply is needed to cover the upcoming natural gas import gap starting already in 2020. The state-of-the-art transport system Nord Stream 2 can contribute to covering the upcoming import gap of *EU 28* as of 2020, while making the EU's gas supply more robust, more economically beneficial, more sustainable, more efficient – and more consumer-friendly.

4 LEGAL FRAMEWORK

This chapter provides an account for the legal framework for the EIA procedure and public participation under Danish law. To this end the chapter provides a short introduction to the legal framework for a construction permit for NSP2. The legal framework under Danish law is described in section 4.1.

EU law applies as part of Danish law. Therefore, the main EU law requirements with respect to environmental information and requirements in relation to the EIA for NSP2 are described in section 4.2.

Denmark has ratified a number of international conventions and treaties regarding laying of pipelines and marine environment. International environmental requirements must therefore be observed in the assessment of the EIA for NSP2. The main international environmental requirements are described in section 4.3. Further, the international legal framework for a construction permit to NSP2. the EIA procedure and public participation are described in section 4.3.

A scoping process has been carried out for NSP2 to ensure transparency and stakeholder engagement. The NSP2 scoping process is described in section 4.4 of this chapter.

Nord Stream 2 AG´s approach for ensuring public participation in the construction and operation of NSP2 is described in section 4.5.

4.1 Legal framework under Danish law

4.1.1 Legal basis for construction of NSP2

Permits for construction of pipelines for transportation of hydrocarbons produced outside Danish territory in Danish territorial waters and on the Danish Continental Shelf are required pursuant to the Continental Shelf Act /1/, the Danish State's sovereignty over its territorial waters, and Administrative Order on Pipeline Installations /2/.

Permit for construction and operation of such pipelines in Danish territorial waters is regulated by the Administrative Order on Pipeline Installations pursuant to Denmark´s sovereignty over its territorial waters. The Administrative Order on Pipeline Installations also regulates permit for construction of pipelines on the continental shelf area, since such licenses are also regulated by the Continental Shelf Act.[8]

The application for such permits must be submitted to the Danish Energy Agency, which manages the applications and issues the permits on behalf of the Danish State[9].

The Danish Energy Agency may include various terms in the permits. Such terms are non-exhaustively listed in the Administrative Order on Pipeline Installation. Further, the permit may include terms regarding supervision and preparation of monitoring programmes.

Further permits and approvals may be required subject to other Danish legislation in order to carry out the construction of offshore pipelines.[10] For instance, the impact on fishing grounds must be assessed and addressed, if relevant, according to the Danish Fishery Act /3/.

[8] Thus the establishment of the pipeline in Danish territorial waters and on the Danish continental shelf area, to some extent, is subject to the same regulation.

[9] The Danish Energy Agency may inter alia require the applicant to provide all information necessary for the Agency to process the application, see s. 4c of the CSA and s. 4 of the Administrative Order on Pipeline Installations.

[10] NSP2 is not subject to the provisions of the Danish Natural Gas Supply Act (consolidated act no. 1331 of 25 November 2013, as subsequently amended) pursuant to § 2 s. 4 of the act since the pipelines will not be connected to the Danish natural gas system.

4.1.2 Legal basis for EIA procedure and public participation

Permits for the construction of pipelines for the transportation of gas, oil and chemicals with a diameter exceeding 800 mm and a length of more than 40 km may only be granted on the basis of an Environmental Impact Assessment ("EIA") pursuant to the Continental Shelf Act[11] and the Offshore EIA Administrative Order /4//7/.

Hence, a national Danish EIA report is required for NSP2, and is to be submitted to the Danish Energy Agency together with the application for the construction permit. The requirements for the content of the EIA in accordance with the EIA Directive are outlined in the Offshore EIA Administrative Order.

The EIA report must as a minimum contain the information listed in the Offshore EIA Administrative Order in Appendix 2, including a description of the factors likely to be significantly affected by the project, both inside and outside of Danish territory, in particular: population, fauna and flora, land, seabed, water, air, climate, material assets, cultural heritage, including architectural and archaeological aspects, and landscape and the interrelationship between the aforementioned factors[12]. The EIA report must also include a description of the main realistic alternative approaches to the project /4/.

The Offshore EIA Administrative Order calls for an overall assessment of the project as a whole, both inside and outside of Danish territory, including direct effects and any indirect, secondary, cumulative, transboundary, short-term, medium- term and long-term, permanent and temporary, positive and negative effects of the project.

The Danish EIA procedure does not require a scoping process for NSP2. Such scoping process is however carried out to ensure transparency and stakeholder engagement, see section 4.4.

The Danish Energy Agency must publish information concerning the application and the EIA report in national newspapers and on the Agency's website and the information must be sent to affected authorities and organisations /4/. Further, affected authorities must also receive the application and the EIA report for consultation. Where appropriate, the Danish Energy Agency can also request the Danish Environmental Protection Agency to provide an opinion regarding the EIA report.

A deadline of not less than 8 weeks from the publication will be given for making comments or raising objections to the application and the EIA report. Nord Stream 2 AG´s approach for ensuring public participation in the construction and operation of NSP2 is described in section 4.5.

Where a project subject to a Danish national EIA potentially may have significant impact on the environment of other EU Member States, or other states that have ratified the Espoo Convention, the procedure under the Espoo Convention applies (Espoo procedure) as implemented in the Offshore EIA Administrative Order, see further section 4.3.2.1 below. Thus, a consultation and coordination between Denmark and the affected states as well as the relevant authorities and Nord Stream 2 AG is required for implementation of NSP2 given the pipelines' transboundary routing.

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[11] See Continental Shelf Act §a, and Offshore EIA Administrative Order §9. If relevant, an assessment must also be made of the impact on international nature protection areas or areas with protected species, regarding the protective measures for the location.

[12] See Offshore EIA Administrative Order §5 and Appendix 2, no 3. The Danish Energy Agency can decide that further information than listed in Appendix 2 must be provided in order to assess the impact on the environment, cf Offshore EIA Administrative Order §5, s. 3.

It follows from the Offshore EIA Administrative Order that the Danish Agency for Water and Nature Management[13] (now the Danish Environmental Protection Agency) has to provide affected states with both a description of the project and its potential transboundary effects and information on the nature of the possible decision.

Thus, after the Danish Energy Agency has made its decision whether to grant the permit, the Agency must publish the decision in the same places where information concerning the application and EIA report was published.

The environmental circumstances in the permit decision may be appealed to the Danish Energy Board of Appeal within 4 weeks from the issuance of the permit. [The non-environmental circumstances in the permit decision may be appealed to the Ministry of Energy, Utilities and Climate.] A permit may not be utilised before the complaints period has expired.

Rights to appeal to the Danish Energy Board of Appeal over the environmental aspects of a construction permit follows from the Continental Shelf Act, see further section 4.3.2.2 below. Additionally, the public generally has access to environmental information with the authorities, including the Danish Energy Agency pursuant to the Environmental Information Act, see further section 4.2.2 below.

4.2 Legal framework under EU law

Denmark is a member of the EU, and a number of EU directives lay down environmental and planning requirements relevant to NSP2. These are described in the following, with reference to the relevant sections below.

Legal basis for procedure and public participation

4.2.1 EIA Directive

The EIA Directive requires that public and private projects which are likely to have significant effects on the environment are assessed on the basis of an EIA before permits are granted to the projects.

The EIA directive as currently implemented in the Continental Shelf Act and the Offshore EIA Administrative Order, Pursuant to the EIA Directive, as implemented in the Offshore EIA Administrative Order, see section 4.1.1 above, permits for the construction of pipelines for the transportation of gas, oil or chemicals with a diameter exceeding 800 mm and a length of more than 40 km may only be granted on the basis of an EIA /4/. As the dimensions of NSP2 exceeds these requirements, an EIA in accordance with the abovementioned regulation is required.

4.2.2 Environmental Information Directive and Public Participation Directive in the environmental area

The Environmental Information Directive and the Public Participation Directive were adopted by the EU to ensure compliance with the requirements under the Aarhus Convention (see section 4.3.2).

The Environmental Information Directive guarantees the public access to environmental information held by, or for, public authorities, both upon request and through active dissemination. It sets out the basic terms, conditions and practical arrangements where access upon request may be exercised.

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[13] The Offshore EIA Executive Order §. 8 says the Ministry of the Environment, today, the Ministry of the Environment and Food. The point of contact under Espoo Convention is the Danish Environmental Protection Agency.

The Public Participation Directive provides for public participation in respect of the drawing up of certain plans and programs relating to the environment and amending with regard to public participation and access to justice.

Provisions for public participation in environmental decision-making are also found in the EIA Directive.

In Denmark, the Environmental Information Directive and Public Participation Directive are implemented, *inter alia*, in the Environmental Information Act and the Offshore EIA Administrative Order.

The Environmental Information Act applies to all public authorities[14], including the DEA, which must therefore generally make environmental information[15] available to the public upon request. This may include information submitted to the DEA by NSP2.

Under the Offshore EIA Administrative Order[16], the DEA shall publish information on applications and EIAs, such as received from NSP2, on its website and in national newspapers for comments from the general public. Information on the final decision on the permit application shall also be published in the same way as the information on the application and EIA was published.

Public participation in relation to NSP2 is described in section 4.5.

Legal basis for main environmental requirements

4.2.3 Habitats Directive

The Habitats Directive ensures the conservation of a wide range of rare, threatened or endemic animal and plant species, and establishes the EU wide Natura 2000 ecological network ("Natura 2000 network") of protected areas, safeguarded against potentially damaging developments /8/.

The Natura 2000 network is the largest ecological network in the world, ensuring biodiversity by conserving natural habitats and wild fauna and flora in the territory of the EU. The network comprises special areas of conservation designated by EU States under the Habitats Directive. Furthermore, the Natura 2000 networks also includes special protection areas classified pursuant Birds Directive /9/.

Annexes I and II to the Habitats Directive contain the types of habitats and species whose conservation requires the designation of special areas of conservation. The Habitats Directive set out that an appropriate assessment procedure is to be performed to assess the projects compatibility with the preservation objectives of protected Natura 2000 sites.

The Habitats is implemented in Danish Law through a number of orders (or regulatory instruments), *inter alia,* through the Continental Shelf Act and Offshore EIA Administrative Order.

The Danish Natura 2000 sites are appointed in the Administrative Order no. 926 of 27 June 2016 on Designating and Managing International Nature Protection Areas and Protection of Certain Species, which also set out rules for the management of the sites .

Pursuant to the Continental Shelf Act and the Offshore EIA Administrative Order, for a project that is likely to significantly affect the designated international nature protection areas (SACs, SPAs and Ramsar sites) within or outside Danish territory, the EIA shall, among other things,

[14] Authorities etc., which fall within the scope of § 1 of the former Public Administration Act /6/ as subsequently amended). The Act also applies to bodies, including natural and legal persons who have public responsibilities or performing public functions or services related to the environment and which are subject to public scrutiny.

[15] As defined in § 3 of the act.

[16] See § 6 of the administrative order.

include an impact assessment of the project's implications for the site in terms of conservation objectives, and the assessment must show that the project will not harm the international nature protection area /4/. A construction permit may not be issued if the integrity of a Natura 2000 site is affected, unless there are imperative reasons of overriding public interest /5//10/.

The requirements for the assessment of the impact on the Natura 2000 sites in accordance with the Habitats Directive are outlined in the Offshore EIA Administrative Order.

4.2.4 Birds Directive

The Birds Directive aims to conserve all wild birds in the EU by setting out rules for their protection, management and control. EU Member States must take action to maintain or restore the populations of endangered species to a level, which is in line with ecological, scientific and cultural requirements, while taking into account economic and recreational needs.

The Birds Directive establishes a network of Special Protection Areas (SPAs) for those bird species covered by Annex 1 of the directive, including all the most suitable territories for these species. Since 1994, all SPAs are included in the Natura 2000 network.

Further, Annex 1 of the Birds Directive lists the bird species which should be the subject to special conservation measures and may not be affected (physically or disturbed) inter alia by the construction or operation of an infrastructure project such as NSP2.

The Birds Directive is implemented in Danish law, *inter alia,* through the Continental Shelf Act and Offshore EIA Administrative Order.

As the SPAs form part of the Natura 2000 network, an assessment of the impact on NSP2 on the SPAs has been carried out in accordance with the requirements in the Offshore EIA Administrative Order.

An assessment of NSP2s compatibility with the preservation measures of protected Natura 2000 sites is included in section 9.12.

4.2.5 Marine Strategy Framework Directive

The Marine Strategy Framework Directive /11/ ("MSFD") aims to achieve "good environmental status" ("GES") of the EU marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.[17] Additionally, the EU-Commission has issued a set of detailed criteria and indicators to help Member States implement the Marine Directive /12/.

The MSFD is implemented in Danish law through the Marine Strategy Act /13/[18]. The Marine Strategy Act provides the overall framework for the strategies that should be prepared under the directive in order to ensure that good environmental status are achieved or maintained in the Danish waters.

In accordance with the MSFD and the Marine Strategy Act, the Danish Nature Agency (now the Danish Environmental Protection Agency) in 2012 prepared an overall marine strategy for Danish

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[17] The Marine Strategy Framework Directive takes the obligations of the EU and EU Member States under UNCLOS into account. When applying or interpreting the Marine Strategy Framework Directive, UNCLOS must thus be considered.

[18] Act 117 dated January 26th 2017. The marine strategy act establishes a framework for the necessary measures to achieve or maintain good environmental status in the Danish marine environment. Under the Act, the Danish Minister for Environment and Food has authority to develop and implement the individual parts of the marine strategies.

waters, including the Baltic Sea and the waters around Bornholm (the "Danish Marine Strategy").[19] The Danish Marine Strategy therefore applies to NSP2 due to its planned location.

The Danish Marine Strategy involves an assessment of GES in Danish waters with a definition of GES at regional levels based on the eleven qualitative descriptors for determining GES in Annex 1 of the MSFD.

Further, the Danish Marine Strategy involves an integrated assessment and classification of environmental status of Danish waters.[20] The classification scheme for the environmental status used in the Danish Marine Strategy is either "good" or "not-good" in accordance with the classifications in the MSFD. In order to achieve 'GES' both ecological and chemical statuses must be good /14/.

Following the Danish Marine Strategy, the Minister for Environment and Food adopted a programme of measures for the Kattegat Sea has been adopted in 2016, and six areas have been designated in the Kattegat.

Furthermore, a proposal for a programme of measures executed under Denmark's Marine Strategy from 2012 has been launched for public consultation for 12 weeks from 21 December 2016. The programme of measures includes existing initiatives and 20 new initiatives. Of relevance to NSP2, is that one of the proposed initiatives is the appointment of an inter-ministerial working group that is charged with the task of examining whether there is a need to designate additional marine protected areas in the central Baltic Sea and in the North Sea (in addition to those already designated in the Kattegat). If need be, the working group is to make recommendations for how such areas should be designated. The working group will base its work on sound analysis and involving stakeholders in its work before it comes with its recommendations. The working group is expected to start its initial work in 2017 and to report its results in mid-2019.

The marine strategy framework in relation to NSP2 is addressed in section section 10.

4.2.6 Water Framework Directive

The Water Framework Directive has a number of objectives, such as preventing and reducing pollution, promoting sustainable water usage, environmental protection, improving aquatic ecosystems and mitigating the effects of floods and droughts /15/. The Water Framework Directive sets out clear deadlines for each of the requirements under the Directive up to 2027, including achieving good environmental status of surface water and groundwater. The Directive also covers transitional and coastal waters up to 1 nm off the coast for ecological status and 12nm for chemical status.

The Water Framework Directive is implemented in Denmark by the Act on Environmental objectives[21] and the Act on Water Planning /17/.

On the basis of the WFD, Denmark has in June 2016 adopted river basin management plans for the directive´s second plan period (2015-2021) and issued administrative orders on environmental targets for Danish surface waters and programmes of measures that apply to each of Denmark's river basin districts, including Bornholm. The environmental objectives and programmes of measures for the river basin district Bornholm are set out in Annex. in the Order on environmental objectives for surface and ground waters /18/ and the Order on programmes of measures for river basin districts[22], respectively. The environmental objectives set out for Bornholm reflect

[19] The Danish Marine Strategy applies to all Danish waters, including the seabed and the subsoil, and in the territorial waters and in the exclusive economic zone. However, the Danish Marine Strategy does not apply to Danish waters 1 nautical mile from the baseline to the extent such waters are covered by the Water Planning Act (and the Environmental Objectives Act).

[20] The integrated assessment and classification is based on the HELCOM HOLAS assessment, see section 10.

[21] Act 119 dated January 26th 2017..

[22] Se Annex 3 of Administrative Order no 794 of 24 June 2016.

the requirements under WFD. The directive aims to achieve the environmental objective *good status.* This status is obtained for surface water when both the ecological status and chemical status is good, as classified in WFD Annex V.

Surface waters include coastal waters, which are defined as waters within 1nm of the coastal line of a district with respect to ecological status. In relation to chemical status, however, surface waters also include territorial waters which are 12nm of the coastal line of a district in line with the directive.[23]

The proposed NSP2 routing will cross the 12 nm zone from Bornholm and Christiansø. An assessment of how the construction and operation of NSP2 may potentially affect the environmental status of the coastal water and territorial waters around Bornholm is included in section section 10.

4.2.7 Maritime Spatial Planning Directive

The Maritime Spatial Planning Directive creates a common framework for maritime spatial planning in Europe /19/. While each EU country will be free to plan its own maritime activities, local, regional and national planning in shared seas would be made more compatible through a set of minimum common requirements.

In Denmark, the Maritime Spatial Planning Directive is implemented by the Act on Maritime Spatial Planning /20/. No draft plans are however available for area crossed by the proposed NSP2 route and therefore no further consideration has been given in this EIA.

4.3 International legal framework

4.3.1 Legal basis for constructing NSP2 under international law

UNCLOS defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources, and is generally accepted as a codification of customary international law of the sea /21/.

UNCLOS was concluded in 1982 and entered into force in 1994. Denmark ratified UNCLOS in 2003. Before Denmark´s ratification of UNCLOS, Danish law was in compliance with parts of UNCLOS. UNCLOS is incorporated in Danish law, by several regulations, e.g. by the Act on Protection of the Marine Environment and the Continental Shelf Act, and was fully incorporated into Danish law in 2005 /22//23/.

UNCLOS Article 79 entitles all States to establish pipelines on the continental shelf of a coastal State, but UNCLOS also obliges each coastal state to preserve and protect the marine environment /24/. In short: UNCLOS gives a state the right to lay down pipelines on the continental shelf of a coastal state, but it must be done - among other things - with due respect to the environment.

The sovereignty of Denmark extends to its territorial waters in accordance with UNCLOS /25/. The rights of Denmark over its continental shelf follow from article 77 of UNCLOS under which Denmark has sovereign rights for the purpose of exploring the continental shelf and exploiting its natural resources.

[23] According to the river basin management plan for Bornholm, the environmental target for the territorial waters (outside of the coastal waters) is limited to chemical pollution by substances found in directive 2013/39/EU on priority substances in the field of water policy.

The Danish continental shelf is defined in accordance with UNCLOS as comprising the submerged prolongation of the land territory of the coastal State - the seabed and subsoil of the submarine areas that extend beyond its territorial sea to the outer edge of the continental margin, or to a distance of 200 nautical miles where the outer edge of the continental margin does not extend up to that distance, as well as the seabed and subsoil of similar submarine areas around islands /26//27/.[24]

The Exclusive Economic Zone (EEZ) for Denmark comprises areas beyond and adjacent to the territorial waters extending seaward to a distance of 200 nautical miles from the applicable coastal baselines /28//29//30/.

The outer limit of Denmark's territorial waters is the applicable baselines drawn so that the distance from any point on these lines to the nearest point of the baseline is 12 nautical miles measured in accordance with UNCLOS/31//32//33/.

Under UNCLOS all states are entitled to lay down pipelines on the continental shelf of a coastal state as the coastal state may not impede the laying or maintenance of such pipelines. However, the coastal state has the right to take reasonable measures for the exploration of the continental shelf, the exploitation of its natural resources and the prevention, reduction and control of pollution from pipelines. Further, the delineation of the course for the laying of such pipelines on the continental shelf is subject to the consent of the coastal state /34/.

Hence, under UNCLOS the right to lay down pipelines on the Danish continental shelf may be granted a foreign state, given that this respects Denmark's rights to exploring the continental shelf and exploiting its natural resources. There are no similar provisions under UNCLOS for other states to lay down pipelines in the territorial waters of a coastal state.[25] However, the sovereignty of Denmark extends to its territorial waters in accordance with UNCLOS. Hence, the legal basis for obtaining the right to lay down pipelines in the territorial waters in Denmark is the Danish State's sovereignty over the territorial waters.

4.3.2 Legal basis for EIA procedure and public participation under international law

4.3.2.1 Espoo Convention

The Espoo Convention sets out the obligations for public authorities of parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of states to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries. The Convention was adopted in 1991 and entered into force on 10 September 1997.

The Espoo Convention was implemented in Denmark in 1999 by an administrative order comprising a translation of the text of the Convention[26], and through implementation of the EIA and SEA Directives.

Under the Espoo Convention national authorities must notify countries concerned of planned activities as listed in Appendix I of the convention, when the activity might have a significant adverse transboundary impact. Appendix 1 section 8 comprises large-diameter pipelines for transportation of oil, gas and other chemicals. Hence, the Danish authorities is to notify countries concerned of NSP2 and transmit relevant information about the EIA procedure and relevant information on NSP2's possible significant adverse impact in a a transboundary context.

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[24] See §1 in Act 411 dated May 22nd 19996 concerning Exclusive economic zones, order 584 dated June 24th 1996. And UNCLOS section 55 and 57.

[25] See /34/. Hence, Denmark is not bound by UNCLOS to permit the laying of pipelines in its territorial waters.

[26] Order no. 71 of 4 November 1999.

In Denmark, the Danish Environmental Protection Agency, on behalf of the Ministry of the Environment and Food, administrate the Espoo Convention rules and is the responsible authority for the process of exchanging relevant information from the project owner to the potentially affected countries and possible comments from those countries in connection with the Espoo Consultation Process[27]. See further in section 4.1.2.

NSP2's potential transboundary significant adverse impacts to the environment are assessed in section section 14 in accordance with the Espoo Convention.

4.3.2.2 Aarhus Convention

The Aarhus Convention was adopted on 25 June 1998 in the Danish city of Aarhus. It entered into force on 30 October 2001.

The Aarhus Convention is about government accountability, transparency and responsiveness. The Aarhus Convention establishes a number of rights of the public (individuals and their associations) with regard to the environment. The parties to the Convention are required to make the necessary provisions so that public authorities (at national, regional or local level) will contribute to these rights to become effective, including access to environmental information, public participation in environmental decision-making, and access to justice.

The Aarhus Convention is implemented by the EU through the Environmental Information Directive(/35/) and the Public Participation Directive. Provisions for public participation in environmental decision-making are furthermore to be found in a number of other environmental directives, such as the SEA Directive (/36/), the Water Framework Directive (/37/), and the EIA Directive (/38/)..

The Aarhus Convention was implemented in Danish law by Act no. 447 of 31 May 2000 on Amendments to Certain Environmental Acts, including amendments to the Continental Shelf Act which applies to the NSP2 project and provides for public access with respect to complaints over environmental aspects of a construction permit under the act. Further requirements for public participation, namely consultation of the EIA for NSP2, follow from the Offshore EIA Administrative Order.

Public participation for NSP2 is addressed in section 4.5.

4.3.3 Legal basis for main environmental requirements under international law

4.3.3.1 UNCLOS

UNCLOS underlines that states have an obligation to adopt necessary measures for the effective protection for the marine environment from harmful effects which may arise from activities in the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction. This includes, inter alia, measures preventing the interference with the ecological balance of the marine environment, and particular attention must be paid to the need for protection from harmful effects of such activities as drilling, dredging, excavation, disposal of waste, construction and operation or maintenance of installations, pipelines and other devices related to such activities.

UNCLOS further contains requirements regarding decommission of offshore installations. Decommissioning of pipelines is not covered by UNCLOS which decommissioning requirements therefore do not apply to NSP2.

The requirements under UNCLOS are incorporated in Danish law. See section 4.1 above.

[27] Until 1 February 2017, these tasks were under the Agency for Water and Nature Management (SVANA).

4.3.3.2 London Convention and Protocol

The London Convention has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. In 1996, the London Protocol was agreed to further modernise the London Convention and, eventually, replace it. Under the Protocol, all dumping of waste is prohibited, except for possibly acceptable wastes on the so-called "reverse list"[28]. The Dumping of wastes on the "reverse list" requires a permit. The Danish Agency for Water and Nature Management (now the Danish Environmental Protection Agency) under the Ministry for the Environment and Food is the granting authority of such permit.

The requirements under the London Convention and Protocol are implemented in the Act on Protection of Marine Environment, and further fully incorporated in Danish law by the adoption of Orders that comprise the text of the convention and protocol , respectively /39/.

The Act on Protection of Marine Environment, inter alia, applies to pipelines for transportation of hydrocarbons produced outside Danish territory in Danish territorial waters and on the Danish Continental Shelf, and to foreign ships in or outside the Danish EEZ to the extent this is consistent with international law. Therefore, the requirements regarding dumping of wastes under the London Convention and Protocol apply to NSP2 and any ship operations in connection hereto.

4.3.3.3 MARPOL

The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) entered into force on 2 October 1983.[29]

MARPOL 73/78 and its six technical Annexes address pollution from ships[30] by oil, by noxious liquid substances carried in bulk, harmful substances carried by sea in packaged form, sewage, garbage, and the prevention of air pollution from ships.

The Baltic Sea is designated as a "special area" under MARPOL 73/78 Annexes I and V (MARPOL 73/78 Special Area). Therefore, a higher level of protection is required in the Baltic Sea. The Baltic Sea is further designated as a so-called "SOx Emission Control Area" under MARPOL 73/78, and therefore contains specific requirements for prevention of air pollution from ships within the Baltic Sea.[31]

MARPOL 73/78 is incorporated in Danish law through the Act on Protection of Marine Environment (Marine Protection Act) /40/ and Orders issued pursuant to the Act /41//42//43/.

During the construction and operation of NSP2, ship operations will be carried out in relation to e.g. pipe-lay, inspection and monitoring. Therefore, requirements under MARPOL 73/78 as incorporated in Danish law apply to all project vessels, including the stricter requirements for MARPOL 73/78 Special Areas and SOx Emission Control Areas as the ship operations are carried out in the Baltic Sea.

Prevention of pollution by oil is regulated in Annex I of MARPOL 73/78 as incorporated in s. 11 of the Marine Protection Act on Protection of Marine Environment whereby any discharge of oil into the Danish sea territory is prohibited. Further, any discharge of oil in the Danish EEZ or outside

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[28] See appendix 1 to the London protocol, which includes; dredged material, sewage sludge, fish wastes, vessels and platforms, inert, inorganic geological material (e.g., mining wastes), organic material of natural origin, bulky items primarily comprising iron, steel and Concrete, and carbon dioxide streams from carbon dioxide capture processes for sequestration, cf. Annex 1 of the London Protocol.

[29] As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The conventions is subsequently amended by the Protocol of 1997 and kept updated with relevant amendments.

[30] Under the convention, a "ship" means a vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms.

[31] See Annex VI of MARPOL 73/78.

Danish sea territory may only take place if the requirements under the Order on Disposal of Oil from Ships are complied with[32].

Prevention of pollution by sewage from ships is regulated in Annex IV of MARPOL 73/78, s. 20 of the Marine Protection Act and the Order on Disposal of Sewage from Ships and Platforms outside Danish Territorial Waters and in the Baltic Sea Area /41/.

Regulations for the prevention of pollution by garbage[33] from ships are contained in Annex V of MARPOL 73/78. The Marine Protection Act lays down that disposal of garbage, except fresh fish and parts thereof, is prohibited in the Danish sea territory, and in the Baltic Sea, disposal into the sea of food wastes shall be made at least 12 nautical miles from the nearest land.[34]

Annex VI of MARPOL 73/78 regulates prevention of air pollution from ships and sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. Further, Annex VI establishes specific requirements for ships within the Baltic Sea (SOx Emission Control Area), inter alia, that the sulphur content of fuel oil used on board these ships does not exceed 1.5% m/m. Air pollution from ships is regulated in the Order on Prevention of Air Pollution from Ships and Platforms /44/ and the Order on Categorisation, Classification, Transport and Disposal of Noxious Liquid Substances Carried in Bulk issued pursuant to the Act on Protection of Marine Environment /45/.

Pollution from ships in relation to NSP2 is addressed in sections section 9.4 and 9.5.

4.3.3.4 Ballast Water Management Convention

The Ballast Water Management Convention aims to prevent the spread of harmful aquatic organisms from one region to another, by establishing standards and procedures for the management and control of ships' ballast water and sediments.

Under the convention, ships are, inter alia, required to have on board and implement a Ballast Water Management Plan approved by the administration, and a Ballast Water Record Book to record when ballast water is taken on board; circulated or treated for Ballast Water Management purposes; and discharged into the sea. It should also record when Ballast Water is discharged to a reception facility and accidental or other exceptional discharges of Ballast Water.

The convention was adopted by IMO in 2004, and Denmark ratified it in 2012. The convention will enter into force on 8 September 2017. The ballast water management standards will be phased in over a period of time, and will apply to ships that operate in connection to NSP2 activities.

4.3.3.5 Ramsar Convention

The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. The Convention is fully incorporated in Danish law in 1978 /46/.

Under the "three pillars" of the Ramsar Convention, the contracting parties commit to:

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[32] Act 174 dated February 25th 2014 on discharge of oil. Chapter 4 details discharge of oil into the Baltic Sea (MARPOL 73/78 Special Area).

[33] Garbage" means all kinds of victual, domestic and operational waste excluding fresh fish and parts thereof, generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in other Annexes to MARPOL 73/78.

[34] See ss. 21-22 of the Act on Protection of Marine Environment. Chapter 4 of the Order on Disposal of Refuse from Ships and Platforms further regulates discharge of garbage into the Baltic Sea (MARPOL 73/78 Special Area).

- designate suitable wetlands for the List of Wetlands of International Importance ("Ramsar List") and ensure their effective management;
- work towards the wise use of all their wetlands through national land-use planning, appropriate policies and legislation, management actions, and public education
- cooperate internationally concerning transboundary wetlands, shared wetland systems, shared species, and development projects that may affect wetlands.

Ramsar areas in relation to NSP2 are addressed in section section 9.12.

4.3.3.6 Convention on Biological Diversity

The Convention on Biological Diversity (CBD) entered into force in 1993. CBD comprises the global framework of actions on biological diversity. In Nagoya in 2010, the CBD adopted a 10-year Strategic Plan to combat biodiversity loss in the world, including concrete targets (the Aichi targets) in order to achieve this overall objective, and a Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation (ABS Protocol). The EU and its member states are parties to the CBD (/47/), and these commitments are reflected in the EU's 2020 Biodiversity Strategy and regulations implemented pursuant to the strategy /48/.

At EU level, biodiversity are protected by several laws including the Birds Directive and the Habitats Directive. Further, the Regulation on Invasive Alien Species (/49/) and the ABS Regulation (/50/) bring EU law into line with international obligations under CBD.

According to the EU 2020 Biodiversity Strategy, indirect drivers of biodiversity loss are further addressed through EU legislation that support biodiversity objectives, including the Water Framework Directive and Marine Strategy Directive which require the achievement of good ecological status for water and marine ecosystems by 2025 and 2020, respectively. Biodiversity indicators have been developed to monitor, assess and report on progress towards the EU strategy's target. Data and information on EU biodiversity indicators and related EU targets are available at the Biodiversity Information System for Europe (BISE) /51/.

The CBD apply to NSP2 under Danish law through the implementation of the EU environmental legislation mentioned in the above and the Executive Order no. 142 of 21 November 1996 on Convention of 5 June 1992 on Biological Diversity, as subsequently amended /52/.

4.3.3.7 Bern Convention

The Bern Convention came into force in 1982 and aims to conserve wild flora and fauna and their natural habitats. Special attention is given to endangered and vulnerable species, including endangered and vulnerable migratory species specified in appendices of the Convention.

The obligations under the Bern Convention apply to NSP2 through the implementation of the convention at EU level by both the Birds Directive and Habitats Directive and by Order no. 83 of 15 September 1986 on Convention of 19 September 1979 on Conservation of European Wildlife and Natural Habitats, as subsequently amended.

The relevance of said rules for the Danish section of NSP2 is addressed in section 7.12, 7.13 and 9.

4.3.3.8 Helsinki Convention

The Baltic Sea is protected by the Helsinki Convention[35]. The EU, Denmark and other Baltic Sea region countries[36] have ratified the Helsinki Convention, which covers the whole of the Baltic Sea

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[35] Convention on the Protection of the Marine Environment in the Baltic Sea Area. The first Helsinki Convention was signed in 1974 and entered into force 1980. The Helsinki Convention was since revised in 1992, and the 1992 Helsinki Convention entered into force on 17 January 2000.

[36] Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden.

area, including inland waters as well as the water of the sea itself and the sea-bed. The convention is incorporated in Danish law in 2011[37]. Therefore, the Helsinki Convention's requirements for protection of the marine environment of the Baltic Sea area apply to NSP2.

The Helsinki Convention is a regional convention, and its governing body, HELCOM[38], provides the cooperation structure that aim to protect the marine environment in the Baltic Sea.[39]

The HELCOM Baltic Sea Action Plan[40] forms basis for HELCOM's work. It is a programme to restore the good environmental/ecological status of the Baltic marine environment by 2021, and it sets four goals and objectives for eutrophication, hazardous substances, biodiversity and environmentally friendly maritime activities, respectively. HELCOM evaluates how far we have come in achieving a Good environmental status by use of indicators and associated quantitative boundaries for specific elements of the marine ecosystem.

According to the HELCOM Recommendation 15/5 as superseded by the HELCOM Recommendation 35/1, HELCOM has designated areas with particular nature values as protected areas, (HELCOM MPAs). Each HELCOM MPA shall have a unique management plan or management measures drafted for the area in question. Such plans and measures regulate or compensate harmful human activities through different actions. The Danish HELCOM MPAs are identical to the Danish Natura 2000 sites.[41]

The obligations under the Helsinki Convention, including the HELCOM recommendations and the goal and objectives in the HELCOM Baltic Sea Action Plan must be taken into account in the EIA of NSP2. In relation of the Danish section of NSP2 this is further addressed in section 9.11. Further, whenever an EIA of a proposed activity that is likely to cause a significant adverse impact on the marine environment of the Baltic Sea area is required by international law or supranational regulations, the contracting party must notify HELCOM and any contracting party which may be affected by a transboundary impact on the Baltic Sea area.

HELCOM MPAs and their management plans are addressed in section 7.12 – and an assessment is presented in section 9.11.

4.3.3.9 CMS Convention

The CMS Convention, also referred to as the Bonn Convention, is an intergovernmental treaty, concluded under the United Nations Environment Program. The CMS Convention aims to conserve terrestrial, aquatic and avian migratory species throughout their range.

Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the CMS Convention. For this reason CMS acts as a framework convention and encourages the Range States to conclude global or regional agreements. The agreements may range from legally binding treaties to less formal instruments, such as memoranda of understanding, and can be adapted to the requirements of particular regions. Under the CMS Conven-

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[37] See Act 24 dated September 5th on the protection of the marine environment in the Baltic Sea (Helsinki convention), which refers to the Official Journal of the European Union L 73 of 16 March 1994.

[38] The Baltic Marine Environment Protection Commission (HELCOM). HELCOM makes recommendations on measures to address certain pollution sources or areas of concern, which are to be implemented by the contracting parties through their national legislation. HELCOM also follows up the implementation of the Helsinki Convention and HELCOM's recommendations.

[39] The Marine Strategy Framework Directive (MFSD) requires that EU Member States use exiting regional cooperation structures in developing their marine strategies, where practical and appropriate. HELCOM is the coordinating platform for regional implementation of the MSFD in the Baltic See, cf. Ministerial Declaration from the HELCOM Moscow Ministerial Meeting held on 20 May 2010.

[40] HELCOM Baltic Sea Action Plan (2007) updated on ministerial meetings in Moscow on 20 May 2010 and inCopenhagen on 3 October 2013

[41] The Natura 2000 network protects natural habitats and species deemed important at EU level, whereas the HELCOM MPAs network aims to protect marine and coastal habitats and species specific for the Baltic Sea.

tion, a number of agreements and memoranda of understanding have been signed. Agreements under the auspices of CMS, aim to conserve a number of marine, terrestrial and avian species.

The CMS Convention entered into force in Denmark in 1983 and was fully incorporated in Danish law in 1986 /54/. The requirements under the CMS Convention further apply to NSP2 through the implementation of the convention at EU level by the Birds Directive, which meets the obligations for bird species under the convention.

Relevant to NSP2 is the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas ("ASCOBANS"), which was concluded under the auspices of the CMS Convention in 1991. ASCOBANS is incorporated in Danish law in 1994 /55/.

The relevance of said rules in relation to the Danish section of NSP2 is addressed in section 7.13 – and an assessment is presented in section 9.12.

4.4 NSP2 scoping phase

4.4.1 National scoping process

There is no distinct scoping procedure defined in the Danish law and the project developer is in principle only required to submit the application for construction permit together with an EIA report and appropriate assessments. However, to ensure project transparency and provide the opportunity for relevant stakeholders to comment on the project at an early stage the scoping phase is recommended.

Based on a comprehensive feasibility study an EIA programme was developed and submitted to the DEA in April 2013. DEA distributed it among relevant authorities. The purpose of the EIA programme was to:

- Describe the proposed project
- Describe the environmental baseline in the project area and the potential environmental impacts to be assessed
- Provide authorities with information about the project to enable them to execute the national scoping procedure
- Provide stakeholders with a good overview of the project, allowing them to determine their level of interest in the proposed project.

A public consultation was held on Bornholm in May 2013. Here the project was presented and the participants had the opportunity to discuss the project and raise questions and concerns. Comments from the following stakeholders were received:

- Danish Maritime Authority
- Danish Environmental Protection Agency
- Regional Municipality of Bornholm
- Danish Meteorological Institute
- Danish Agency for Culture
- Danish Nature Agency (now the Danish Environmental Protection Agency)

The overall feedback received from the relevant stakeholders regarding the EIA programme is summarised in Table 4-1. The table highlights the overall key areas of concern as well as the main focus areas noted from the received comments. All comments received have been analysed and taken into consideration when developing the EIA.

Table 4-1 Summary of key issues from the comments received to the EIA programme

Key areas of concern	Focus area
Maritime traffic	Crossing of the TSS south of Adlergrund and that the pipelines will not give rise to problems for the ship traffic, including the ships' manoeuvrability in emergency situations.
Environmental monitoring	Duration of some programme should take into account that some effects might take a long time to develop.
Fishery	Reduction of impact on fishery.
Munitions	Potential removal of munitions to be assisted by the Admiral Danish Fleet and Maritime Monitoring Centre South.

4.4.2 International scoping process

In addition to the national scoping process, an international scoping process under the Espoo convention has been completed. A PID intended for the assessment of environmental impacts in a transboundary context according to the Espoo Convention were developed for this purpose. In this process, the Danish authorities have provided comments and the project have also received comments from interested parties in other affected countries. The comments have been assessed and managed in the Espoo documentation and the comments that are relevant for the Danish part of the project, have been assessed in the Danish EIA.

113 comments related to the Espoo documentation were received from authorities, organizations and private individuals. The key areas of concern were summarised and focused on impacts resulting from the disturbance of sediments on the seabed and disturbance of chemical warfare agents, impacts on underwater cultural heritage resources and impacts on marine mammals and bird life. Additionally, socio-economic environment concerns were raised and included impacts on planned and future projects, fishery and maritime traffic. A specific focus was made on onshore and offshore route alternatives and requests were made for the need to undertake risk assessments.

The overall feedback received from the relevant stakeholders regarding the Espoo PID is summarised in Table 4-2. The table highlights the overall key areas of concern as well as the main focus areas noted from the received comments.

Table 4-2 Summary of key issues from the comments received to the PID

Key areas of concern	Focus area
Marine mammals, birds and fish spawning/nursery areas	Minimising impacts on marine mammals, birds and fish spawning/nursery areas.
Seabed and sediments	Minimising impacts on seabed and sediments.
Planned and future projects, fishery, maritime traffic, CWAs and cultural heritage	Investigation of planned and future projects and minimising impacts on fishery, maritime traffic, CWAs and cultural heritage.
Direct and indirect cumulative impacts	Addressing of direct and indirect cumulative impacts.
Alternatives and zero alternative	Investigation of alternative routes and the zero alternative.
Risk assessments	Emergency preparedness.

4.5 NSP2 public participation

In accordance with the Offshore EIA Administrative Order /7/, the EIA Directive and the Aarhus Convention, the authorities must enable public participation in environmental decision-making.

The Danish Energy Agency must publish information concerning the application and the EIA report on the Agency's website and allow at least 8 weeks for public consultation. Public participation may also involve stakeholder meetings and public presentations of technical material.

During the public consultation, the public affected and environmental non-governmental organisations may provide comments or raise objections to the application and the EIA report.

Nord Stream 2 AG is dedicated to transparent communication of the project and active consultation with relevant stakeholders: regulatory bodies, non-governmental organisations, experts, affected communities, and other interested and affected parties. The aim of active stakeholder engagement is to disseminate information about the project and to give stakeholders an opportunity to express their views on the project. Consultation is also invaluable in identifying useful information regarding baseline conditions and concerning vulnerable resources and receptors in the study area. A project grievance mechanism will be developed to ensure that stakeholder concerns and comments are taken into account in developing the project and in assessing and mitigating potential impacts.

For the realisation of its existing pipelines (NSP), Nord Stream AG has been following an extensive and transparent communications strategy using various communications channels to disseminate information about NSP. Nord Stream 2 AG has already engaged with various stakeholder groups to inform them about the envisaged NSP2 project and to understand their views towards the project.

It is Nord Stream 2 AG's aim to continue with the proven and active stakeholder engagement approach through regular, genuine dialogue with relevant regulatory bodies, designated experts, affected communities and other stakeholders of the project. The process of stakeholder engagement and identification of potentially affected communities is therefore ongoing /56/.

Advanced planning of the stakeholder engagement process will ensure that the consultation activities are carried out in a timely manner, are readily accessible, and facilitate informed participation. Stakeholders' feedback will be systematically collected, reviewed and included in a database to enable tracking and monitoring of follow up actions that may be required, to ensure issues to be properly addressed.

During construction and operational phases, Nord Stream 2 AG will report regularly via its website and other means (i.e. working groups, round tables and conferences) on Project progress, implementation of mitigation measures, stakeholders engagement process and results, compliance with ESMS and overall performance.

5 ALTERNATIVES

The NSP2 study of route options in Danish waters is naturally built on previous planning and experience from the existing Nord Stream pipelines (NSP) and supplemented with new route surveys and seabed investigations. Furthermore, the experience from installation of NSP has given important input to the planning and technical design of NSP2.

This section describes the NSP2 planning and design philosophy with respect to avoiding and minimising environmental and social impacts and its application across the project with respect to alternatives for routing, design, and construction methodology. An overview of the alternatives that were considered and discarded is presented in the sections below.

The technical design of NSP2 corresponds to the design of NSP and will be in accordance with industry standards, e.g. DNV-OS-F101 (Submarine Pipeline Systems). Options for alternative technical pipeline design are limited and they are evaluated to have no influence of significance for the route planning and conclusions in this EIA.

5.1 Route development and optimisation

Pipeline routing which factors in engineering design and environmental criteria is one of the most important considerations in avoiding or minimising impacts. Refer to section 15 for further information on impact minimisation measures.

To minimise seabed disturbance, NSP2 has implemented a number of mitigation measures (where reasonably feasible) with respect to routing. Environmental and social considerations that were imbedded in the process of identifying an optimal pipeline route, included:

- Parallel routing to Nord Stream pipeline system so the combined footprint on the seabed is minimised
- Minimisation of overall pipeline length and number of route bends
- The presence of protected and environmentally sensitive areas, including fishing banks and nursery spawning areas
- The presence of cultural heritage
- Existing and future infrastructure
- Shipping lanes
- Munitions
- Military practise areas
- Extraction areas

Routing considerations also include avoiding sea bottom conditions that give rise to free spans and, therefore, the requirement for seabed intervention works (including trenching and rock placement) which have potential environmental impacts.

When selecting the optimal route for the NSP2 pipelines, a number of factors are taken into account.

The first criterion was environmental aspects and focused on avoiding protected and/or sensitive designated areas and other areas with ecologically sensitive species of animals or plants. Minimising any seabed intervention works that might cause local environmental impacts was also taken into account.

The second criterion looks at socio-economic factors to minimise any interference with shipping, fishing, dredging, the military, tourism and existing cables and wind turbines. Likewise, no impacts to present or future raw extraction activities in the area should take place. Avoiding areas with known discarded conventional and chemical munitions is also a priority in the route selection process.

The third criterion covers technical considerations regarding pipeline design, component manufacture, installation method, operation, integrity and risk assessment results. These include water depth for pipeline stability, seabed roughness, minimum pipeline bend radii, installation, maintenance and repair, criteria for cable and pipeline crossings as well as distance to and crossing of shipping lanes. Furthermore, minimising construction time, and therefore any disruptions, as well as reducing the technical complexity of the operation to keep the use of resources low has been considered.

The presence of both conventional and chemical munitions on the seabed continues to pose a hazard in the Baltic Sea region. In preparation for the construction of the NSP pipelines, Nord Stream AG initiated an exchange of information within various fields of munitions expertise. Munitions screening surveys were performed to establish the locations of potentially unexploded munitions that could constitute a danger for the pipeline or the environment during pipeline installation works. Nord Stream 2 AG is fully aware of the risks posed to humans and the environment owing to the potential presence of both conventional and chemical munitions in the route corridor and are conducting equivalent surveys and activities to manage associated risks. Activities during the construction of NSP in the vicinity of areas where anchoring is discouraged because of the potential presence of CWA were proven to be manageable without significant risk to the environment and to third parties.

Maritime cultural heritage is protected by legislation, and national authorities have developed procedures to avoid impacts on cultural heritage from construction projects. Specific surveys will allow Nord Stream 2 AG to exactly locate cultural heritage sites and to implement protection strategies in close consultation with national authorities.

On the basis of the experience of Nord Stream 2 AG and available data on the existing pipelines, and taking the selection criteria described above into account, a thorough desk study corridor assessment has been performed which identified a number of feasible route corridor and landfall options as a basis for further planning. The route corridors have been divided into four geographical sections for evaluation purposes: Russian landfall, Gulf of Finland, Baltic Proper and German landfall.

Based on the above, the preferred route (proposed route) and the defined alternatives are shown in Figure 5-1.

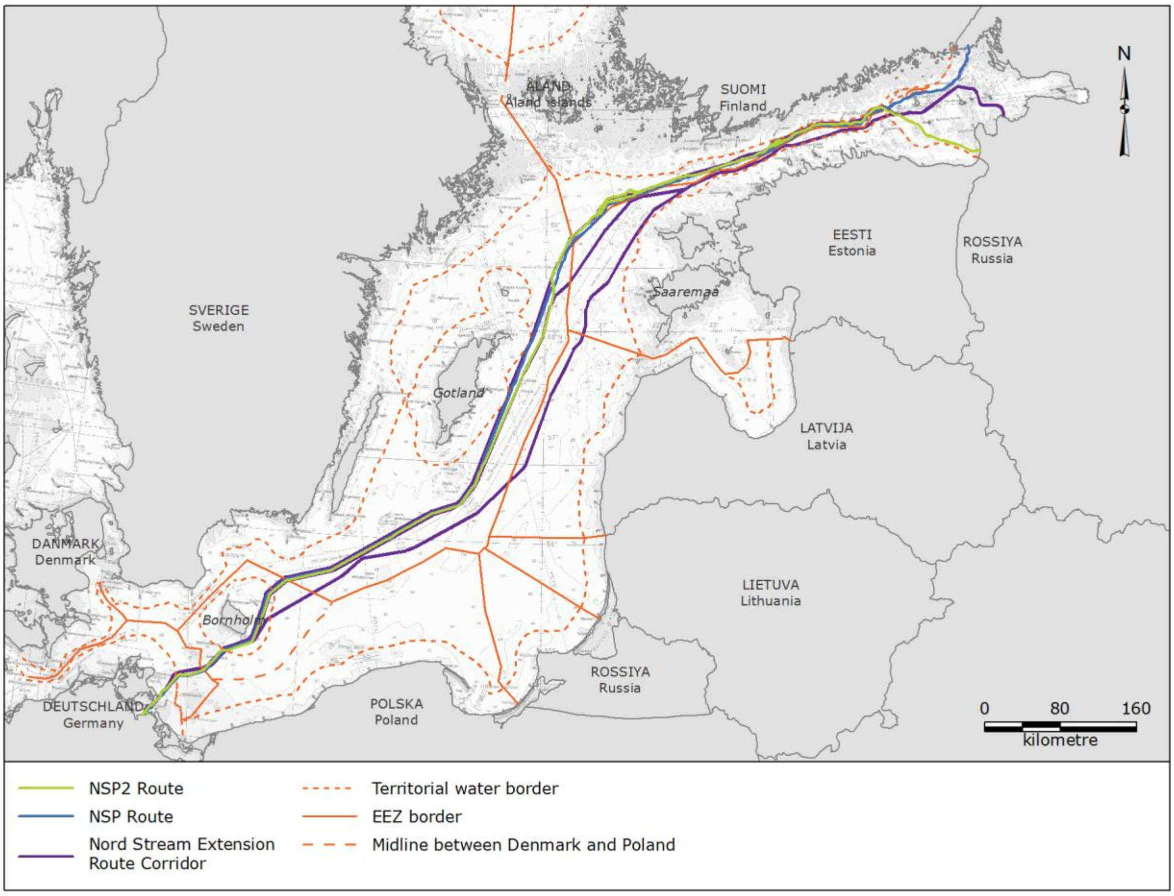


Figure 5-1 Route corridor options developed for the NSP2 project

5.2 The Nord Stream (NSP) route

The NSP route in Danish waters was from 2006 to 2009 subject to a series of in-depth field investigations and assessments covering optional routes both north-west and south-east of Bornholm. The route was challenged by a number of factors, such as the EEZ-border between Poland and Denmark not yet being settled by agreement between Denmark and Poland, intensive maritime traffic with several traffic separation schemes. Furthermore the route needed to consider a European important commercial fishery (with bottom trawling) in particular east of Bornholm, as well as the location of a WWII chemical munitions dumping ground limiting the possibilities for seabed intervention in an area close tothe Swedish EEZ-border.

The final NSP route was advised by the Danish Energy Agency as the best pipeline corridor passing Bornholm taking all stakeholder interests into account, and NSP has been built and operated without limitation to fishery and it has proven to have no significant environment impacts. Building on this experience and advice, the NSP2 route takes point of departure in the same corridor as NSP.

In the following the main challenges in the area around Bornholm is described,

1) Pipe-lay in the area with potentially high intensity of CWA remains may cause problems during pipeline installation. During NSP – and NSP2 – the dumping site was avoided in order to safeguard the environment as well as the pipe-lay equipment.

2) Further to the south on the eastern side of Bornholm, the border between Poland and Denmark is not yet settled by agreement between the countries. This means that the jurisdiction

to issue a permit to pipeline construction in this area is claimed by both countries. During NSP, consultation between Denmark and Poland on this particular issue was conducted without advising any clear process for the permitting. NSP was therefore at the time guided by the Danish Energy Agency to avoid entering into the area where the border between Poland and Denmark is not yet settled by agreement. The status of the disputed area has not changed, and there is still no clear jurisdiction. NSP2 will therefore – as NSP - avoid entering into the area.

3) NSP also studied a route north and west of the island outside of territorial waters. This route is not significantly longer, but more exposed; in particular to the very intensive marine traffic in Bornholmsgat, which is the traffic scheme between Bornholm and Sweden. These relatively narrow straits is the main entrance or exit to and from the Baltic Sea and one of the most trafficked areas in the world, see section 7.15. The risk of interaction from grounding and/or sinking ships and dragging anchors was assessed by the competent authorities as significant.

Based on the above described constraints and by applying the ALARP (As Low As Reasonably Practicable) principle, the final route for NSP was advised by the Danish Energy Agency. The route north of Bornholm was abandoned, and the benefits of being far from the CWA areas and from the area with intensive commercial fishery were assessed to be secondary only, in comparison to the maritime safety risks.

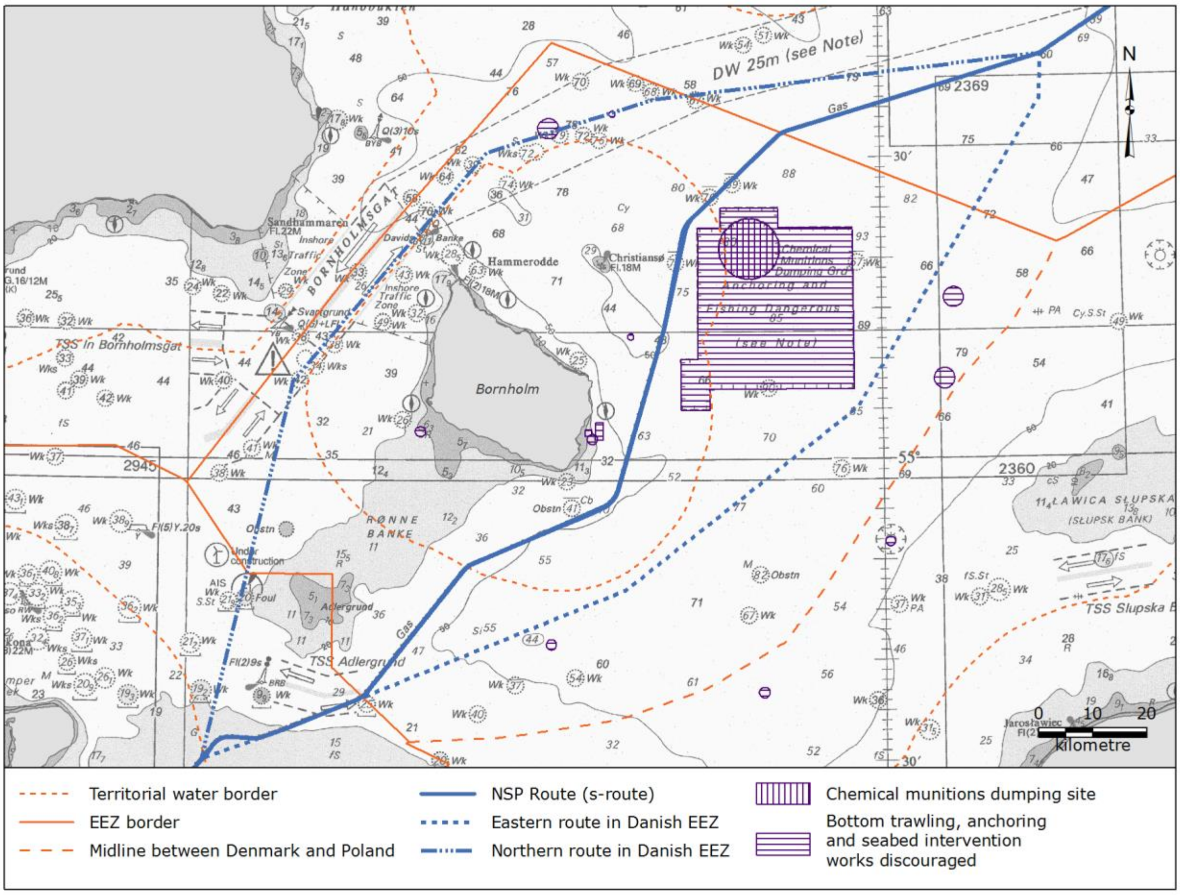


Figure 5-2 Schematic illustration of the different route options for NSP

5.3 Initial route evaluation for NSP2

The issues and arguments for pipe-lay in the waters around Bornholm have not changed since permitting of NSP. On the contrary, NSP has proven that it is possible to install and operate pipelines in the route east of Bornholm without significant negative impacts, neither on the environment, nor on the important commercial fishery. Building on the experience from NSP, the route planning area for NSP2 has consequently focused on an area east of Bornholm including the possibility for a more direct route through the CWA area, see Figure 5-3.

NSP2 is committed to working to good international industry standards with regards to technology, environmental protection, social responsibility, labour conditions, safety, corporate governance and public consultation. Accordingly, NSP2 has planned and designed the pipelines through an integrated and iterative environmental management, survey and engineering design process which satisfy the following objectives:

- Minimise environmental and social impacts
- Meet international good practise in relation to health and safety
- Ensure pipeline integrity and safe operability of the scheme over a 50 year life
- Satisfy minimum design standards and constructability requirements

Environmental criteria relate to the potential effects of the pipelines' installation and operation on the environment of the Baltic Sea, including protected or environmentally sensitive areas hosting ecologically sensitive species of animal or plant life. Furthermore, any project-associated work that might disrupt the natural composition of the seabed must be minimised.

With regard to socio-economic criteria, the key has been to minimise any restrictions on marine spatial planning concepts and marine users – those working in shipping, fishing, offshore industries, the military, tourism or recreation – and paying attention to existing and planned offshore installations, such as cables, pipelines or wind farms. Analysing and avoiding offshore munitions dumping sites and cultural heritage sites also falls within this category.

Technical considerations relate to pipeline design, component manufacture, installation method, operation, integrity, and risk assessment results. These include water depth for pipeline stability, installation, maintenance and repair, minimum pipeline bend radii, criteria for cable and pipeline crossings, distance to and crossing of shipping lanes and seabed roughness. Here, it is also important to consider how to reduce construction time while minimising the operation's technical complexity, environmental impacts and use of resources.

Based on NSP experience and taking the selection criteria described above into account, a feasibility study was undertaken identifying different route corridor options for NSP2. The different route options were presented in the Project Information Document (PID) which also described specific project details in general terms such as pipeline design, landfall sites and construction methods /57/. The PID was used in the projects notification phase as basis for the national and transboundary consultation in 2013 and for scoping of the necessary surveys, field investigations and EIA documentation.

In Denmark the following three different routes for NSP2 were identified during the feasibility study (Figure 5-3). These routes were consulted with relevant Danish authorities under coordination of the Danish Energy Agency. The consultations were based on the PID together with the EIA programme for the Danish section /58/:

- FS route – west of NSP
- ES route – east of NSP
- RA route - direct route through area where anchoring and fishing is discouraged

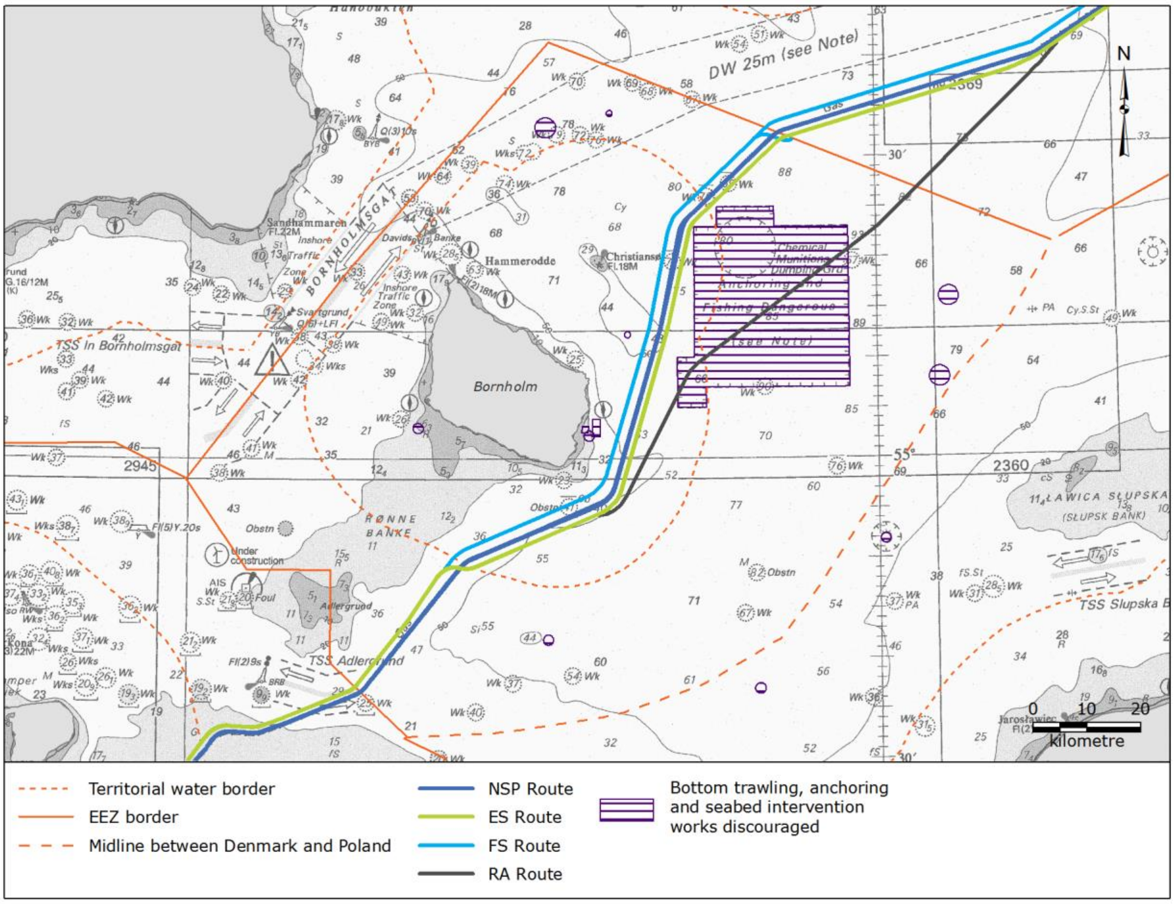


Figure 5-3 Initial route evaluation for NSP2 in Denmark

After an initial engineering evaluation, the FS route was assessed to entail the largest amount of post-lay trenching and/or rock placement since this route is closest to shore with shallower water depths and harder substrates. Therefore, this route can potentially cause the largest environmental impacts. Furthermore, this route is the closest route to the Natura-2000 area Ertholmene, see section 7.13. It was assessed that as-laid embedment of the pipelines will also be limited and likely the least of the three considered route options due to the harder seabed closer to shore. Therefore, trawling in the area might be affected the most by this route. Therefore, initial evaluation resulted in the FS route being disregarded at an early stage of the project.

5.4 Evaluation and comparison of the route alternatives for NSP2

For the assessment of the two route alternatives - ES and RA - relevant biological and socio-economic aspects in Danish waters have been selected and evaluated as described in this section. These aspects have been selected on the basis of consultation feedback and experience on NSP. The following aspects were scrutinised:

- Maritime safety
- CWA area
- Fishery in the area
- Marine spatial planning
- Military areas
- Extent of intervention works during construction
- Impacts on biological environment

The two route alternatives have been evaluated for all the aspects above and it has been evaluated which route option would give rise to the least potential for environmental or socio-economic impact; see Table 5-1 to Table 5-6.

5.4.1 Maritime safety

The main entrance/exit to the Baltic Sea for international ship traffic and one of the most trafficked areas in the world is through the Bornholmsgat located north of Bornholm. A ship separation zone has been defined for the area where more than 50,000 annual ship movements are observed, see section 7.15. Additionally, ship traffic routes to and from the south-east coast of the Baltic Sea are located north-east and south-east of Bornholm (see also section 7.15) and there is a number of small routes for ships sailing to/from Bornholm.

NSP has the potential to have an impact on navigation mainly during construction phase in the high traffic areas due to safety areas established around pipe-lay vessels. However, the pipeline route alternatives are evaluated to constitute the same level of impacts on marine safety given that, as mentioned, the main traffic is located in Bornholmsgat north of Bornholm which is unlikely to be impacted by either alternative.

Table 5-1 Comparison summary for the routes in relation to maritime safety

Route	Comparison Summary	Route preference
ES route	The main traffic separation scheme Bornholm Gat is not impacted. Therefore, the impact level is comparable to the RA route.	Comparable
RA route	The main traffic separation scheme Bornholm Gat is not impacted. Therefore, the impact level is comparable to the ES route.	Comparable

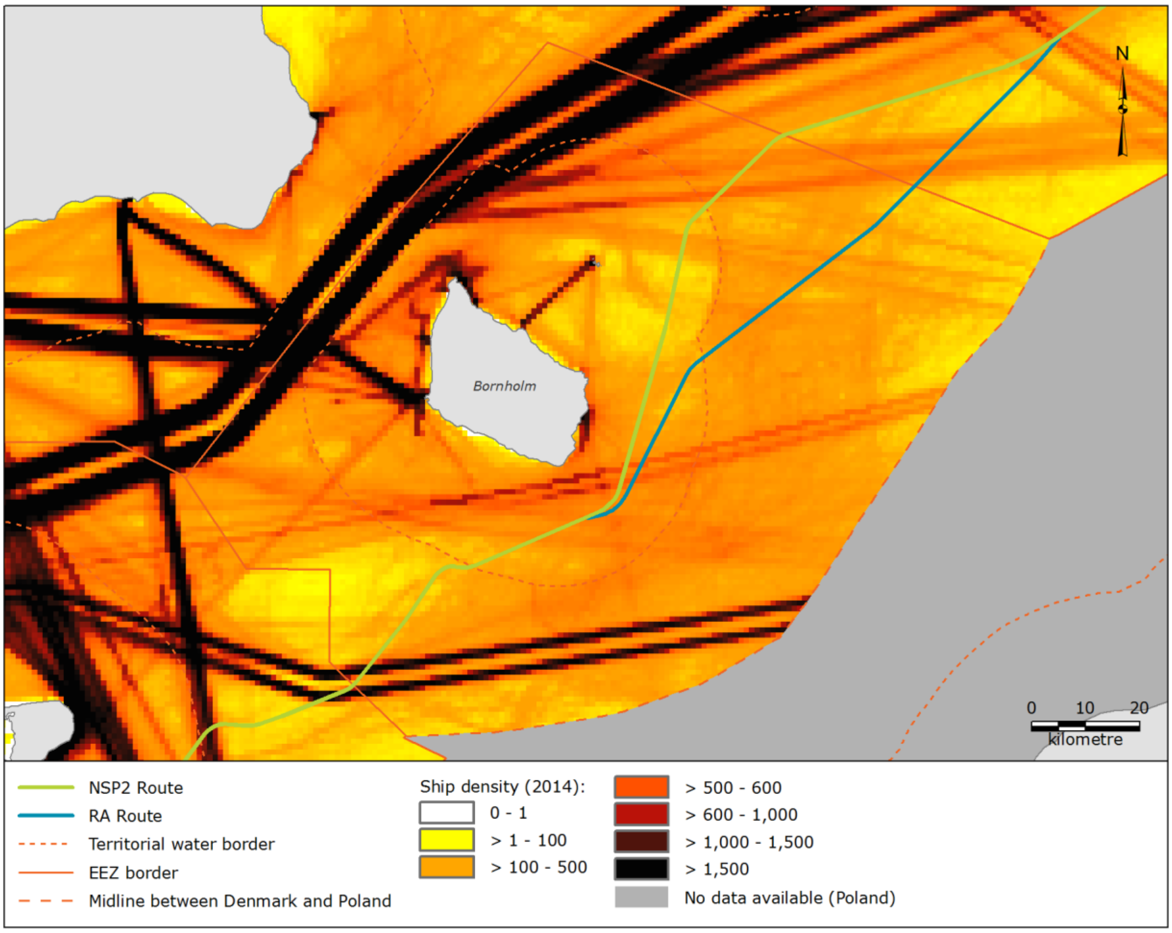


Figure 5-4 Ship density and route alternative

5.4.2 CWA area

The RA route crosses approximately 40 km of the area that has restrictions on anchoring and fishing due to the potential presence of chemical munitions or CWA. Although shorter, and thereby less expensive to install, it can be assumed that the risk of encountering chemical munitions is high compared to other areas. This would present health and safety concerns during construction and operation of the pipelines and has the potential to impact the marine environment.

The ES route does not cross the restricted area, thus having less CWA-related risks.

Detailed investigations of the presence of CWA along the ES route and the direct RA route completed as part of the NSP2 project also show that the levels of CWA and thereby the risks of exposure to CWA along the RA route are higher compared to the proposed ES route, see section 7.3.

The potential for environmental impact in relation to the potential presence of CWA is therefore considered higher for the RA route compared to the ES route which is located outside the restricted area.

Table 5-2 Comparison summary for the routes in relation to CWA areas

Route	Comparison Summary	Route preference
ES route	The route does not cross the CWA-contaminated area. Therefore, the risks of exposing environment to CWA are less than for the RA route. The route is considered to be the one with the least potential for environmental impact.	Preferred
RA route	The route crosses the CWA-contaminated area. Therefore, the risks of exposing environment to CWA are higher for this route.	

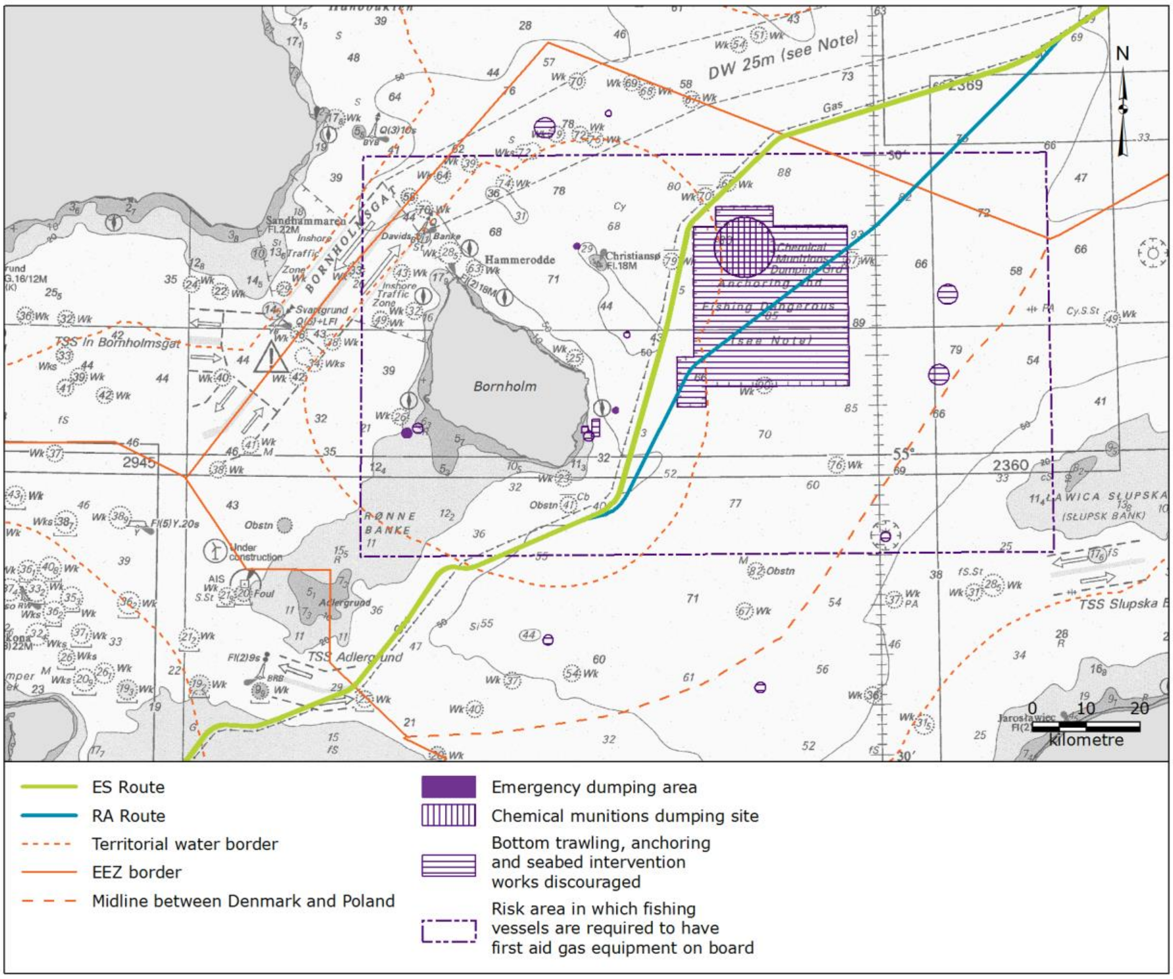


Figure 5-5 CWA area and route alternative

5.4.3 Fishery

Impacts on fishery may occur due to the presence of the pipelines on the seabed and due to navigation restrictions around the pipe-lay vessel during construction. Intensity of fishery in the corresponding areas should be taken into account when assessing the two alternatives.

The intensity of trawl fishing is higher in the area of RA route (compared to the ES route) inspite of the registered advice against trawling due to risk of CWA in this area (see section 7.16). Therefore, despite the fact that the pipelines are expected to sink into the soft seabed on a large part of the route, there is higher potential for interaction with fishery operations along the RA route.

However it is noted that construction activities are expected to be similar along ES- and RA route with pipe-lay vessel moving with the speed of approximately 2.5 km a day and therefore, the duration of the fishery ban at any given location will be very limited.

The RA-route deviates from the existing NSP route to a greater extent than the ES-route. For the ES-route, the distance between the existing NSP pipelines and the proposed pipelines, where parallel, will be approximately 1,200 m (see section 7.16). This is considered sufficient for the fishing vessels to trawl and turn between the two pipeline systems and would have less impacts on fishing operations.

Table 5-3 Comparison summary for the routes in relation to fishery

Route	Comparison Summary	Route preference
ES route	Lower intensity of fishery activities in the area. Therefore, this route is considered to be the one with the least potential for socio-economic impact.	Preferred
RA route	Higher intensity of fishery activities in the area. Therefore, the potential for socio-economic impact is considered higher for this route.	

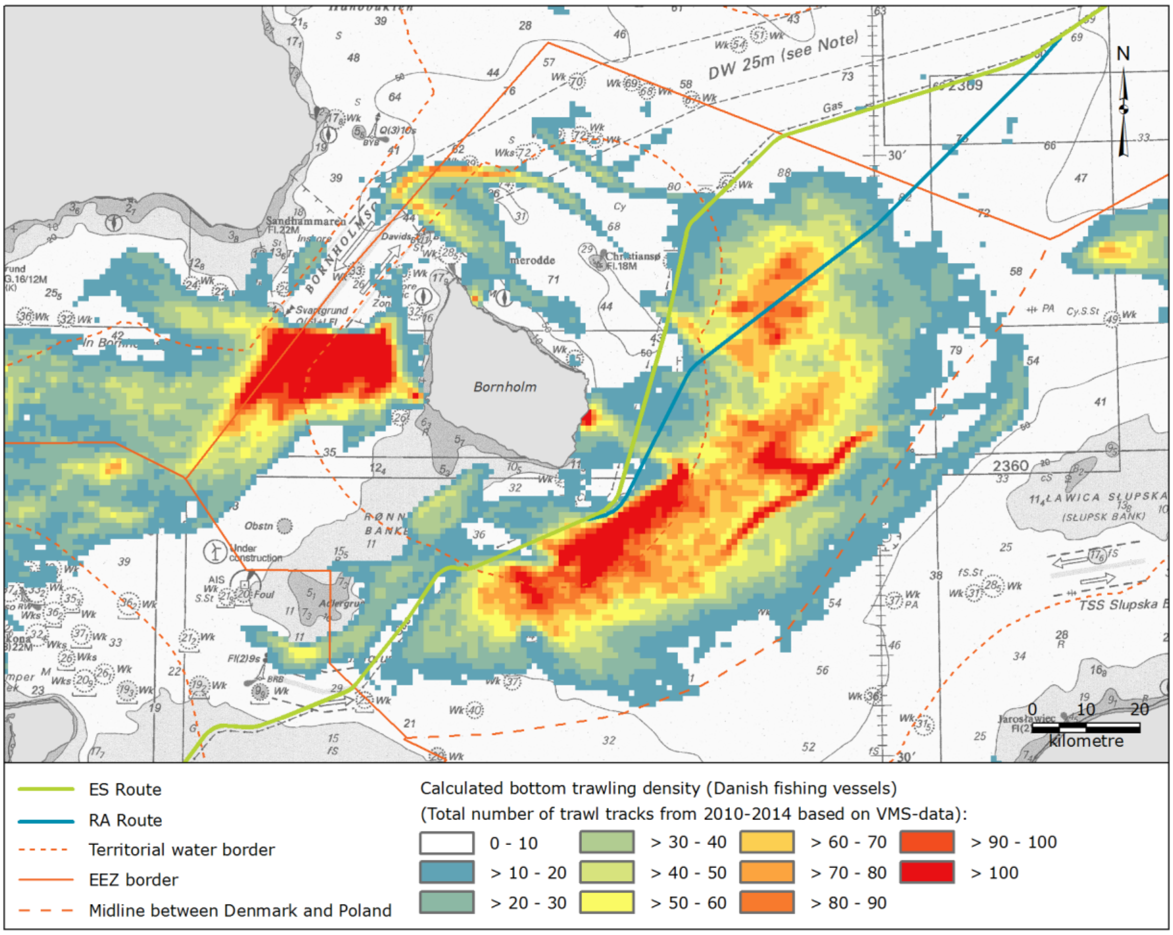


Figure 5-6 Bottom trawl density and route alternative

5.4.4 Maritime spatial planning

It shall be noted that Denmark in 2016 has passed legislation on maritime spatial planning aligned to the European Directive on establishing a framework for maritime spatial planning (Directive 2014/89/EU). This new legislation will oblige NSP2 to align to the current plans.

A spatial planning pilot project was undertaken by Germany for the Arkona Basin in 2012. Outside of the formal planning purposes, a planning exercise was undertaken which resulted in a draft spatial plan. The draft spatial development plan is of strategic character and a tool for balancing the different Interests in the use of sea space, based on the sustainability principle. The draft plan is suggesting an area specifically reserved for cables and pipelines. The ES route follows this suggested area.

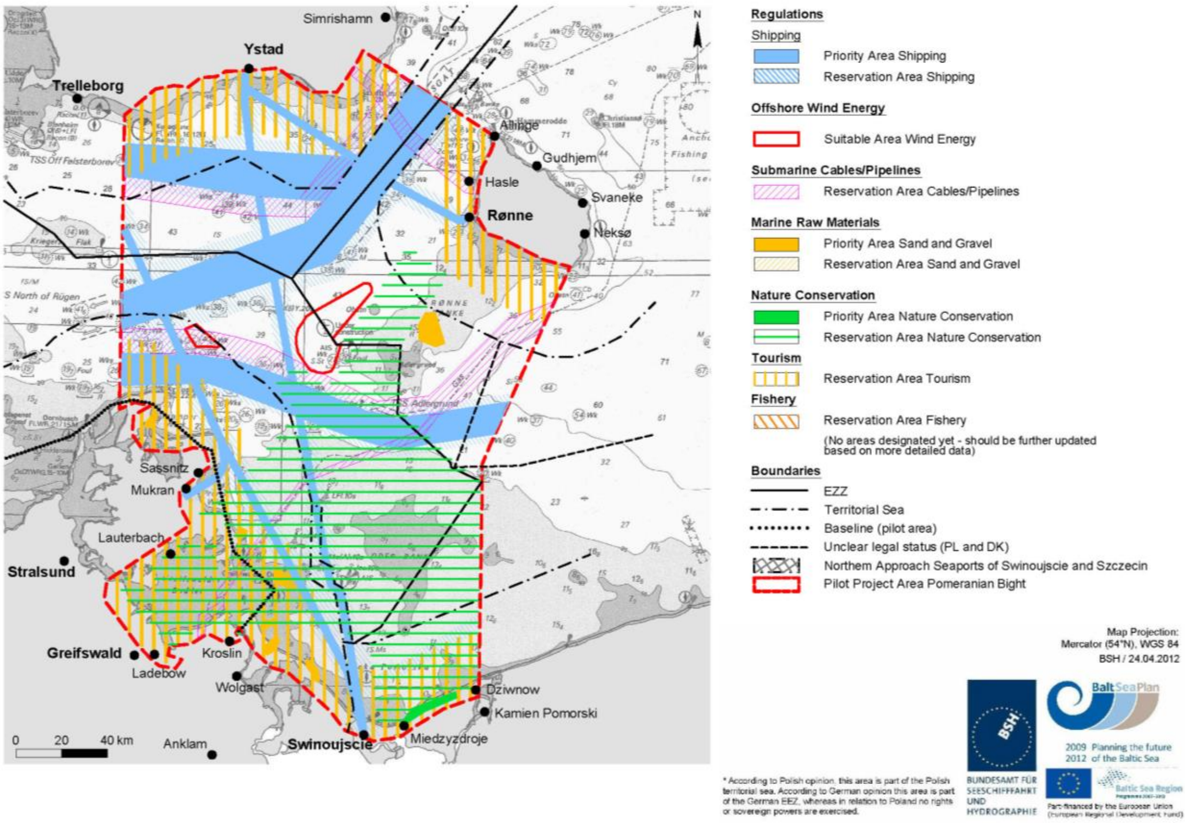


Figure 5-7 Pilot project – draft maritime spatial plan for Arkona Basin and Pomeranian Bight /23/

It is anticipated that the ES route will be preferred by the authorities in relation to maritime spatial planning, since this route will occupy the smallest area on the seabed if NSP and NSP2 are considered together. There is, however, no Danish legislation regarding e.g. bundling of pipelines at present. Therefore, the potential for socio-economic impact is considered slightly higher for the RA route alternative than the ES route in relation to marine spatial planning.

Table 5-4 Comparison summary for the routes in relation to maritime spatial planning

Route	Comparison Summary	Route preference
ES route	The ES route will occupy a smaller area when assessing NSP and NSP2 together. Therefore, this route is considered to be the one with the least potential for socio-economic impact.	Preferred
RA route	The RA route will occupy a bigger area when assessing NSP and NSP2 together. Therefore, the potential for socio-economic impact is considered slightly higher for this route.	

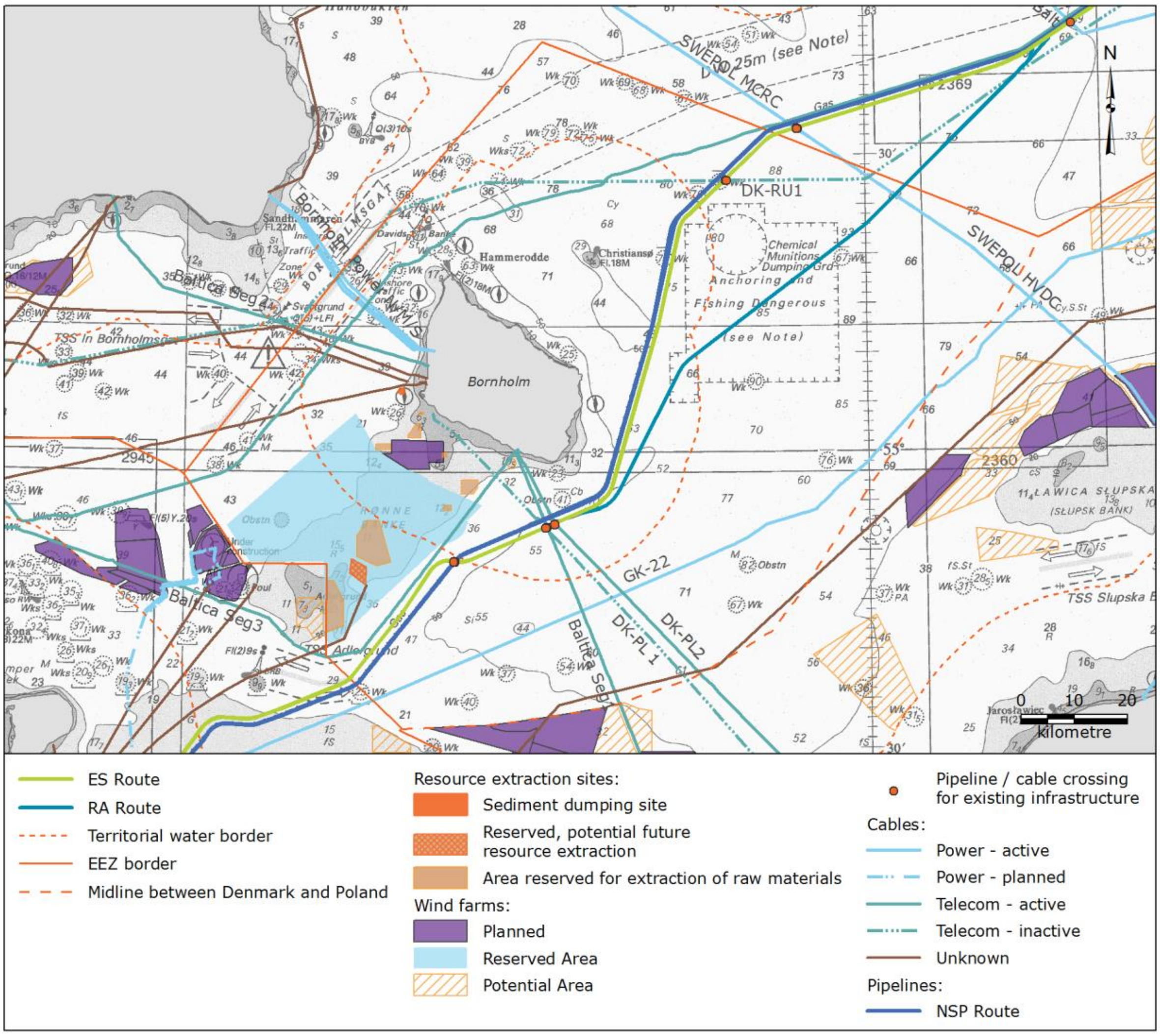


Figure 5-8 Maritime spatial planning and route alternative

5.4.5 Military practice areas

Construction of the pipelines might interfere with the military practice activities in Danish Waters. In the Danish EEZ and TW east of Bornholm, there are a number of military areas (see section 7.23). The ES route crosses a military firing danger area, while the RA route crosses a submarine exercise area.

Although the ES route would cross a military firing danger area, no concerns from the Danish Navy were received. The RA route would have the potential to result in a disturbance to military activities in a new U-boot exercise area, and the German Navy advised against this route due to close proximity to German military areas /59/. Therefore, the potential for socio-economic impact is considered higher for the RA route alternative in relation to military areas.

Table 5-5 Comparison summary for the routes in relation to military practice areas

Route	Comparison Summary	Route preference
ES route	No concerns from the Danish Navy in relation to the military practice areas were received for the ES route. Therefore, this route is considered to be the one with the least potential for impact om military practice areas.	Preferred
RA route	The RA route is discouraged by German Navy due to the new U-boot exercise area east of Bornholm. Therefore, the potential for socio-economic impact is considered higher for this route.	

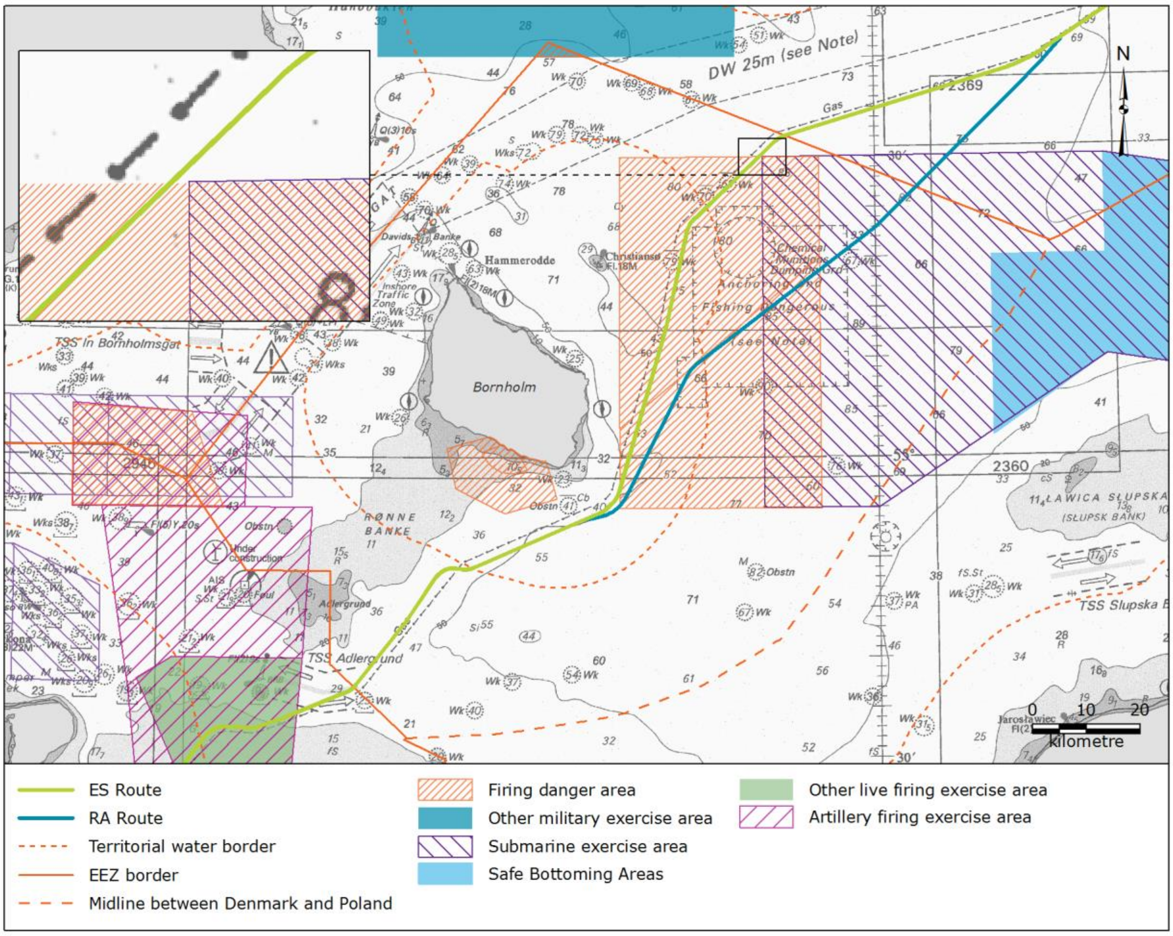


Figure 5-9 Military practice areas and route alternative

5.4.6 Intervention works

Besides the actual pipe-lay, the construction activities in Danish waters would include preparation for cable crossings, post-lay trenching and/or rock placement which are defined as intervention works.

Post-lay trenching describes the process of ploughing a trench into the seabed and subsequently lowering the pipeline into the newly dug trench. For this purpose, a pipeline plough is deployed on the seabed and towed by a tugboat.

Rock placement will be used provide additional stability or to support the pipeline where it crosses another structure or cable. Rock placement may be used as an alternative to post-lay trenching in areas with large freespans, where the pipeline will need support points of rock and gravel. The material used for rock placement is coarse, and will typically be installed by means of a fall pipe-line to ensure maximum precision.

The RA route is expected to include less intervention works than the ES route since the seabed is softer in the northern part of the RA route and therefore greater natural embedment is foreseen in this area.

However, based on experience from the construction of NSP, impacts from intervention works are not expected to be significant. The differences between the route options in relation to the impacts from intervention works are therefore considered to be relatively small.

Table 5-6 Comparison summary for the routes in relation to intervention works

Route	Assessment summary	Route preference
ES route	Post-lay trenching and/or rock placement is expected. The impacts are expected to be insignificant. However, since more intervention works take place, the potential for environmental impact is considered slightly higher for this route compared to the RA route.	
RA route	Post-lay trenching and/or rock placement is expected. The impacts are expected to be insignificant. Less intervention works are expected; therefore, this route is considered to be the one with the least potential for environmental impact.	Preferred

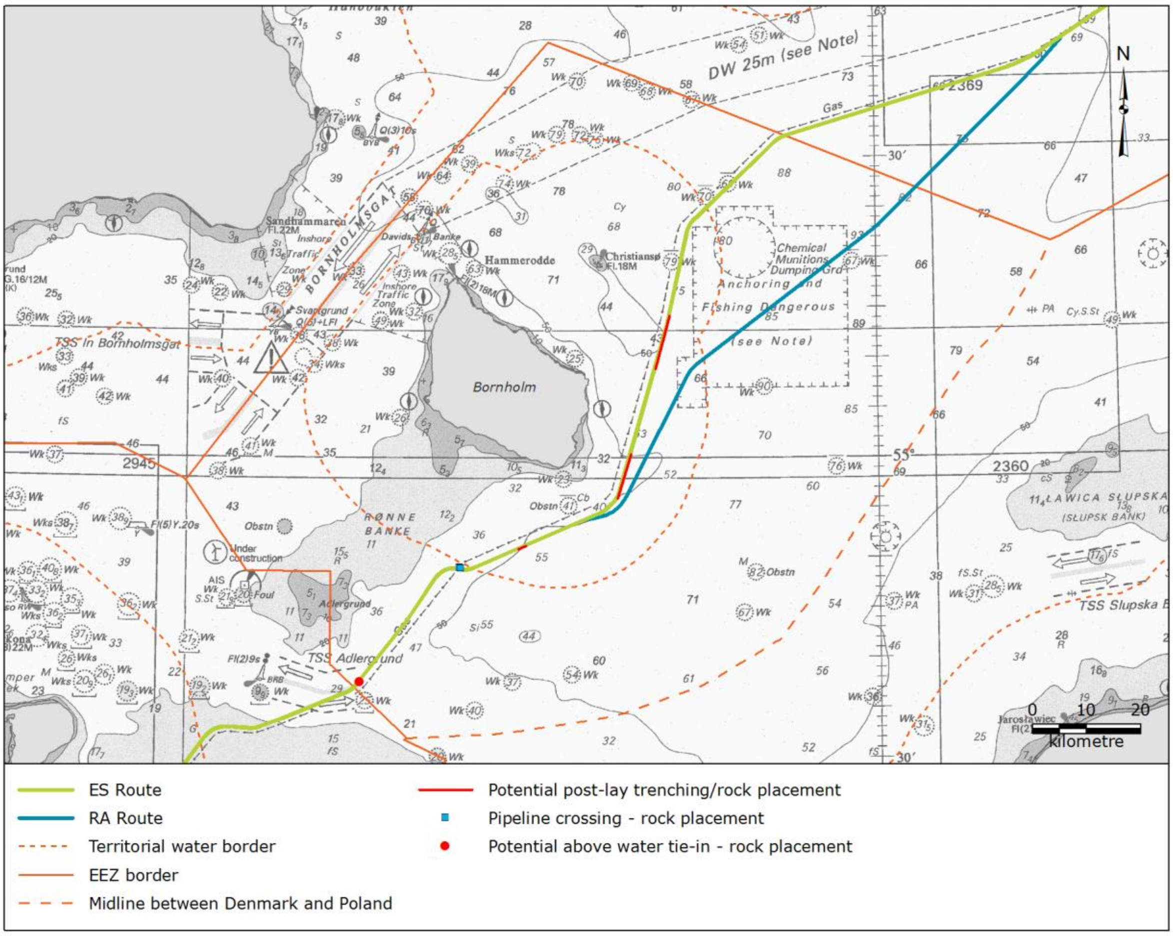


Figure 5-10 Intervention works and route alternative

5.4.7 Biological environment

Impacts on the marine biological environment are expected to result from construction and operation activities. During the construction phase, vessel operations, pipe-lay and seabed intervention works are expected to cause dispersion of sediments and contaminants into the water column and to create underwater noise which can potentially impact the biological environment. During the operational phase presence of the pipelines and supporting structures on the seabed may potentially impact biological environment.

It is assumed that impact from the vessel operations and pipe-lay will be the same along the two route alternatives. Differences in potential impacts on the biological environment along the two routes may arise from the extent of intervention works required for installation of the pipelines and levels of contaminants including metals, organic compounds and CWA in the seabed sediment along the routes.

As mentioned earlier, the RA route is expected to require less intervention works (post-lay trenching and/or rock placement) than the ES route since the seabed is softer in the northern part of the RA route and therefore greater natural embedment is foreseen in this area. Due to greater degree of intervention works along the ES route, it is anticipated that more sediments will be suspended into the water column and more underwater noise will be created. On the other hand, the deeper and softer sediments along the RA route are likely to contain higher levels of contaminants including metals and organic compounds than sediments along the ES route. Furthermore, the RA route passes through the area with increased risk of encountering CWA in the sediment which may impact the biological environment.

Based on the above, both ES and RA routes have a potential to impact the biological environment. However, based on experiences from construction and operation of the existing NSP pipelines, it can be expected that the impacts on the biological environment related to intervention works and contaminants in the seabed for both route alternatives will be limited.

Three Natura 2000 sites, three HELCOM Marine Protected Areas (MPA), two Important Bird Areas (IBA) and one Ramsar site are located in Danish waters. Neither the ES route nor the RA route crosses any of the protected areas except for the IBA Ronne Banke where both routes cross the area for approximately 10 km (up to the border with Germany). However, no intervention works are planned for this area, and no significant impacts from either of the route options are thus anticipated. The ES route is closer to some of the protected areas than the RA route, but given the distances (approximately 13 km to the closest Natura 2000 site and to the closest RAMSAR/HELCOM MPAs for the ES route), the potential impacts on protected areas from the ES route are not expected to differ from those of the RA route. Therefore, impacts from ES route and RA route are comparable in relation to the protected areas.

In conclusion, the two route alternatives are considered comparable in terms of impacts on the biological environment.

Table 5-7 Comparison summary for the routes in relation to the biological environment

Route	Assessment summary	Route preference
ES route	There is a need for additional seabed intervention works (post-lay trenching and/or rock placement) along the ES route compared to the RA route. This may result in increased levels of suspended sediments and underwater noise. However, the impacts on biological environment associated with intervention works are considered to be limited.	Comparable
RA route	The route passes through an area with potentially higher levels of contaminants in the sediment compared to the ES route. Exposure to contaminants has a potential to impact biological environment. However, the impacts on biological environment associated with contaminants are considered to be limited.	Comparable

5.4.8 Summary

The comparison in relation to relevant environmental, socio-economic and technical aspects in Danish waters is summarized in Table 5-8 and the sections below.

Table 5-8 Comparison of the considered routes for NSP2

Risk issue	Route preference	
	ES route	RA route
Maritime safety	Comparable	Comparable
Chemical Warfare Agents (CWA)	Preferred	
Fishery	Preferred	
Marine spatial planning	Preferred	
Military practice areas	Preferred	
Intervention works		Preferred
Biological environment	Comparable	Comparable

5.5 Preferred route

Based on the above, the ES route has been adopted as the preferred and proposed route for the NSP2 project. The following were key considerations in the decision:

- The ES route lies to the east of the existing NSP pipelines for the most part of the route in Danish waters, and is thus further from Bornholm;
- The ES route reflects positive aspects of marine spatial planning (NSP and NSP2 run parallel and the occupied area which could affect other uses of the seabed is thus reduced to a minimum);
- ES route avoids CWA-risk area and the area extensively used for fishery;
- The ES route is preferable in respect to technical feasibility, existing knowledge from NSP and known permitting process whilst also seeking to avoid or reduce the potential for significant environmental impacts.

The assessments conducted as part of this EIA report has therefore been performed for the construction and operation of a pipeline system following the ES route, see section 6.

5.6 No-action alternative

An environmental impact assessment should include a no-action (or zero-) alternative describing a situation in which the planned project is not carried out; in the present case that the Nord Stream 2 natural gas pipeline system is not constructed and operated in Danish waters. Non-implementation would mean that there will be no environmental or social impact from the project, neither adverse nor positive.

The impacts of the 0-alternative therefore can be confined to be the natural changes from the baseline. As the construction of the NSP2 pipeline system in Danish waters is planned to last approximately 135 days this timeframe is used to define the period for natural changes in the environment from the baseline. During this very short period of time no essential natural changes are expected to occur in the physical and chemical environment in the Danish Baltic Sea and as a consequence hereof no essential changes of the biological environment can be foreseen either. Likewise, no change in the socio-economic environment is foreseen in the short timeframe of the construction phase in Danish waters.

It should be emphasized that NSP2 has been designed to avoid or minimise environmental and socio-economic impacts. Short-term and local environmental and socio-economic impacts can however be expected during the construction phase along the route. Mitigation measures will be applied and the impacts are assessed to be minor and generally limited to the pipeline corridor. The experience from the former Nord Stream project and the extensive monitoring carried out in this project supports this assessment. The 0-alternative will however avoid these temporary, local and minor adverse impacts and only natural changes are foreseen.

In this context it should be noted that if the NSP2 project is implemented, positive impacts will occur regarding certain socio-economic aspects among the Baltic countries. These positive socio-economic consequences, e.g. increase of employment and other revenues, will not occur if the project is not to be realized.

6 PROJECT DESCRIPTION

The aim of this section is to describe the NSP2 project in sufficient depth to enable the scope and extent of the project to be understood, and for all potential sources of impacts to be identified. Since no onshore activities are anticipated in Denmark this national EIA report only covers offshore activities associated to the construction and operation of the Nord Stream 2 pipeline system in Denmark. In general, the scope of the Danish national EIA report is confined to those project activities that occur offshore in the Danish TW and EEZ.

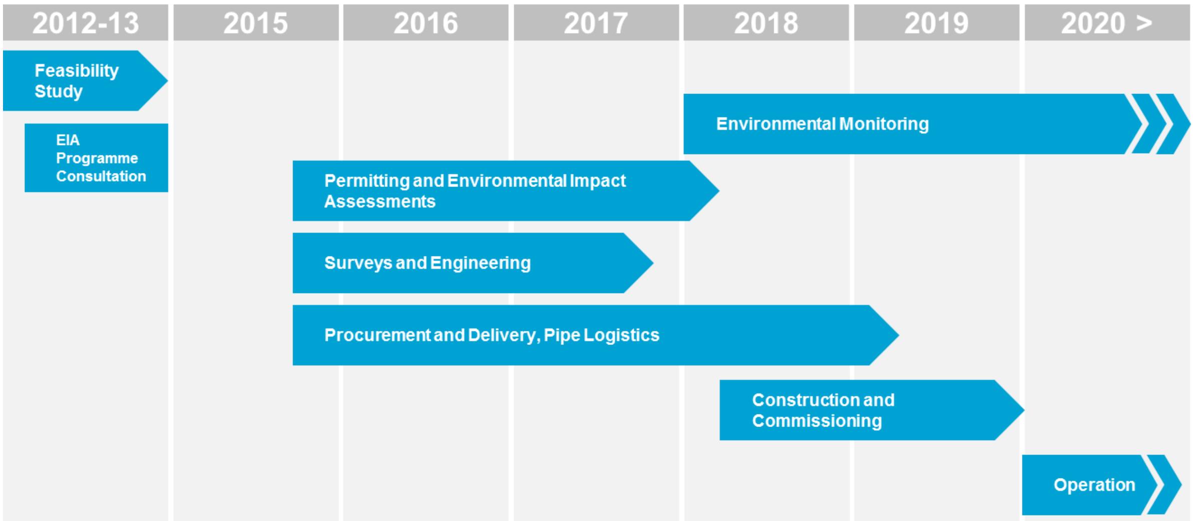


Figure 6-1 General project schedule

More detailed descriptions and assessments concerning onshore or offshore activities related to the project in other national jurisdictions can be found in the Espoo report /60/. In the sections below the onshore activities are described to some extent to give a general understanding of the project in a broader context.

6.1 Proposed pipeline route

NSP2 comprises two 48” diameter subsea pipelines including onshore facilities. The pipelines will extend through the Baltic Sea from the southern Russian coast (Narva Bay) in the Gulf of Finland to the German coast, in the Lubmin area, Figure 6-2.

The entire pipeline route will cover a distance of approximately 1,200 km, depending on the final route selection. While routing through the Baltic Sea the pipelines are generally independent from the existing Nord Stream pipelines. However, they do run in parallel for a substantial distance. The proposed pipeline route crosses the TW of Russia, Denmark and Germany and runs within the EEZs of Finland, Sweden, Denmark and Germany. Figure 6-2 provides an overview of the proposed routing of NSP2.

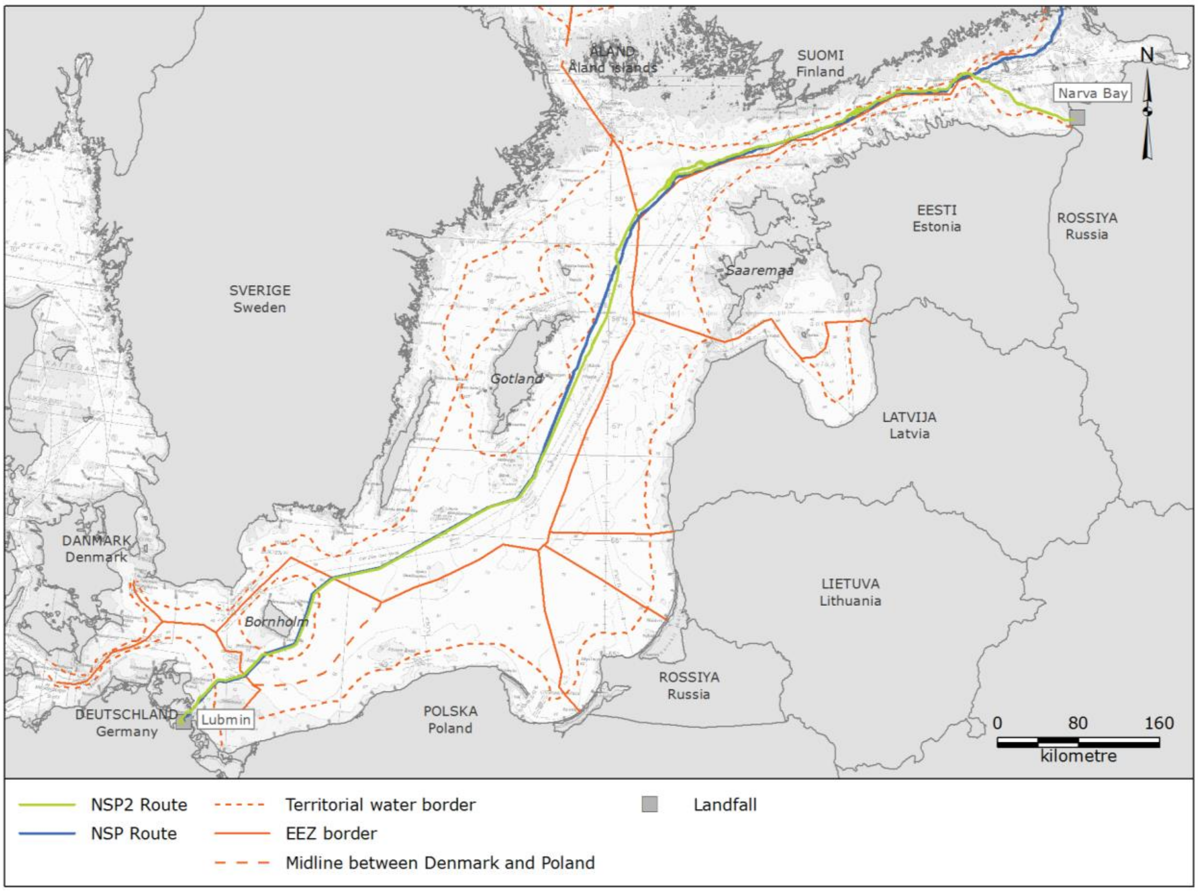


Figure 6-2 Proposed NSP2 routing in the Baltic Sea

Landfall facilities in Russia and Germany will connect the two pipelines to the Russian and European gas networks, which are located beyond the Pig Trap Area (PTA) at each end.

The Narva Bay area has been selected for the landfall in Russia. The PTA in Narva Bay is located approximately 4 km inland from the Land Termination End (LTE). The Lubmin area has been selected for the landfall in Germany. The PTA in Lubmin is located approximately 0.4 km from the LTE.

6.1.1 Route details in the Danish section

In the Danish section the proposed NSP2 route runs south of NSP, following the same "S-shaped" route to avoid crossing the area where anchoring and trawling are discouraged and remaining to the east and south of the Bornholm, see Figure 6-3. South of Bornholm, the NSP2 route crosses the NSP pipelines and continues to the German landfall while remaining to the north of the NSP pipelines. The length of the proposed NSP2 route in Danish waters is approximately 139 km.

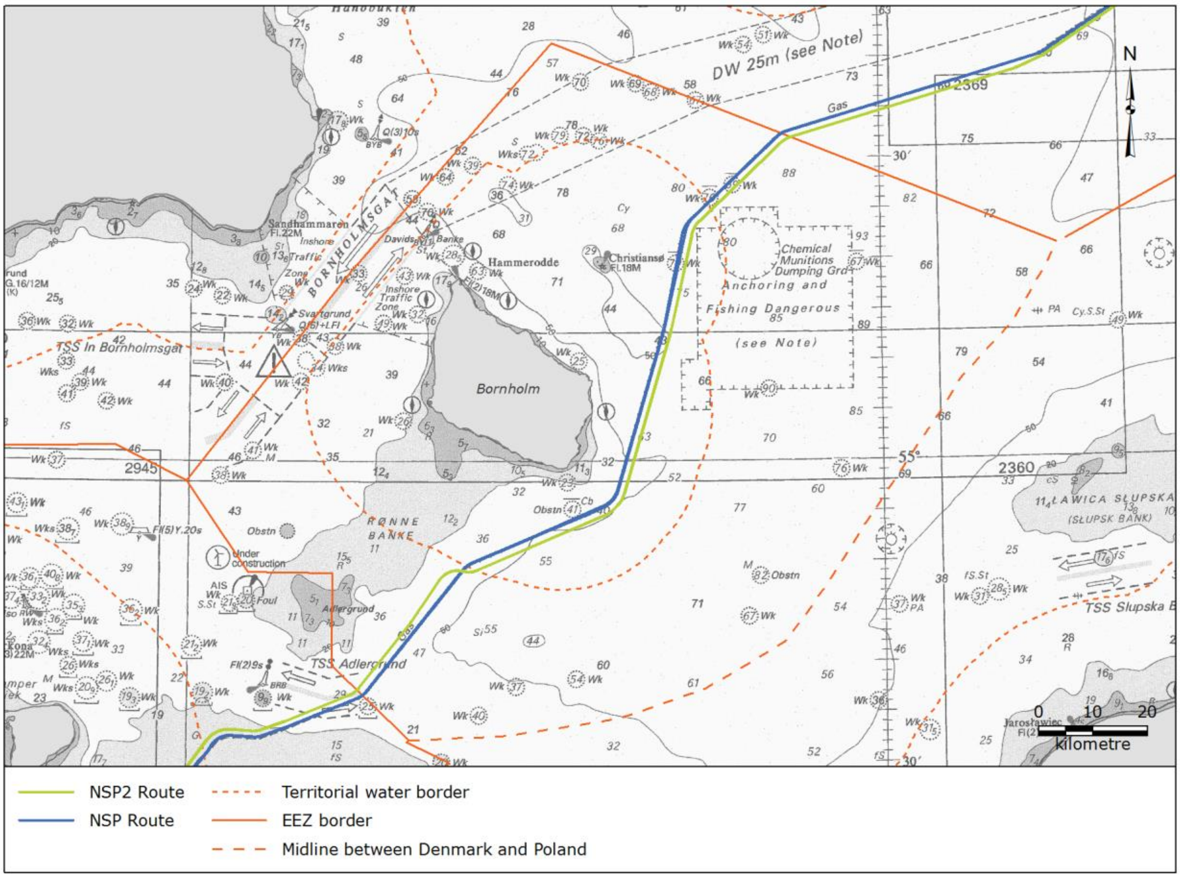


Figure 6-3 Proposed NSP2 routing in Denmark

The two NSP2 pipelines (Line A and Line B) will run almost parallel to one another. The minimum distance between the two pipelines is selected based on the pipe-lay vessel. The separation distance of the two lines may vary between 55 to 105 m in Denmark depending on the pipe-lay vessel.

The distance between the NSP pipelines and the NSP2 pipelines in Danish waters will be approximately 1,200 m.

6.1.2 Route surveys

A number of surveys are carried out as part of the project. The objectives of the surveys are:

- To collate and integrate survey data used as the basis to develop the detailed scope of work for the project;
- To identify and map potential munitions, geological features and environmental constraints that may have the potential to influence pipeline installation works;
- To identify and map features or areas of cultural heritage, e.g. wrecks, to be avoided or safeguarded.

Engineering and environmental surveys, aimed for design and route optimization, have started in 2015 and will continue in 2017. Engineering surveys are shortly discussed in this section, environmental surveys are discussed in section 7. Figure 6-4 shows an approximate schedule of surveys in Danish waters.

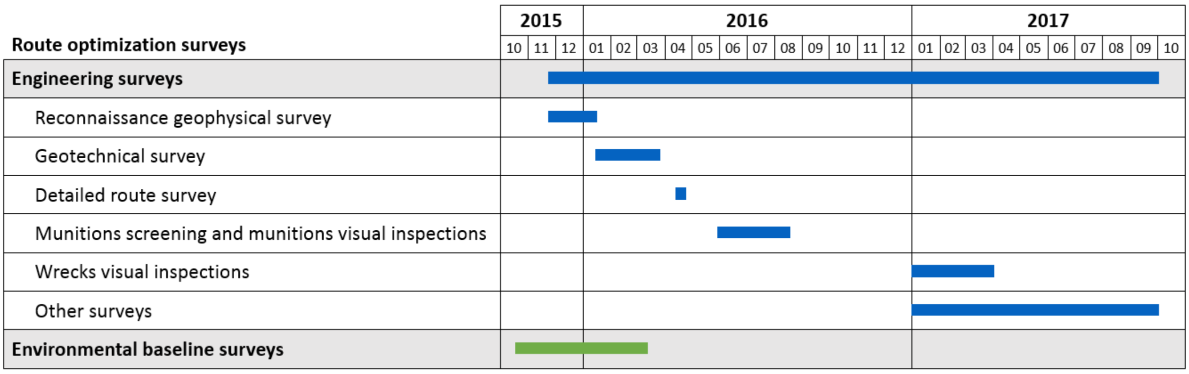


Figure 6-4 Schedule of surveys carries out and planned in Danish TW and EEZ

Initially, a reconnaissance survey covering a corridor approximately 1.5 km width was carried out to allow the preliminary pipeline route to be selected on the basis of information on geological and anthropogenic features /61/.

A geotechnical survey was performed to optimise the pipeline engineering design including the detailed route and required seabed intervention works to ensure the long-term integrity of the pipeline system /62/. Local re-routing optimisation was then based on the available geophysical and geotechnical data.

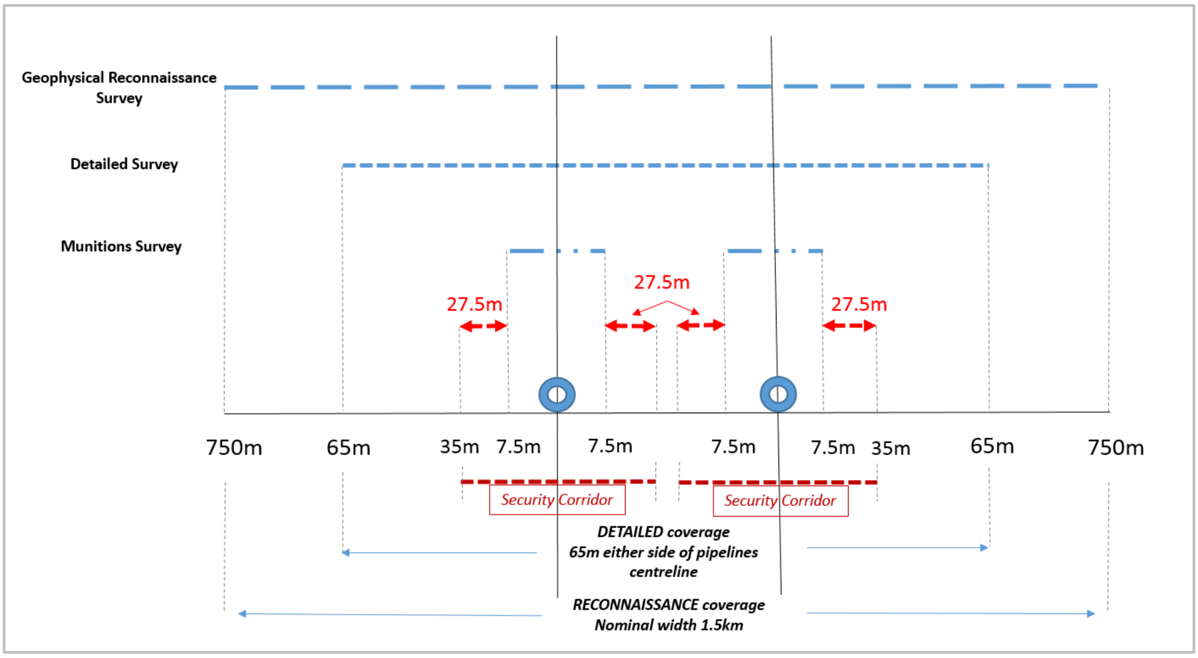


Figure 6-5 Schematic representation of surveys conducted in Danish waters.

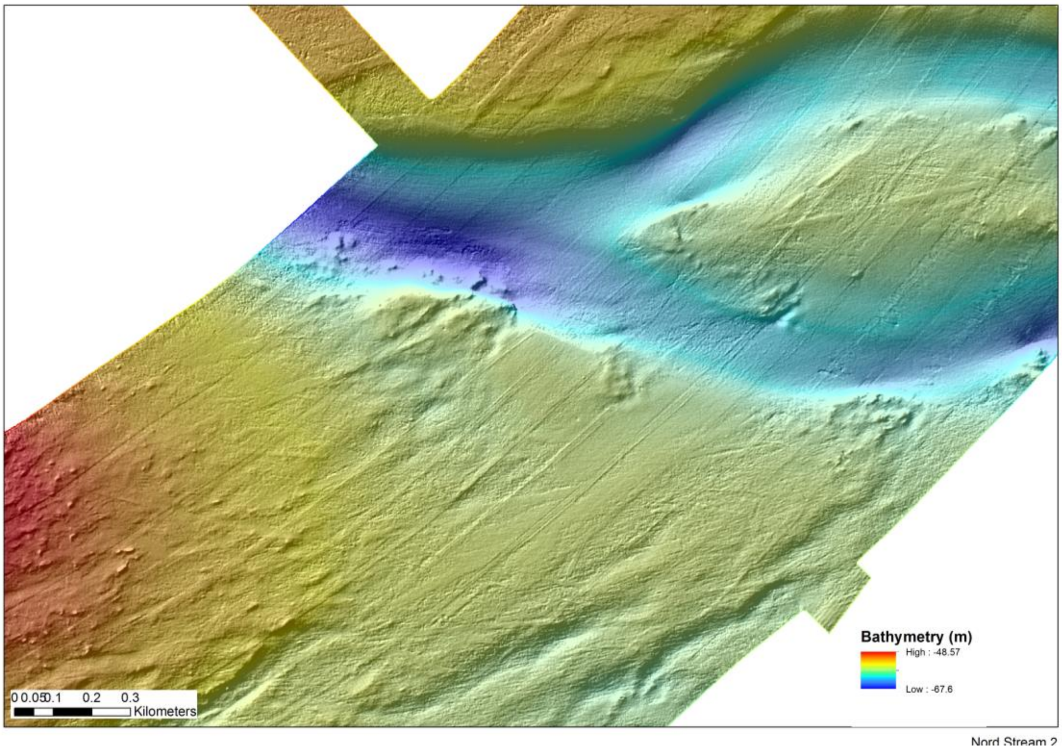


Figure 6-6 Example of bathymetry profile data acquired during reconnaissance survey

Based on the results of the reconnaissance survey and the geotechnical survey a detailed route survey was conducted covering a corridor width of 130 m centred along two new defined routes (A and B) /64/. This "state of the art" survey supported route optimisation and enabled all objects to be detected and enabled detailed profiling along each planned pipeline centreline. This reduced the likelihood of positioning errors known to be problematic in the Baltic Sea due to pycnoclines.

A munitions screening survey was then performed to establish that the pipeline corridor was clear of potential unexploded munitions (conventional and chemical) that could constitute a danger to the pipeline or the environment during the installation and/or the operational lifetime of the pipeline system. The munitions screening survey was performed covering a 16.5 m wide corridor centred on each pipeline design route with wider sections (42 metres) where the pipelines may be post-lay ploughed. All magnetic anomalies over a calibrated threshold were then visually investigated using video and stills cameras mounted on a remotely operated vehicle (ROV). In addition, all targets in excess of 0.5 m (in any dimension) identified during the detailed geophysical survey, were also visually inspected by ROV.

To assess sites of potential cultural heritage value, e.g. wrecks, selected objects identified during reconnaissance and detailed route surveys were visually inspected. Objects of cultural importance are taken into account in NSP2 pipeline route optimisation.

Other surveys include visual inspections and further route optimization surveys. In the event that an anchored lay vessel is used, an anchor corridor survey will be undertaken to identify, verify, and catalogue all obstructions. A dynamically positioned (DP) vessel will not require any further surveys in addition to the detailed geophysical survey and the munitions screening survey.

A pre-lay survey of the installation corridor will be performed prior to pipe-lay to ensure that no new obstacles are present on the seabed. Once the pipelines have been installed an as-laid survey will be performed to document the as-built status of each pipeline.

6.2 Pipeline technical design and materials

The development of the technical design is an ongoing process in which input from investigations of the route corridors, basic engineering, stakeholder consultation, environmental and social impact assessments and regulatory review are continuously used to optimise the design. Therefore, minor changes to the description below may be made during the detailed design period. The design development will however not change the project significantly i.e. resulting in new or worse environmental impacts as determined in this document.

6.2.1 Technical specifications

The design basis of NSP2 is the same as for the existing NSP. NSP2 will consist of two parallel 48-inch steel pipelines with a total capacity of 55 bcm per year. The pipelines will be divided into three pressure segments according to the pressure drop along the pipelines from the Russian landfall to the German landfall.

The main characteristics of the pipelines are shown in Table 6-1.

Table 6-1 Design operating conditions and technical specifications for the NSP2 pipelines

Property	Value (range)
Throughput	55 bcm per annum (27.5 bcm per annum per pipeline)
Gas	Dry, sweet natural gas
Design pressure	Kilometre point (KP) 0 – ~KP 300: 220 bar ~KP 300 – ~KP 675: 200 bar KP 675 – ~KP 1230: 177.5 bar (Denmark)
Design temperature	+40°C (max)/-10°C (min) for the offshore sections
Pipeline inner diameter	1,153 mm
Pipeline wall thickness	41.0 mm, 34.6 mm, 30.9 mm and 26.8 mm (depending on pressure range, 26.8 mm in Denmark)
Buckle arrestor thickness	34.6 mm
Linepipe and buckle arrestor material	C-Mn steel
Internal flow coating	low solvent epoxy, average roughness R_Z <= 3 µm, thickness minimum 90 µm
External corrosion coating	three-layer polyethylene (3LPE) of 4.2 mm minimum thickness
CWC thickness and density	60 mm to 110 mm, 2,250 kg/m^3 to 3,200 kg/m^3
Corrosion protection anodes	zinc-based anodes in low-salinity water; aluminium anodes in other areas (In Denmark only aluminium anodes will be used)

6.2.2 Standards, verification and certification

The pipelines will be designed, constructed and operated in accordance and in compliance with the international offshore standard DNV OS-F101, Submarine Pipeline Systems, along with its associated Recommended Practices, issued by Det Norske Veritas (DNV).

Nord Stream 2 AG has appointed DNV GL as independent third-party expert to confirm that the pipeline system, from pig trap to pig trap, has been designed, fabricated, installed and pre-commissioned in accordance with the applicable technical, quality and safety requirements. When DNV GL has completed third-party verification of all project phases and the pipeline has been successfully pre-commissioned, a DNV GL Certificate of Conformity will be issued for each of the Nord Stream 2 pipelines.

In addition to the above, the Russian and German authorities, within the respective territorial areas of competences, will independently verify the integrity and safety of the pipelines.

6.2.3 Materials and corrosion protection

In this section the pipeline design will be described in general terms. Furthermore, the expected material utilisation required for the pipeline sections in Denmark is presented.

6.2.3.1 Line pipe

The pipelines will be constructed of individual steel line pipes with an average length of 12.2 m that will be welded together in a continuous laying process. The line pipes will be internally coated with an epoxy-based material (see Figure 6-7). The purpose of the internal coating is to reduce hydraulic friction, thereby improving the natural gas flow conditions.

An external three-layer polyethylene (PE) coating will be applied over the line pipes to prevent corrosion. The three-layer polyethylene external anticorrosion coating consists of an inner layer of fusion-bonded epoxy, a middle adhesive layer and a top layer of polyethylene (see Figure 6-7)**.** Further corrosion protection will be achieved by incorporating sacrificial anodes of aluminium or zinc (see section 6.2.3.4 describing anodes for cathodic protection). The sacrificial anodes are a dedicated and independent protection system in addition to the anti-corrosion coating.

A concrete weight coating (CWC) containing iron ore will be applied over the external anti-corrosion coating (see Figure 6-7). While the primary purpose of the CWC is to provide on-bottom stability of the constructed pipeline, the coating will also provide additional external protection against external impacts.

Once the single line pipe joints are transferred onto the lay vessel, they may either be directly transferred into the vessel firing line for welding into the pipeline string, or welded into double joints before being transferred into the vessel firing line for welding and subsequent pipe-lay.

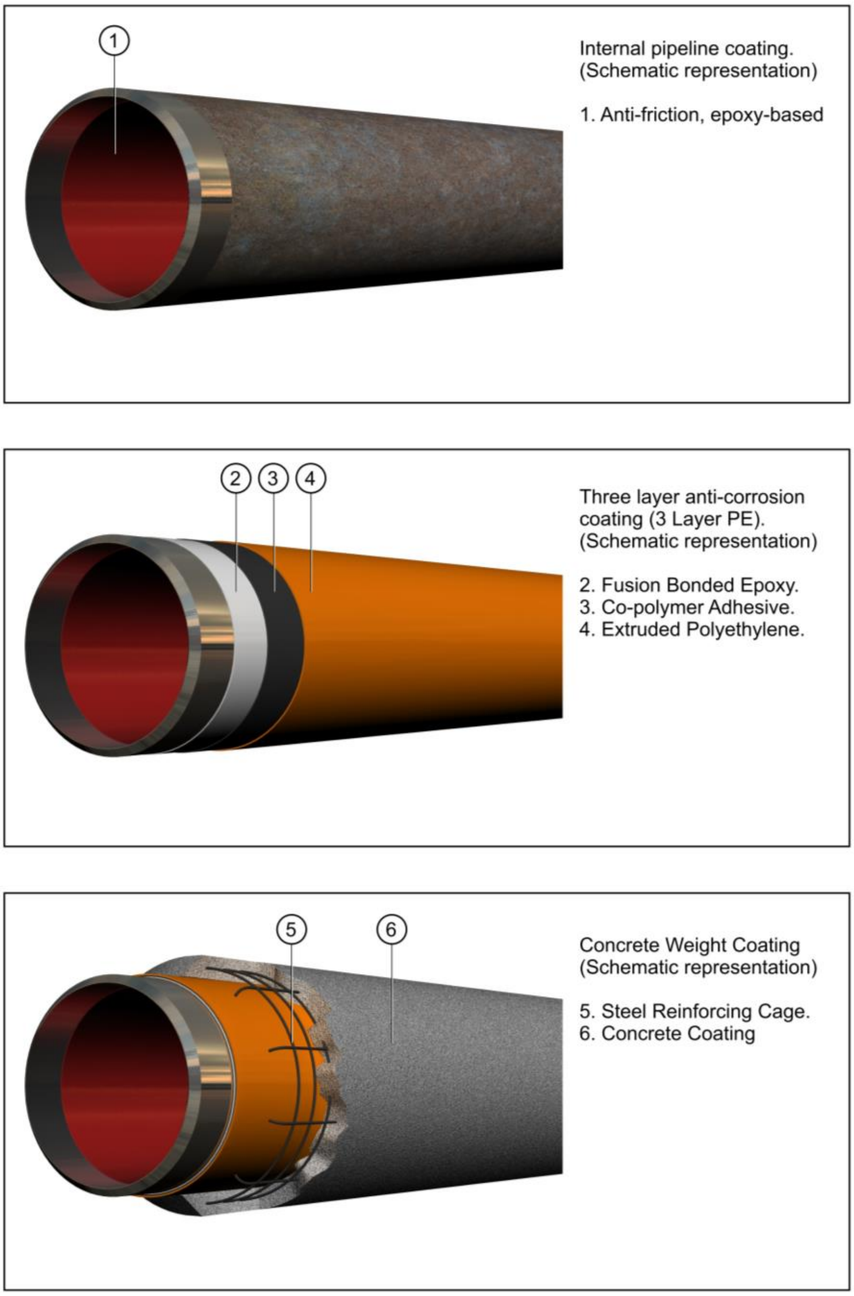


Figure 6-7 Line pipe design

6.2.3.2 Field joint coatings

After the pipe joints are welded together, and non-destructive examination of the weld has been performed, a field joint coating (FJC) system is installed to prevent corrosion of the uncoated pipe ends, and to fill the space between the concrete weight coated sections either side of the field joint.

The field joint area will be cleaned with powered wire brushing before the steel is pre-heated using an induction heating coil, prior to the application of a polyethylene heat shrink sleeve (HSS) that covers the entire exposed steel surface area. The HSS will be wrapped around the bare pipe area and shrunk onto the pipeline surface using either flame torches, or the same induction coil as that used for the pre-heating.

Once the HSS has been installed, a carbon steel, or polyethylene, former will be installed circumferentially around the field joint and secured on to the concrete weight coating each side of the field joint using a maximum of 5 banding straps. Polyurethane foam (PUF) will then be injected into the annular void created by the former. After a short period of time, the PUF solidifies and the coated field joint becomes an integral part of the pipe, maintaining a constant pipeline outside diameter, and facilitating passage of the pipeline string over the rollers as it advances down the stinger and into the water.

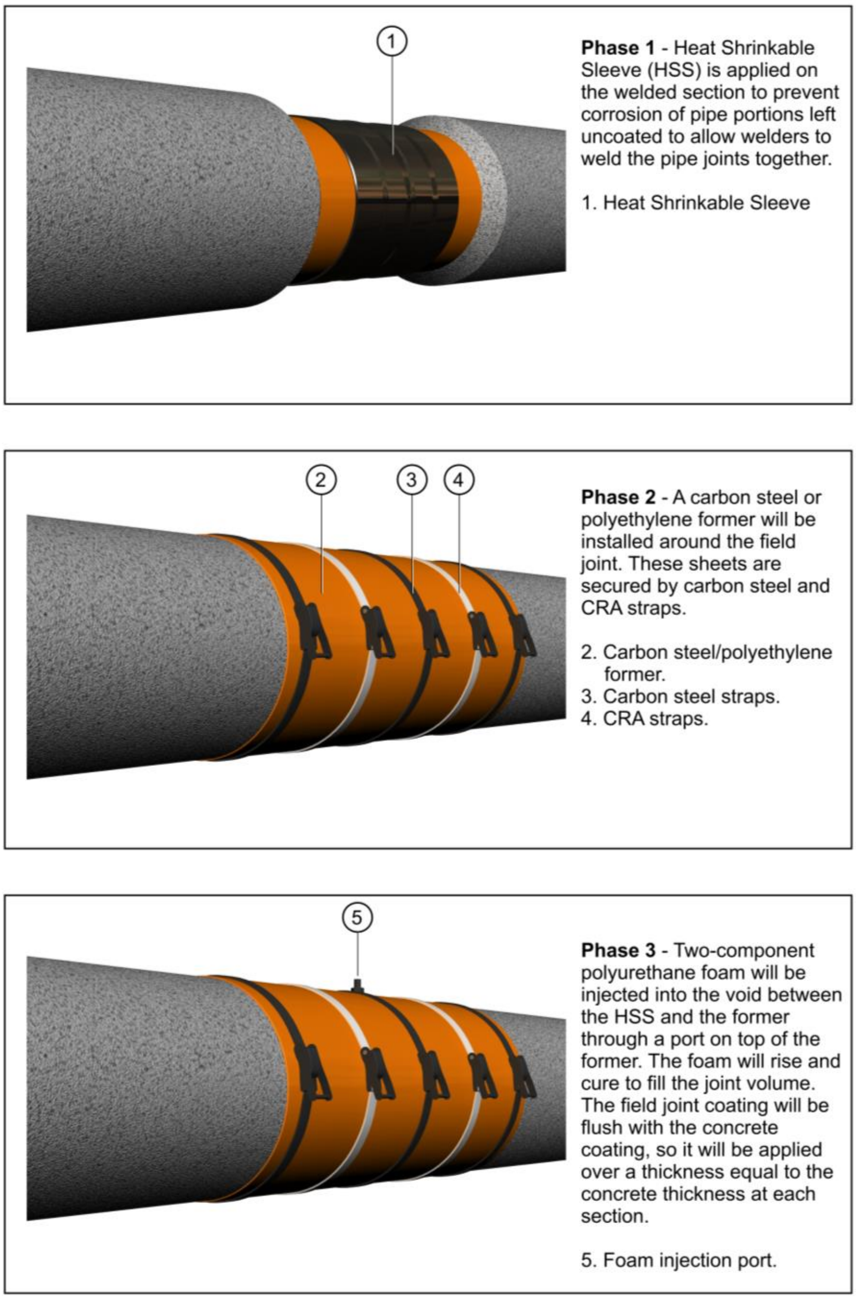


Figure 6-8 Field joint coating, schematic representation

6.2.3.3 Buckle arrestors

To minimise the length of pipeline damaged by a buckle during installation, buckle arrestors (pipe reinforcement) will be installed at specific intervals in susceptible areas. The risk of collapse is when the pipeline is empty, i.e. mainly during installation. Buckle arrestors are full-length pipe joints with overdimensioned thickness that are installed in deep water sections with typically 927 m separation. The buckle arrestors are made of the same steel alloy as the pipelines. The buckle arrestors are machined at each end down to the wall thickness of the adjacent pipes to allow welding offshore. The material requirements and properties for the buckle arrestors are generally the same as for the line pipe.

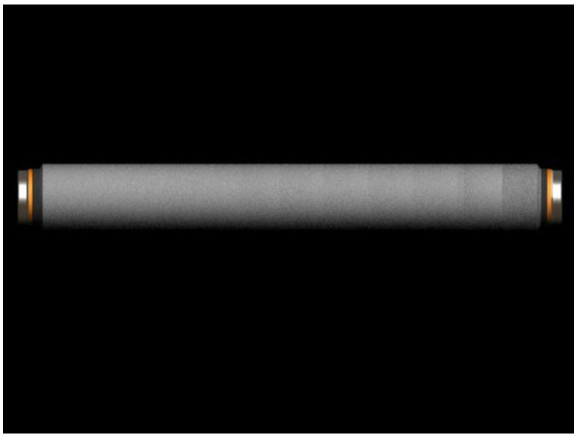
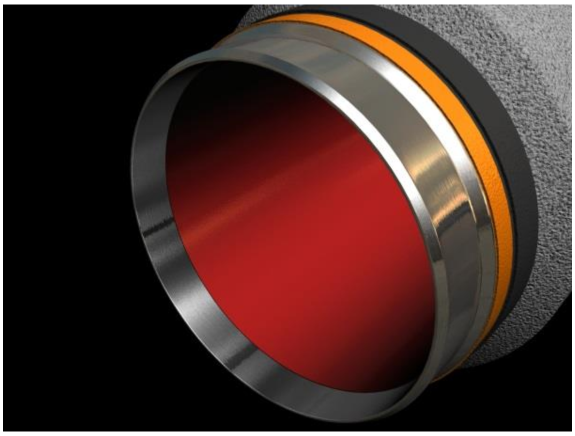



Figure 6-9 Buckle arrestor, schematic representation. Left picture – full length, right picture – zoom in

6.2.3.4 Anodes for cathodic protection

In addition to the three-layer polyethylene external anti-corrosion pipe coating, a secondary anti-corrosion protection will be provided by sacrificial anodes (Aluminium and Zinc alloys) to ensure the integrity of the pipelines over their operational lifetime. This secondary protection will be an independent system that will protect the pipelines in case of damage to the external anti-corrosion coating.

The performance and durability of different sacrificial anodes in Baltic Sea environmental conditions has been evaluated with dedicated tests for the construction of NSP. The tests showed that the salinity of seawater has a major effect on the electrochemical behaviour of aluminium anodes. In the light of the test results, Zinc alloy anodes are foreseen for sections of the pipeline route with very low average salinity. For all other sections indium-activated Aluminium alloy anodes will be used.


Figure 6-10 Bracelet anode. Left, a half shell. Right, two half shells trial fitted to a pipe

In Denmark only Aluminium alloy anodes will be used. The chemical composition of the aluminium anodes are listed in Table 6-2. The anodes will mainly be spaced 8 pipe joints apart and a total of approximately 2,856 anodes are expected to be installed in the Danish sector.

Table 6-2 Aluminium anode composition

Elements	Mass fraction	
	Minimum %	Maximum %
Zn	4.75	5.75
In	0.016	0.020
Fe	-	0.06
Si	0.08	0.12
Cu	-	0.003
Cd	-	0.002
Others	Max 0.02 each	
Al	Remainder	

6.2.3.5 Total materials consumption

The expected material consumption required for the pipeline sections in Denmark is summarised in Table 6-3 below. Quantities are approximate and subject to final optimisation.

Table 6-3 Summary of material consumption in Denmark

Material	Denmark
Total length of two pipelines (km)	278
Steel (t) (including buckle arrestors)	217,700
Concrete-weight-coating (t)	315,000
Anodes aluminium (t)	1,054

6.3 Project logistics

The construction of NSP2 requires onshore support facilities such as weight coating plants and interim stockyards which results in onshore and offshore transportation. No onshore support facilities and onshore transportation are planned on the Danish territory. Offshore pipe supply and material supply (e.g. rocks) are the major logistics activities in Danish waters. Onshore logistics is however shortly described below for better understanding of the project.

6.3.1 Logistics concept

The logistics concept has been designed to reduce onshore and offshore transportation. The use of existing facilities has been favoured in order to avoid new construction wherever feasible. A primary focus in the development of the logistics concept, therefore, has been on minimising environmental impacts and reducing costs. Preparation of the facilities will comply with national legislation and requirements and will be subject to independent, national permitting.

The line pipe logistics will be based on utilisation of existing ports within the Baltic Sea area. NSP2 has entered into agreements with four ports. However, the logicstics concept might undergo further optimization. At present, the port of HaminaKotka (Mussalo) in Finland is considered to serve as a weight-coating location and as a marshalling yard for the eastern pipe route. The port of Mukran in Germany is again selected to serve as the weight-coating location and as marshalling yard for the western part of the route. Two additional ports will serve as marshalling yards along the route, Hanko-Koverhar in Finland and Karlshamn in Sweden, as shown in Figure 6-11. NSP2 is currently investigating the possibility to use the Freeport of Ventspils in Latvia as an additional pipe storage yard.

The logistics concept considers at present that all pipes to be laid in Danish waters are coming out of German production and will be concrete weight coated in the Port of Mukran/Germany. To avoid additional transportation the base concept forsees to load out and ship all pipes to the lay barge operational in Danish waters directly from Port Mukran. Shipments out of Karlshamn are as well an option but so far not considered in the base case planning.

Generally, line pipes will be produced at pipe mills in Russia and Germany (55 % and 45 % of the quantity, respectively). At the mills, they will be internally coated with flow coating and externally coated with anti-corrosion coating before they are transported to weight-coating plants in Kotka in Finland (approx. 110,000 pipes) and Mukran in Germany (approx. 90,000 pipes), where weight-coating will be applied.

After weight-coating, the line pipes will be stored again, close to the weight-coating plant. From Kotka, they will be transported directly to the lay vessel or to the marshalling yards in Hanko-Koverhar. From Mukran, they will be transported directly to the lay vessel or to a marshalling yard along the pipeline route. Having 4 load out ports along the construction route of the pipe-lines guarantees minimal sailing distances to the pipe-lay vessels.

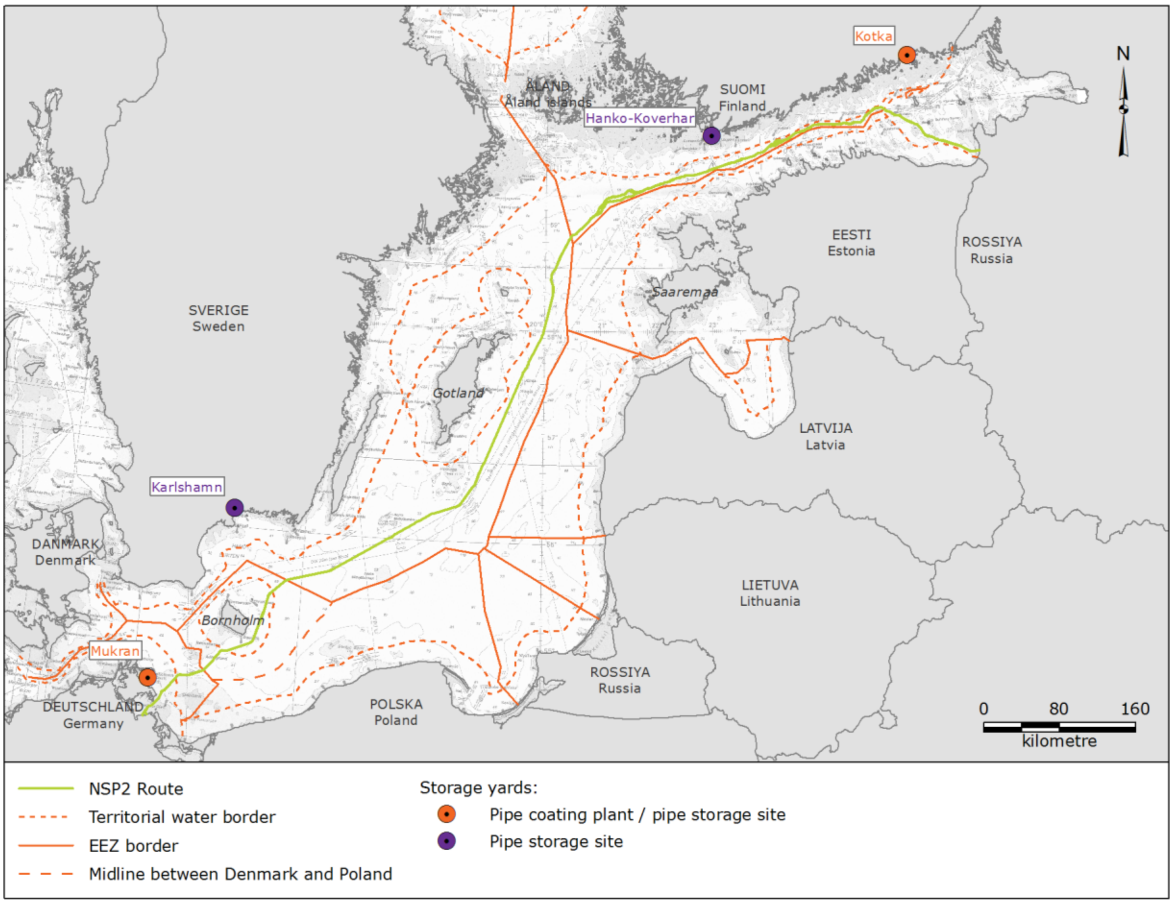


Figure 6-11 Overview of the pipe coating plants and marshalling yards expected to be used in the NSP2 project

In case that Ventspils would be used as an additional pipe storage yard, it would receive weight-coated pipes by rail from Russia (approx. 20,000 pipes) and by coaster vessels from Kotka (ap-prox. 12,800 pipes). From Ventspils the pipes would be transported with pipe supply vessels to the lay vessels when in Swedish and Finnish waters. This would consequently mean that corre-sponding fewer pipes would be transported from Hanko and Kotka to the pipe-laying vessels than shown in Figure 6-12.

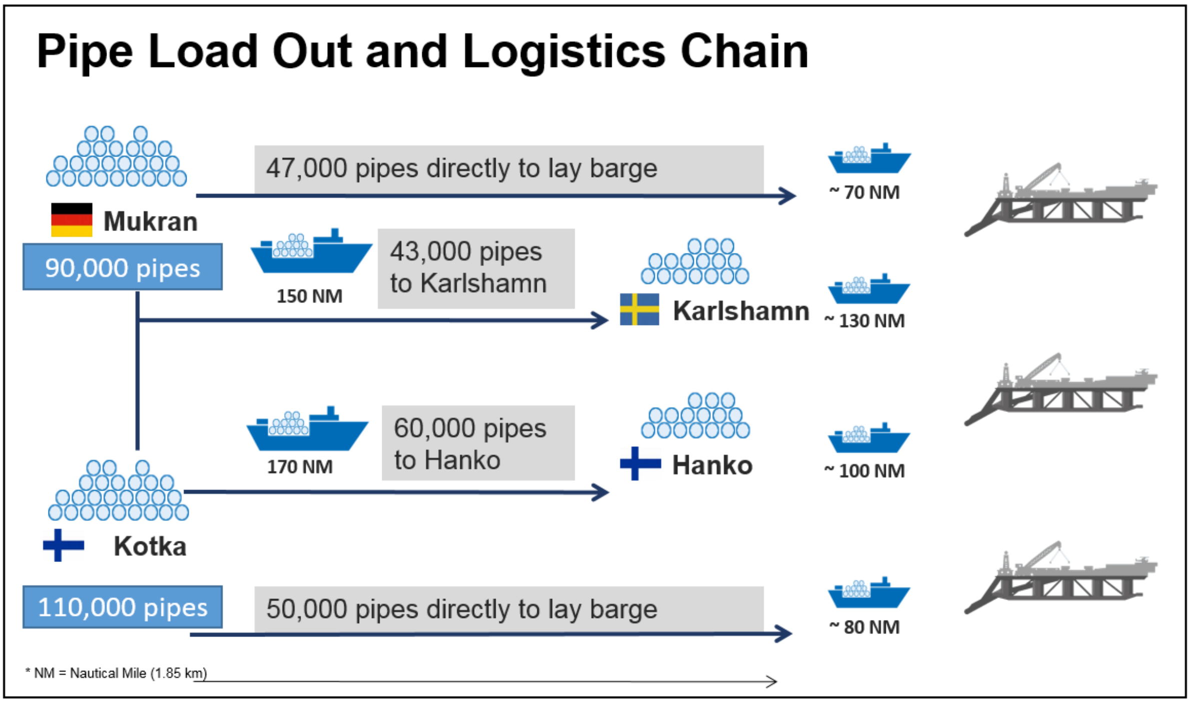


Figure 6-12 Transshipment quantities

6.3.2 Offshore pipe supply

Coated pipe joints will be transported by pipe supply vessel to the pipe-lay vessel using established shipping routes. Approximately 22,800 weight-coated pipes will be transported to the Danish route from Mukran.

The distance from the weight-coating plants and marshalling yards to the pipe-lay vessel is targeted to be utmost minimized in respect of available ports. The contractor will define how many pipe supply vessels that are needed to bring pipes to the lay vessels in a reasonable time in consideration of the effective sailing distances. Load out activities in all ports will be in parallel with the construction work for both pipelines.

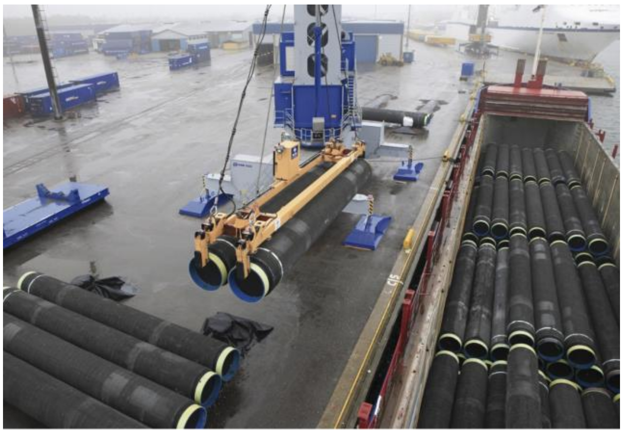


Figure 6-13 Offshore pipe supply

6.3.3 Rock placement material logistics

The selection of the quarries will be made by the rock placement contractor. Loading of rock material will be carried out directly from the quay by use of one or more conveyors.

The rock material will be placed on the seabed by dynamically positioned fall-pipe vessels that are able to place the rock material very accurately on the seabed through the use of fall-pipes.

6.4 Construction activities

The construction activities in Danish waters include pipe-lay, seabed intervention works and potentially installation of an above-water tie-in (AWTI).

The pipeline installation phase in Danish waters is expected to last in total approximately 135 days for the two pipelines and the installation is assumed to be sequential, meaning that one pipeline will be installed at a time in Danish waters. Construction schedule in the Danish waters is shown in the Figure 6-14. It is noted, that the schedule may be subject to change during project development.

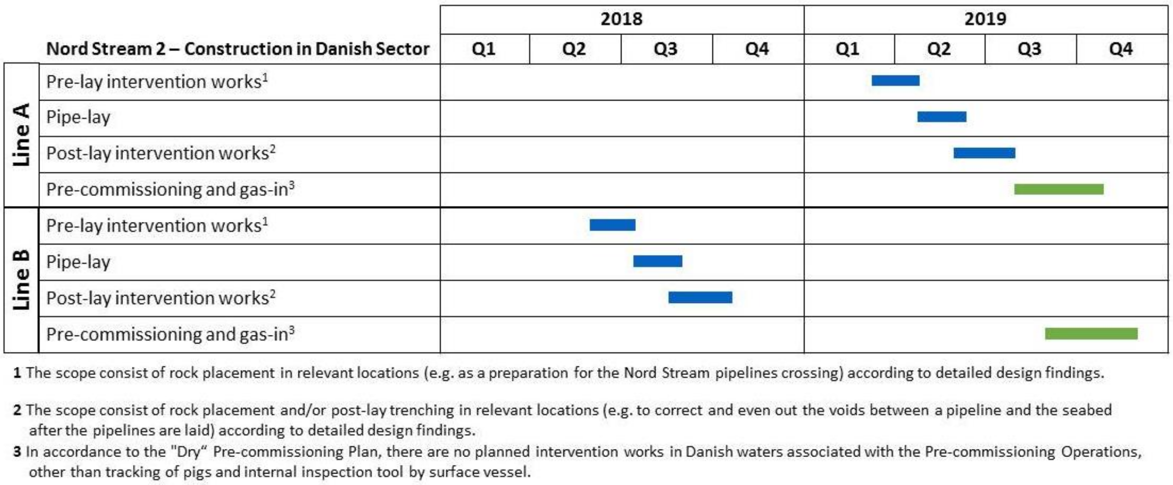


Figure 6-14 Construction schedule in Danish sector.

6.4.1 Pipe-lay

Pipeline installation will be carried out by lay vessels adopting the conventional S-lay technique. This method is named after the profile of the pipe as it moves across the bow or stern of the lay vessel and onto the sea floor, which forms an elongated 'S' (see Figure 6-15). The individual pipe joints will be delivered to the pipe-lay vessel, where they will be assembled into a continuous pipeline and lowered to the seabed.

Both pipelines will be constructed in specific sections for subsequent interconnection. Abandonment and recovery operations involve the leaving and later retrieval of the pipeline somewhere along its route. Abandonment of the pipeline may become necessary if weather conditions make positioning difficult, or cause too much movement within the system.

The average lay rate is expected to be in the order of 2.5 km per day, depending on weather conditions, water depth and pipe wall thickness.

Figure 6-15 The S-lay pipe-lay vessel and survey support vessels

Pipe-lay will be carried out by either anchored or dynamically positioned (DP) pipe-lay vessels. A DP vessel is kept in position by horizontal thrusters that constantly counteract forces acting on the vessel from the pipeline, waves, current and wind.

In the event that an anchored lay vessel is used for pipe-lay, the anchors will interact with the seabed and may cause localised seabed disturbance. The lay vessel is kept in position by up to 12 anchors, each weighing up to 25 tonnes. Independent anchor handling tugs will manoeuvre the anchors, which are directly connected to, and controlled by, a series of cables and winches. The tugs will place the anchors on the seabed at predetermined positions around the lay vessel to move the lay vessel forward and ensure tension can be maintained on the pipeline during laying. A typical anchor pattern is shown in Figure 6-16.

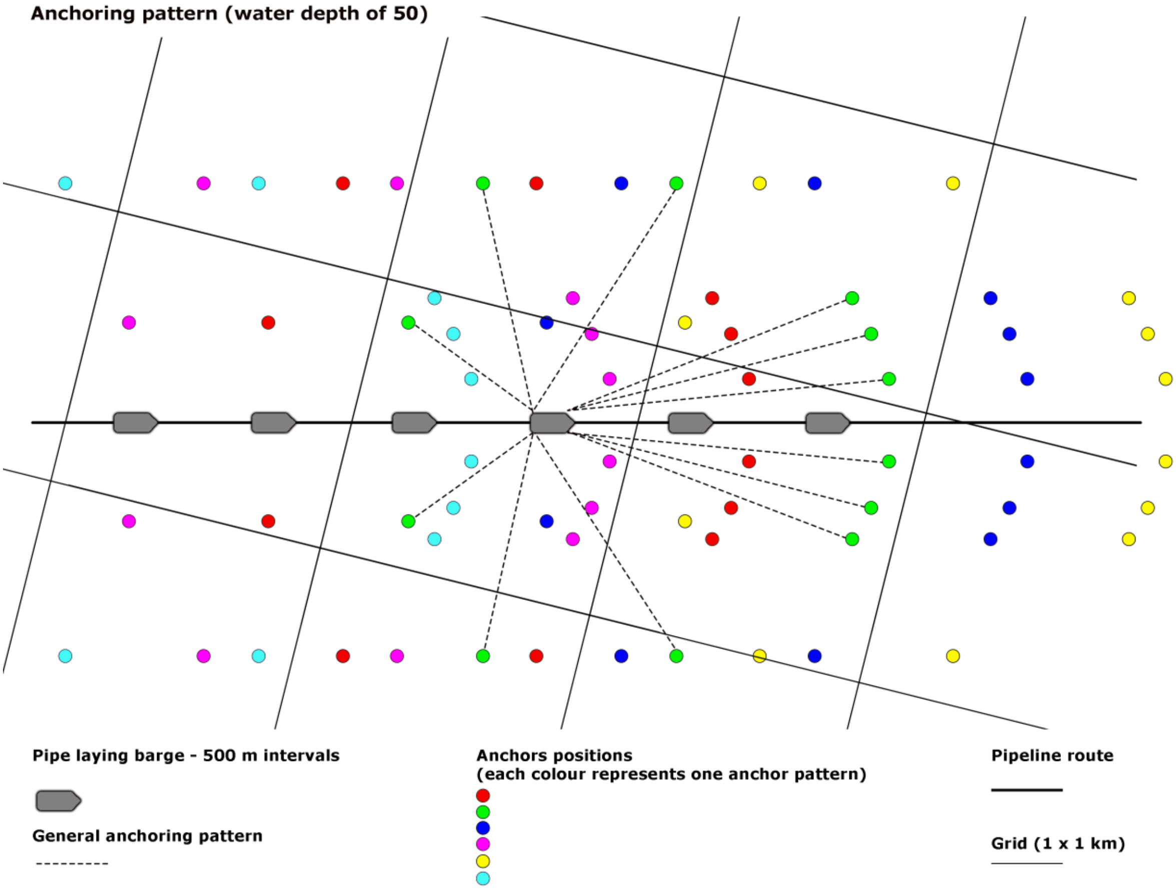


Figure 6-16 Anchoring patterns on the seabed as the pipe-lay vessel moves forward

It has not yet been decided whether an anchored or DP pipe-lay vessel will be used during installation of the Nord Stream 2 pipelines in Danish waters. However, it is anticipated that a DP vessel will be used for pipe-lay in most part of the Danish section of the route.

Pipe-lay operations will require establishment of exclusion zones around pipe-lay and supporting vessels to ensure safe construction. Thus, during NSP construction exclusion zone for a DP vessel Solitaire was defined as 2,000 m (approximately 1 nm) radius centred around the vessel and for an anchored vessel Castoro Sei it was 3,000 m (approximately 1.5 nm) radius centred around the vessel. Ship traffic will be requested to avoid restriction zones. Exclusion zones are to be agreed with national maritime authorities.

6.4.2 Seabed intervention works

The offshore installation of the pipelines in some areas requires additional stabilisation and/or protection against hydrodynamic loading which can be achieved by trenching the pipeline into the seabed or rock placement.

An overview of the proposed pipeline route as well as locations and types of potential seabed intervention works to be carried out in Danish waters is presented in Figure 6-2, Figure 6-3 and Figure 6-17.

In three sections where additional stabilisation of the pipelines might be required the base case approach is post-lay trenching. In total up to a maximum of 20.5 km post-lay trenching is anticipated for each of the NSP2 pipelines. Alternative measure may be the placement of individual rock berms at the three locations. Rock placement will be carried out at the location for crossing the existing Nord Stream pipelines to provide support for separation between the two systems. Additional rock placement might be required at the potential AWTI location.

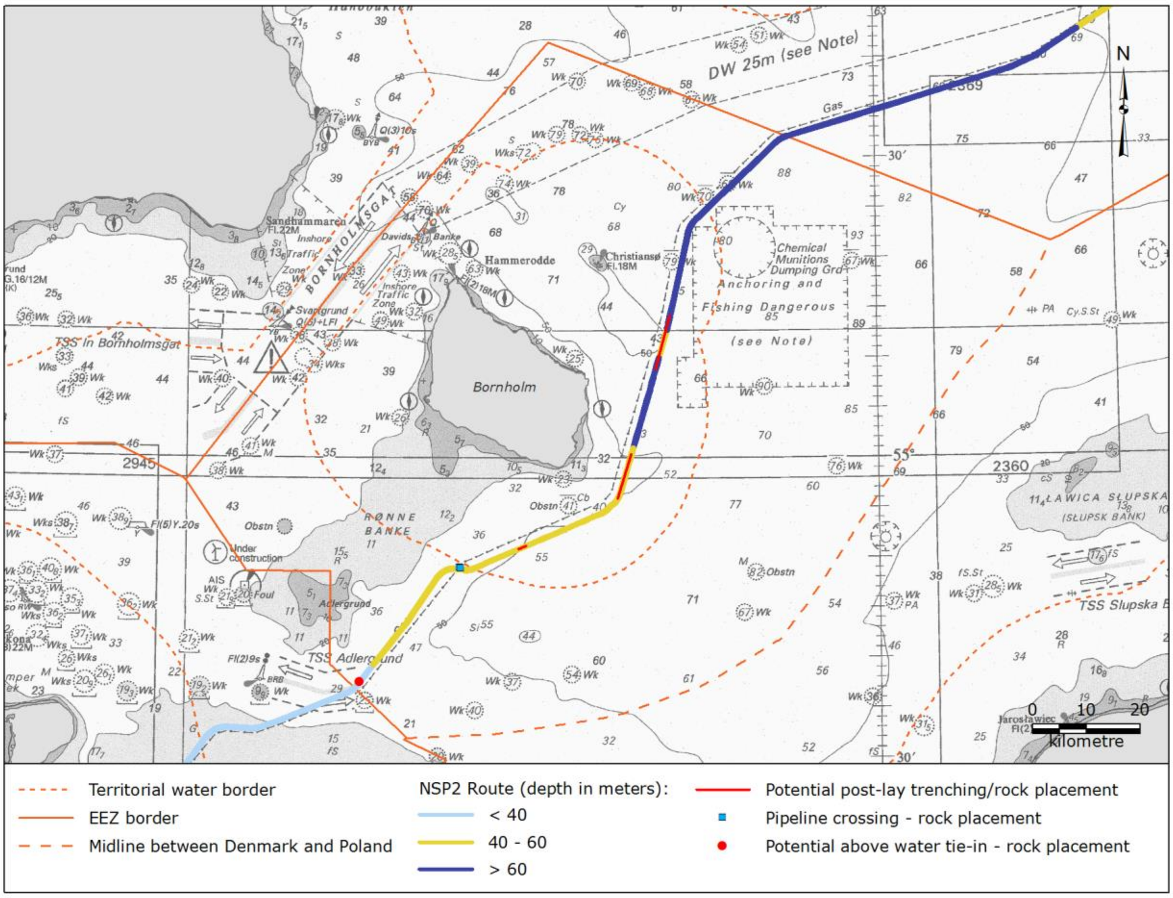


Figure 6-17 Potential intervention works in Danish waters

The extent of the intervention works and volumes of rock needed for or sediments originating from the intervention works are shown in Table 6-4 and Table 6-5. The modelling in the EIA is based on a conservative early estimation. The numbers have been updated in the course of design refinement and project development, outlined in the /63/.

Table 6-4 Sections for post-lay trenching (base case) or rock placement in Danish waters (per line)

	Each Line A and Line B		
Trenching or rock placement	**From KP**	**To KP**	**Length (km)**
Section 1	41.5	51.7	10.2
Section 2	68.0	76.7	8.7
Section 3	95.9	97.5	1.6
Total			20.5

A summary of the possible volumes of trenching and rock placement is provided in Table 6-5. Numbers are approximate and subject to final optimisation.

Table 6-5 Possible sediment and/or rock volumes (conservative approach) for each NSP2 pipelines in Danish waters (per line)

Rock / sediment volumes*	Approx. volume (m^3)
Post-lay trenching - Section 1-3 stabilisation**	127,000
Rock placement - Pipeline crossing - Above-water tie-in*** - Section 1-3 stabilisation (rocks)**	 20,000 10,000 66,000

*Quantities are approximate and subject to final optimisation.

** Base case for stabilisation of the pipelines is post-lay trenching. Contingency measure is rock placement.

*** Decision on location of AWTI to be taken based on consultation with authorities.

Once the pipelines are on the seabed, dependent on the seabed conditions the pipeline may become naturally embedded. Examples of how NSP appears on the seabed are shown in Figure 6-18.

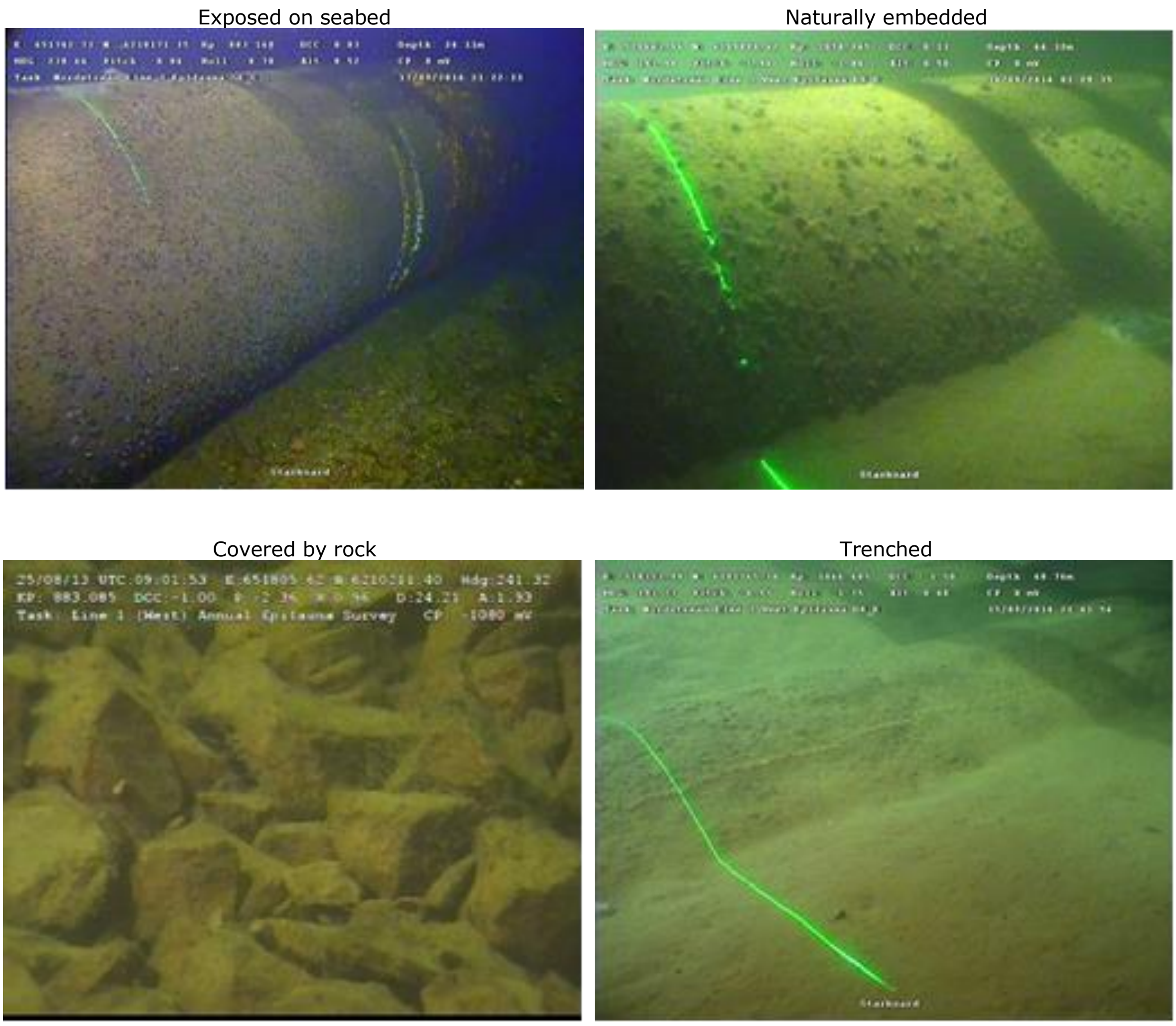


Figure 6-18 Examples of how NSP appears on the seabed

6.4.2.1 Post-lay trenching

Post-lay trenching will be carried out using a pipeline plough (see Figure 6-19) deployed onto the pipeline from a mother vessel located above the pipeline. The pipeline will then be lifted by hydraulic grippers into the plough and supported on rollers at the front and rear ends of the plough.

The rollers will be equipped with load cells to control the loading onto the pipeline during trenching. A tow wire and control umbilical will be connected to the plough from the mother vessel, which will pull the plough along the seabed, laying the pipeline into the ploughed trench as the plough advances.

Typically, the mother vessel is capable of pulling the plough independently, although assistance from another vessel may occasionally be required, depending on the overall tow force generated.

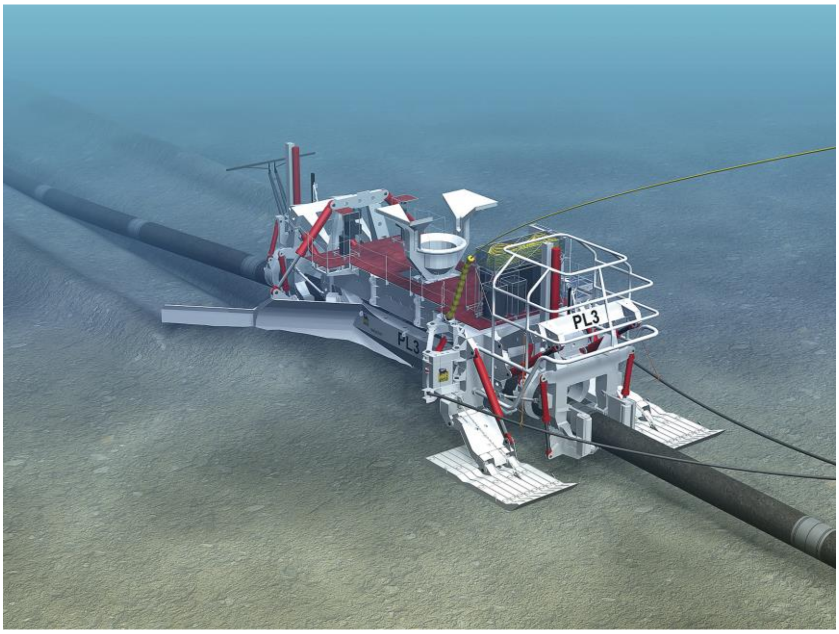


Figure 6-19 Post-lay trenching. Typical pipeline plough in operation on the seabed

The excavated material displaced from the plough trench (also known as "spoil heaps") will be left on the seabed immediately adjacent to the pipeline. Partial, natural backfilling will occur over time due to currents close to the seabed.

6.4.2.2 Rock placement

Rock placement is the use of unconsolidated rock fragments graded in size to locally re-shape the seabed, thereby providing support and cover for sections of the pipeline to ensure its long-term integrity.

Rock placement will be adopted as the main intervention method for freespan correction. Rock placement will be carried out using material extracted from quarries on land. The types of rock placement works that are envisaged for seabed intervention include gravel supports (pre-lay and post-lay) and gravel cover (post-lay) in discrete locations.

To prepare the seabed for pipe-lay, the entire route will be surveyed beforehand. Gravel berms will then be strategically placed in order to support the pipeline in areas of high seabed relief, to serve as basement structures at tie-in and pipeline crossing areas, and to stabilise the pipelines, where required. Rock placement is only envisaged in Denmark for preparation of the pipeline crossing of NSP and following a potential above-water tie-in (AWTI)

Rock placement activities include gravel works in which coarse crushed rock material is placed in a controlled manner by a fall pipe (see Figure 6-20).

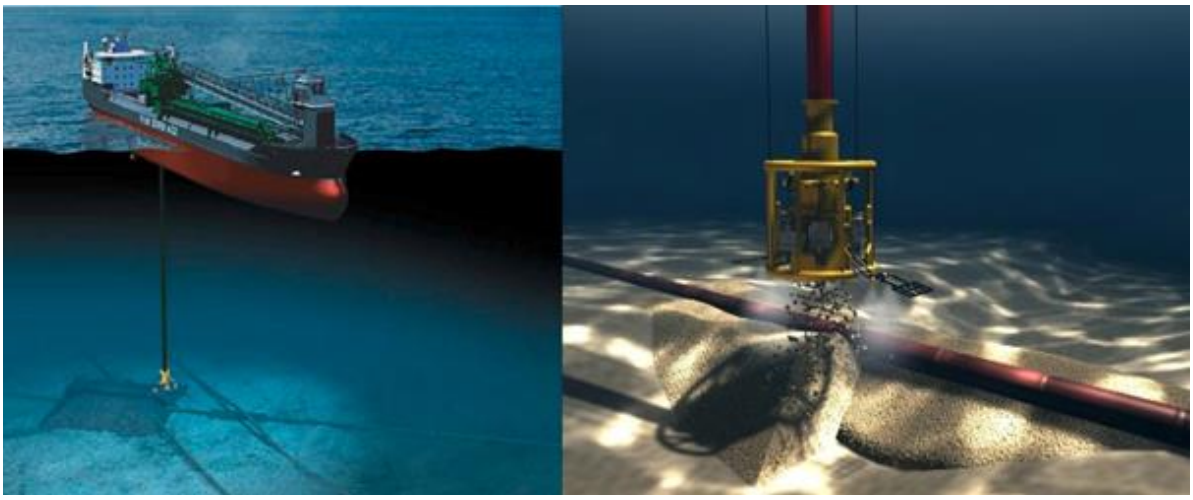


Figure 6-20 Rock placement on the seabed through a fall-pipe

6.4.3 Above-Water Tie-In

A potential AWTI for both pipelines is foreseen in Danish waters at a depth of approximately 30 m. Decision on the location of the AWTI will be taken based on consultations with relevant authorities. The two location options can be seen in Figure 6-21.

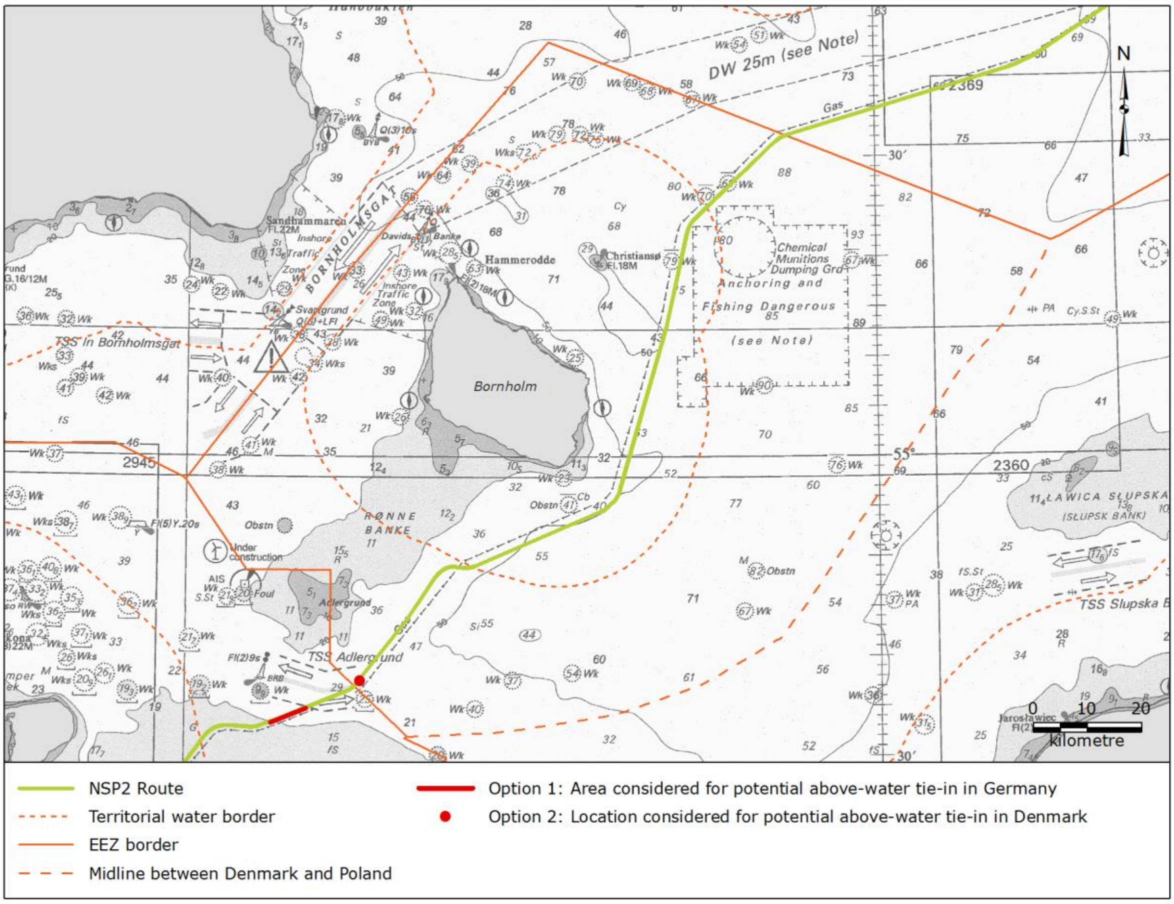


Figure 6-21 Locations considered for AWTI

The above-water tie-in technique is used to connect two pipe sections that have previously been laid down during various phases of the operation. Above-water tie-ins will be carried out by a specific lay-barge positioned over the tie-in location. Each pipe section should be lifted sufficiently clear of the water, suspended alongside the barge and welded together (see Figure 6-22). Once tested, the pipe is then lowered to the seabed. The duration of the entire operation is approximately 10-14 days.

Figure 6-22 Typical pipeline configuration during AWTI

6.4.4 Crossings of infrastructure (cables and pipelines)

The proposed NSP2 route crosses power and communication cables (existing and planned), the two existing Nord Stream pipelines. As successfully done for NSP, it is envisaged to develop specific crossing designs for each cable crossing, typically consisting of concrete mattresses, which will be agreed with the cable owners. There were no pipeline crossings on the NSP project; a typical pipeline crossing design according to normal industry practice, e.g. in the North Sea, shall be developed and agreed upon.

Typical crossing of pipelines is shown in Figure 6-23.

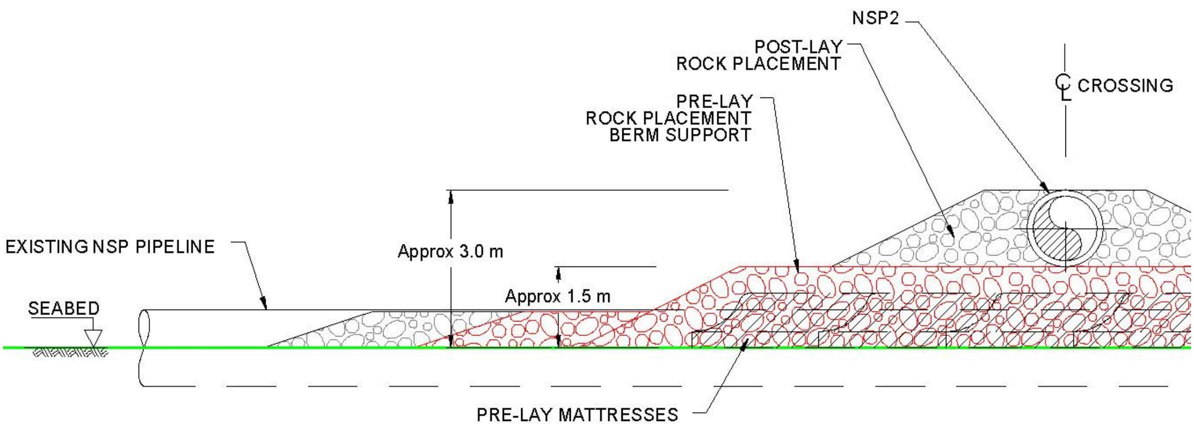


Figure 6-23 Typical crossing of pipelines

6.5 Pre-commissioning and commissioning

The offshore pipeline pre-commissioning concept for NSP2 will be completed after bids have been received and the pipe-lay scenario finalised. Two pre-commissioning concepts are under evaluation – "Wet" and "Dry". Mentioned concepts include the following operations:

<u>"Wet" concept</u>
- Flooding, cleaning, gauging and pressure-testing;
- Dewatering and drying.

<u>"Dry" concept</u>
- Cleaning and gauging in conjunction with pipeline internal inspection and external survey.

Commissioning comprises all activities that take place after pre-commissioning and until the pipelines commence natural gas transport commissioning, include filling the pipelines with natural gas. Prior to the activity of gas-in, all pre-commissioning activities must be completed successfully and the pipeline will be filled with dry air that is close to atmospheric pressure.

After pre-commissioning, the pipelines contain dry air. Nitrogen gas as inert buffer is then inserted into the pipelines immediately prior to natural gas filling. This ensures that the inflowing natural gas will not be able to react with the atmospheric air and create unwanted mixtures inside the pipeline. Commissioning will then proceed by filling the pipelines with natural gas from the connected facilities.

Pre-commissioning and commissioning does not involve any activities in Denmark and is not further described in this EIA. For further details and assessments refer to the EIAs for the project of the specific countries where pre-commissioning and commissioning activities are taking place.

6.6 Operation

Nord Stream 2 AG will be the owner and operator of the pipeline system. The system is designed for an operating life of at least 50 years. An operations concept and security systems will be developed to ensure the safe operation of the pipelines, including avoiding over-pressurisation, managing and monitoring potential gas leaks and ensuring material protection. The operation system is currently planned to be set up in a very similar way as to NSP.

6.6.1 Pipeline Control and Communication System

The protection, control and monitoring strategy for the Nord Stream 2 pipeline system will be based on manned landfall facilities, namely the Pig Trap Areas in Russia and Germany. Both landfalls include the instrumentation and control systems required to monitor pipeline operation. They are supervised by the Main Control Centre (MCC) in Switzerland with a back-up facility, the Back-Up Control Center (BUCC), also located in Switzerland. The Pipeline Control and Communication System (PCCS) is an overall monitoring and safeguard system composed of the following systems: Pipeline Control System, Emergency Shutdown System, Pressure Safety System, Supervisory Control and Data Acquisition System and Pipeline Application Software.

The NSP2 PCCS comprises the following functions:

- Pipeline parameter monitoring;
- Pipeline leak detection;
- Telecommunications system;
- Fire and gas detection and protection;
- Emergency shutdown;
- Pipeline pressure safeguarding;

- Access control and intrusion detection;
- Special operation controls (e.g. pigging operations).

The communication systems will be designed safe and secure, with multiple redundancies to ensure the required communication lines are always available. It includes communication platforms for process safety, process monitoring, intra-office and inter-office communication of personnel, external communication for personnel and data exchange with upstream and downstream facilities.

6.6.2 Normal pipeline operation

Normal operating conditions are those in which the pipeline system flow rate, pressures and temperatures are all within the pipeline design parameters and in which the flow rate is managed in accordance with the notification requirements of the gas transportation agreement.
The pipeline inlet flow rate will be controlled by the number of compressors on line at Russian Compressor Station while the pipeline outlet pressure will be controlled by the Gas Receiving Station control valves. These valves will also control line packing, which occurs when pipeline inlet flow is greater than pipeline outlet flow. The required pipeline inlet pressure will be determined by the sum of the pressure at the pipeline outlet plus the pressure drop along the pipeline. The compressor speed will adjust automatically to achieve the required compressor discharge pressure. To ensure that the outlet gas temperature does not fall below the specified minimum, the line heaters at the Gas Receiving Station will be used.

Transportation operations will be managed remotely from the main control room in the head office in Switzerland. The main control room is staffed 24 hours per day, 365 days per year, by two control room operators. The operators will monitor operation of the pipeline within the normal operating envelope, whilst fulfilling daily transportation nomination requirements and avoiding shutdown of the pipeline system due to malfunctioning of the system. Fiscal metering will be performed by both, the upstream gas supplier and the downstream gas buyer facilities. NSP2 will only provide operational flow measurements used to monitor pipeline operation.

6.6.3 Maintenance operations

Maintenance operations mean the inspection and maintenance of the NSP2 pipeline system in order to ensure integrity of the pipeline system and to enable transport of natural gas through the pipelines in accordance with the requirements of the gas transportation agreement.

Maintenance operations will be carried out as a minimum in accordance with DNV requirements, manufacturer requirements, statutory requirements and good industry practice. Planned inspection and maintenance for the landfall facilities will be carried out throughout the year to ensure operation. Large scale maintenance activities will be performed during a yearly shutdown in non-winter months. The offshore pipelines are designed to be maintenance free, however, planned inspection activities include:

- External inspections of the pipelines (survey inspections)
- Internal inspections of the pipelines (pigging)

External inspections will be conducted from a survey vessel equipped with different types of sensors, such as cameras and scanners, to inspect the general condition of the pipelines and to check for external damage. Internal inspections are carried out to remove any foreign material that may have formed inside the pipeline and to check that no corrosion or changes in pipeline wall thickness caused by external third party impacts have occurred.

If a pipeline free span unexpectedly develops beyond acceptance criteria as a result of seabed movement, it could require correction. This would result in unplanned maintenance activities such as rock placement, mattress installation or sandbag placement.

In addition Nord Stream 2 AG will have an emergency pipeline repair system in the event of significant damage to the pipeline. The system will include: repair procedures; access to internal isolation equipment and material and other equipment to lift, recover or cut the pipeline; agreements with vessels and repair companies; and agreements with authorities for necessary permissions in the different countries.

6.7 Waste management

Waste generation (types and amounts) during the construction of the NSP2 pipelines are anticipated to be similar to that generated during NSP construction (refer to /72/). This section describes generation and management of offshore waste relevant to construction and operations activities in Denmark.

Most of the waste generated during construction of the offshore sections of the pipelines will come from the pipe-lay vessel while the rest will originate from the support vessels. Based on NSP experience more than 90 % of the offshore waste will include:

- Concrete waste, comprising approximately 46% – this includes waste welding flux, which is inert.
- Metal waste, comprising approximately 25% – comprises mainly metal turnings from the pipe bevelling stations.
- General and domestic waste, comprising approximately 23% – relating to general office and non-hazardous waste including personal protective equipment, domestic waste from the living quarters and food waste that was not segregated at source.

Other waste fractions will include: wood waste, hazardous waste, plastic waste, food waste, paper/cardboard waste and glass waste. Figure 6-24 shows percentage ration of the waste types generated during NSP offshore activities.

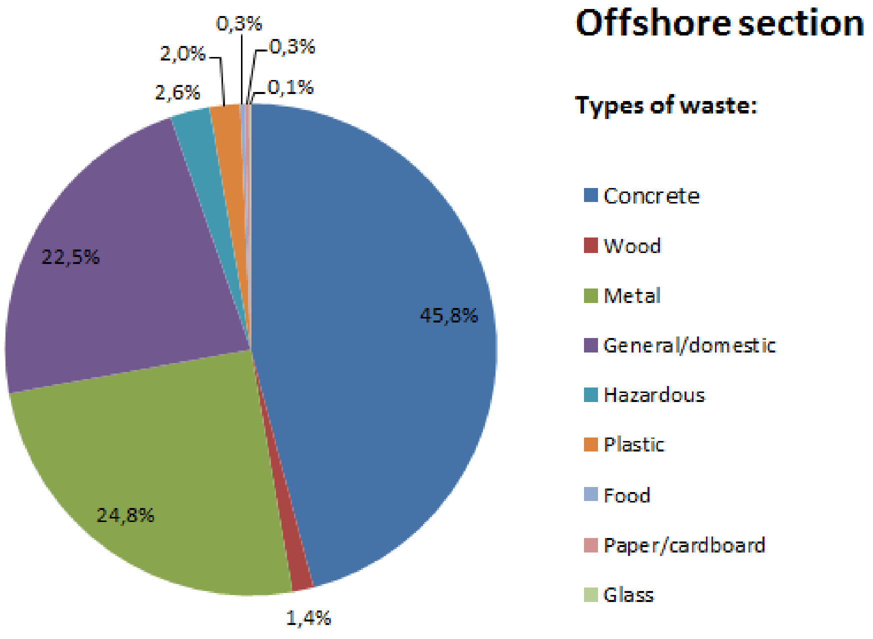


Figure 6-24 Types of waste generated during NSP offshore construction activities

Data on waste related to NSP has been collected from the start of construction in 2010 to the final data submitted in October 2012 at the end of construction (refer to /72/).

Total amount of waste derived from the offshore construction is expected to be approximately 7,000 tonnes. Taking into account that the length of the proposed pipeline route in the Danish waters is approximately 12 % of the total route, waste generated in the Danish waters is expected to be approximately 240 tonnes.

Vessel-generated waste will be routed through a selected port or selected ports in the Baltic Sea area. During the NSP project most of the offshore waste was delivered to the Port of Norrköping, Sweden, with at least 98.7% of the total mass of the offloaded waste being reused, recycled or recovered.

Nord Stream 2 AG will ensure that its contractors are managing wastes to acceptable international standards. Company will develop a Waste Management Plan for the construction and operational phases of the Project. The Waste Management Plan will be an integral part of Company's HSES-MS.

7 EXISTING CONDITIONS IN THE PROJECT AREA

This section presents a baseline description of all relevant environmental and socio-economic resources or receptors in Denmark that may be impacted by NSP2. As described in section 6, the Danish part of the project includes the proposed pipeline route from the German EEZ border south-west of Bornholm through Danish territorial and EEZ waters south and east of Bornholm to the Swedish EEZ border north-east of Bornholm.

The following environmental and socio-economic resources or receptors have been identified and will be described in detail in sections 7.2 to 7.24

Physical-chemical environment
- Bathymetry;
- Sediment quality;
- Hydrography;
- Water quality;
- Climate and air.

Biological environment
- Plankton;
- Benthic flora and fauna;
- Fish;
- Marine mammals;
- Birds;
- Protected areas;
- Natura 2000;
- Biodiversity.

Socio-economic environment
- Shipping and shipping lanes;
- Commercial Fishery;
- Cultural heritage;
- People and health;
- Tourism and recreational areas;
- Existing and planned installations;
- Raw material extraction;
- Military practice areas;
- Environmental monitoring stations.

Although conventional and chemical munitions are not an environmental resource or receptor, and therefore not included in the list above, the topic was identified during consultation as an issue requiring particular consideration, a description of the baseline conditions is therefore included in this section.

Section 7.1 below describes the methods used to describe the baseline conditions.

7.1 Environmental baseline surveys

The environmental baseline description has been prepared on the basis of peer-reviewed scientific literature, relevant EIAs (e.g. the national EIA report for NSP which provided a valuable source of empirical data for the area), as well as other relevant technical reports and data for the area. This has been supplemented by a number of surveys which have been conducted in Danish waters in order to inform route development as well as ensure a solid basis for the baseline description and subsequent impact assessment. A number of these surveys were undertaken to inform route development and are therefore discussed in section 6. Additional environmental surveys are described in general terms below whilst further details can be found in the survey reports, see references below.

7.1.1 Water column and seabed conditions

In October 2015, an environmental survey of water column and seabed conditions was undertaken in Danish waters /65/. Sampling was performed at 22 stations along the proposed and alternative route (ES route and RA route respectively, Figure 7-1).

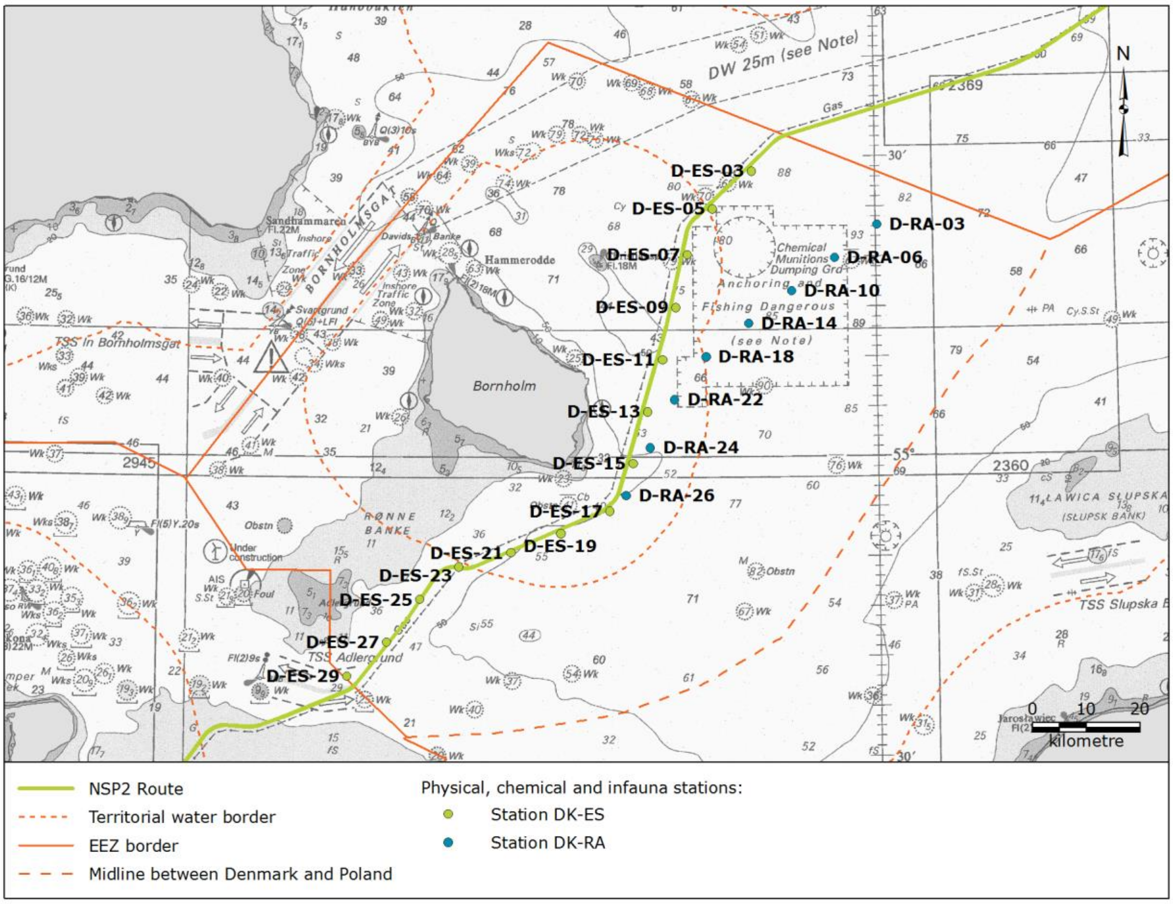


Figure 7-1 Survey stations for analysis of water column and seabed conditions in Danish waters

The survey included the following sampling activities /65/:

- Photographic documentation of the sediment surface at all sampling stations using a video camera mounted in a frame;
- Measurements of physical-chemical properties of the water column carried out with a conductivity, temperature, depth and oxygen (CTDO) recording unit;
- Analysis of surface sediments performed with a haps core sampler.

Equipment used for the survey is shown in Figure 7-2.

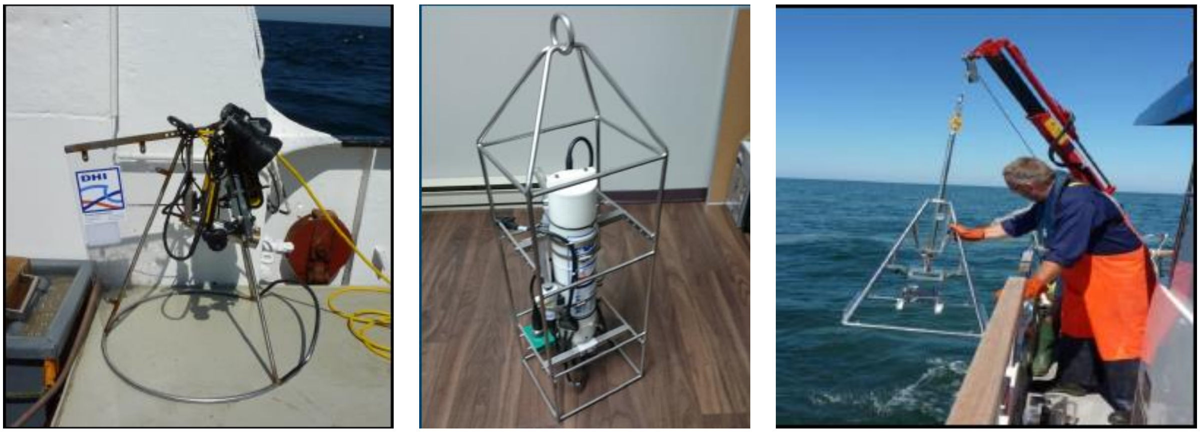


Figure 7-2 Sampling of the seabed and water column was undertaken using a video camera (left), CTDO profiler (centre) and haps core sampler (right)

The surface sediment was analysed for standard physical and chemical conditions (e.g. dry weight, loss on ignition (organic content), grain- size distribution) and concentrations of heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), organochlorine pesticides, organotins and nutrients /65/.

Key results of the survey are presented in sections 7.3, 7.4 and 7.5.

7.1.2 Infauna

In October 2015, an environmental survey of infauna was undertaken in Danish waters /66/. Sampling was performed at the same 22 stations used for sampling of the water column and seabed conditions (Figure 7-1).

The survey included the following sampling activities:

- Quantitative sampling of infauna performed with a Van Veen sampler;
- Photographic documentation of the sediment samples used for infauna analysis;
- Analysis of infauna.

Figure 7-3 Sampling of infauna was undertaken with a Van Veen sampler (left). An example of an infauna sampling (right)

Organisms were identified to species level (except for Oligochaeta and Nemertea) and counted, measured and/or weighed. A number of statistical analyses, e.g. diversity indices and Bray-Curtis dissimilarity indices, were carried out. Key results of the survey are presented in section 7.8.

7.1.3 Chemical warfare agents (CWA) in seabed sediments

In October 2015, an environmental survey of CWA was undertaken in Danish waters /67/. Sampling was performed at 103 stations along along the proposed and alternative routes (ES route, RA route and FS route respectively, Figure 7-4).

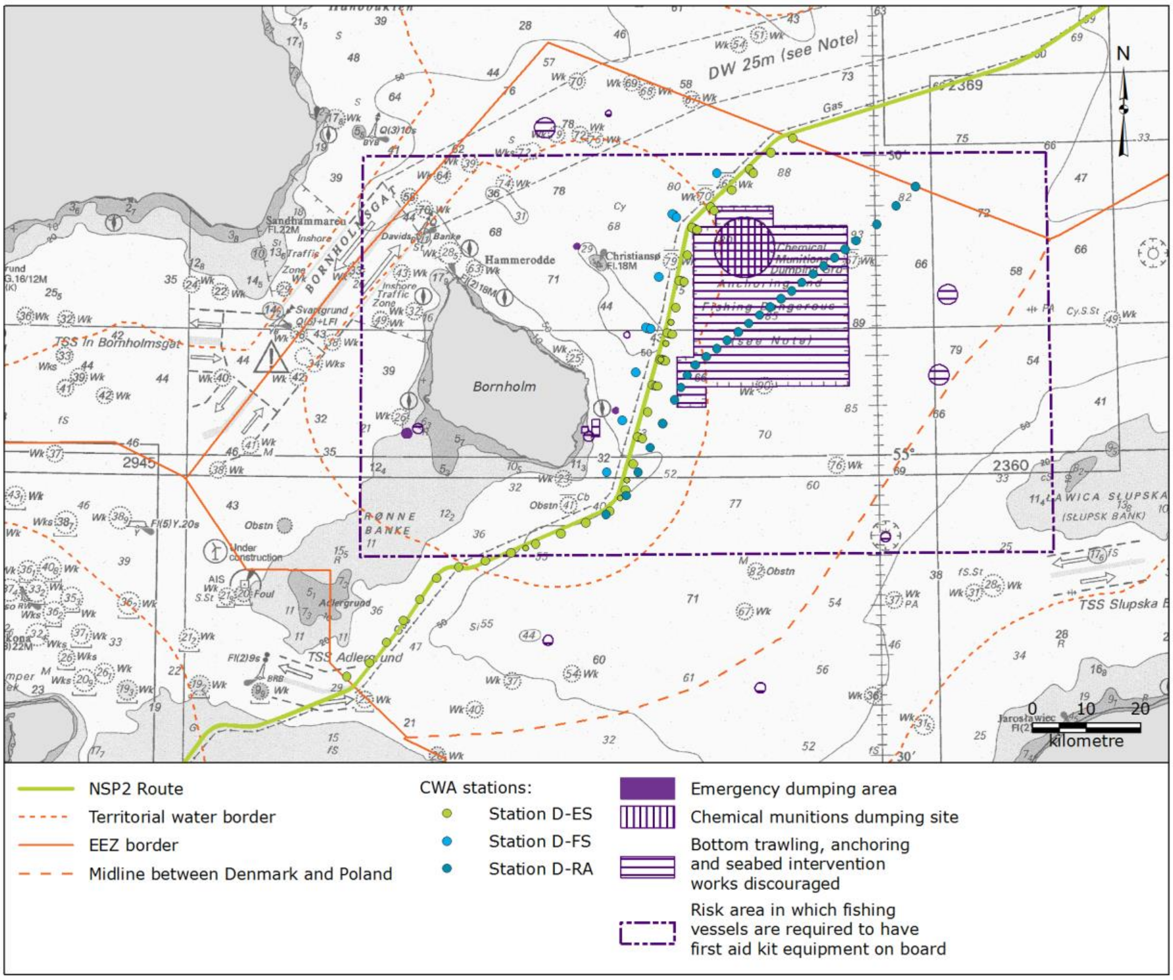


Figure 7-4 Survey stations for chemical warfare agents (CWA) in Danish waters

The survey included the following sampling activities:

- Seabed sampling performed with a Van Veen sampler or haps core sampler (Figure 7-2, Figure 7-3);
- Photographic documentation of the sediment samples used for CWA analysis.

The surface sediment was analysed for intact chemicals as well as degradation products and derivatives /67/, as summarised in Table 7-10.

During 2016, a supplementary survey was undertaken and sediment samples were collected in the areas where post-lay trenching is proposed.

Key results of the survey are presented in section 7.3.

7.2 Bathymetry

The Baltic Sea is characterized by its deep basins and shallow sills that, together with meteorological conditions, control the exchange of salt water with the North Sea. As will be described in this section, this influences the conditions for life both in the water column and on the seabed. The depth of the seabed is also an important descriptor of the life. The bathymetry of the Baltic Sea is therefore considered an important receptor.

The Baltic Sea is one of the largest brackish water bodies in the world. It is located between 53° and 66° N and between 10° and 26° E and is bordered by the Scandinavian Peninsula, the mainland of Northern Europe, Eastern Europe and Central Europe, and the Danish islands. The sea covers an area of 415,000 km^2, and its total volume is approximately 21,700 km^3. The catchment basin is approximately 1.7 million km^2, stretching from densely populated temperate areas in the south to subarctic rural areas in the north. The average depth is 52 m, and the maximum depth is 459 m /68//69/. The topography of the seabed is characterised by several basins separated by sills at different depths /70/. The names of the major basins of the Baltic Sea are shown in Figure 7-5, and the bathymetry is shown in Figure 7-6 and in Atlas Map BA-1.

The Baltic Sea is connected to the North Sea through the shallow and narrow Danish straits Little Belt, Great Belt and Oresund (0.8 km, 16 km and 4 km wide, respectively). Two sills in this transition zone (the Dars Sill in Femern Belt, with a water depth of 18 m, and the Drogden Sill in Oresund, with a water depth of 8 m) effectively limit the inflow of saline, oxygen-rich water to the Baltic Sea to rare occurrences of storms from the west.

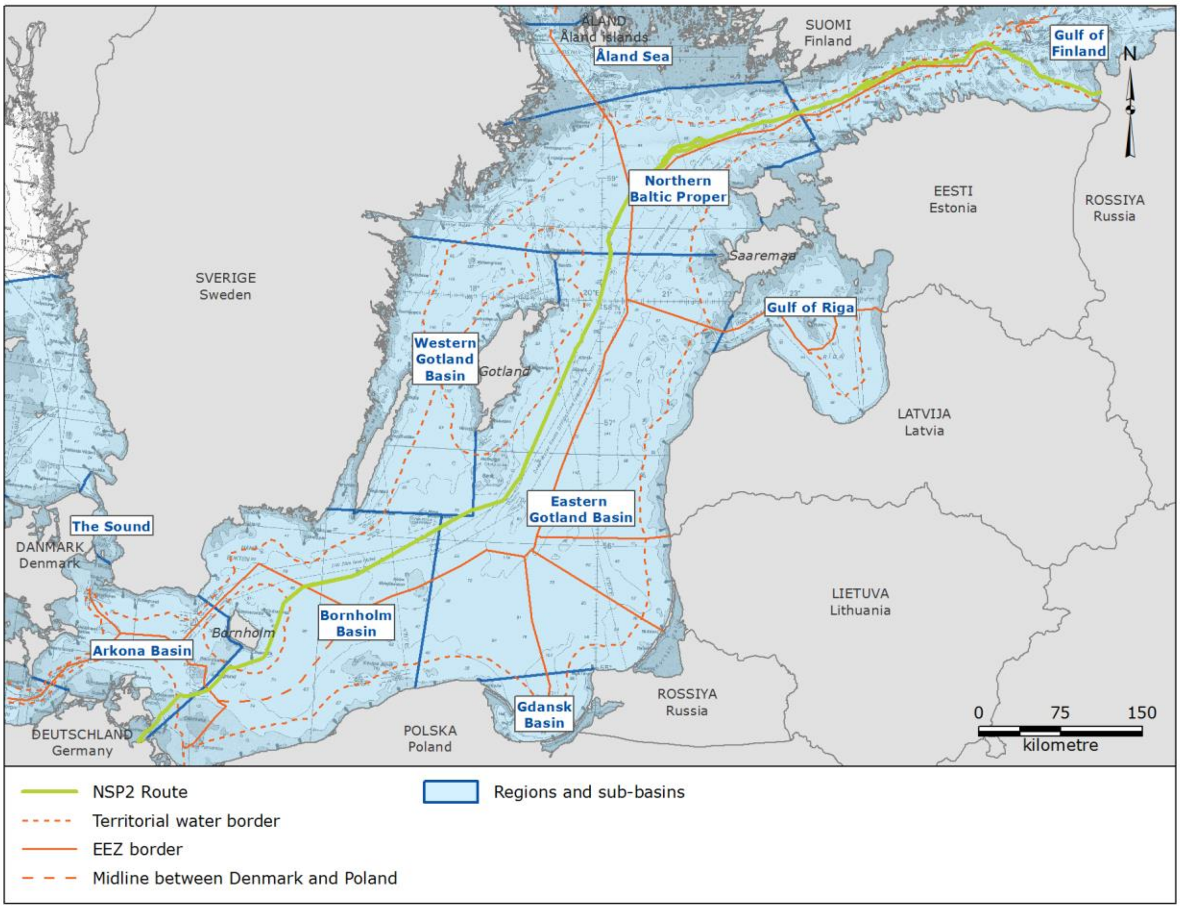


Figure 7-5 Major basins in the Baltic Sea

The Danish waters around Bornholm include the Arkona Basin (maximum depth 55 m) and the Bornholm Basin (maximum depth 106 m within the Swedish EEZ). The maximum depth of the Bornholm Strait, which separates the Arkona Basin from the Bornholm Basin, is 45 m. The inflow to the Arkona Basin is controlled by the sills at Dars and Drogden. The outflow of the Bornholm Basin is controlled by the Stolpe Channel, which separates the Bornholm Basin and the Gotland Deep and reaches depths of approximately 60 m /71/. The bathymetry of the Danish waters around Bornholm and the areas mentioned above is shown in Figure 7-6. The bathymetry and sub-basins in the Baltic Sea and Danish waters are shown in ATLAS map BA-01.

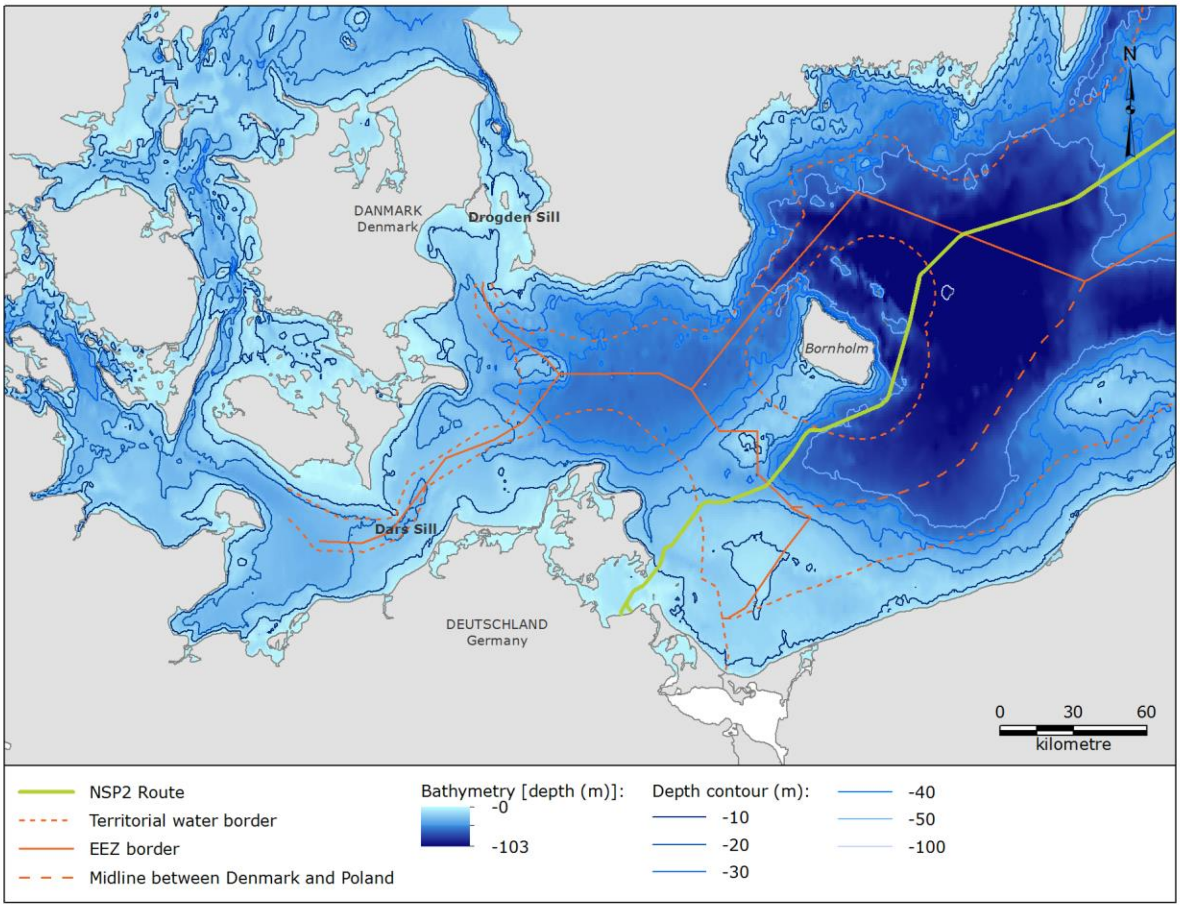


Figure 7-6 Bathymetry in the Danish sector of the Baltic Sea

A geophysical reconnaissance survey was performed along the NSP2 route through the Danish waters in the period from November 2015 to January 2016 to determine the seabed morphology, sediment types and the presence of wrecks, munitions or other features on the seabed. The survey corridor covered a nominal width of 1,500 m along the NSP2 route /61/.

The bathymetry along the proposed NSP2 route is illustrated in Figure 7-7 and shows that the seabed within the northern and deepest part of the Danish sector is generally flat and featureless, with depth gradients averaging less than 0.5°. The shallower areas, south of Bornholm, are characterised by irregular topographic highs and channels, and depth gradients of up to 27.5° were measured within the survey corridor. Depth gradients measured in the direction of the proposed NSP2 route do not exceed 6.5° at any point within Danish waters. The seabed rises to its shallowest depth in the southern part towards the boundary between Danish and German waters.

Linear depressions, interpreted to be relict iceberg plough marks, are present intermittently on topographic highs at depths of less than 60 m.

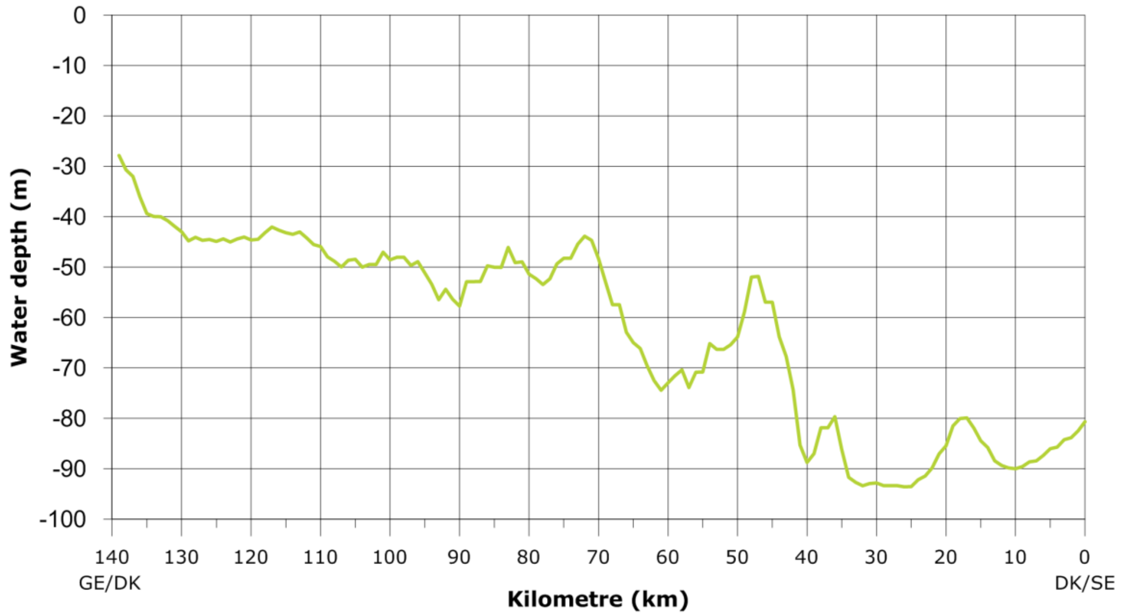


Figure 7-7 Water depth along the proposed NSP2 route in Danish waters.

7.3 Sediment quality

The quality of the sediment in the Baltic Sea, including its chemical and physical characteristics, is an important factor which influences the benthic environment and the living conditions for the associated fauna and flora. Benthic organisms such as mussels, crustaceans and benthic fish are an important food source for fish, birds and mammals inhabiting other parts of the Baltic Sea ecosystem. The presence of contaminants in the sediment has the potential to impact individuals of lower trophic levels as well as cause bioaccumulation and bio-magnification through the food chain and thus affect top predators, including humans. The sediment quality in the Baltic Sea is therefore considered an important receptor.

7.3.1 Geology

The geology of the Baltic Sea generally comprises Precambrian, Palaeozoic, Mesozoic and Palaeogene bedrock and Quaternary sedimentary cover. The bedrock geology of the Danish Baltic Sea is shown together with the proposed NSP2 route in Figure 7-8 and in Atlas Map GE-01-D. Along the proposed NSP2 route in Danish waters, the bedrock mainly consists of crystalline basement, chalk and limestone.

The major neotectonic activity in the Baltic Sea area is associated with the isostatic rebound of the Earth's crust following deglaciation at the end of the latest ice age. During glaciation, the crust was compressed by the weight of the ice sheet. When the ice sheet melted, the crust began to rebound. Along the entire NSP2 route, the recent relative uplift varies between less than 3 mm/year to about -1 mm/year. In the Danish section of the NSP2 route, the uplift ranges from -1 to 0 mm/year /72/.

The Tornquist zone in the southern part of the Baltic, partly in Danish waters, is a zone of deformation that has been tectonically active on a number of occasions. The zone is a transition between the East European Plate, consisting of the Baltic Shield and the East European Platform, and the West European Plate. Along this transition is a zone of dextral strike-slip faults and tension cracks. The geology of the zone is characterised by a complex pattern of block-faulted horsts and grabens. Due to block faulting during and after periods of sedimentation, the bedrock is highly variable. Bornholm is situated partly within the Tornquist Zone, and is also characterised by faults.

The Baltic Sea region is nearly devoid of earthquake activity in global terms /74/. However, seismic activity in the form of small-scale earthquakes occurs occasionally. This activity is the result of stress release in the lithosphere, caused by isostatic deflection and rebound following glaciation or intra-plate stress caused by plate tectonics. As mentioned above, the uplift caused by the rebound is limited in the Danish section of the NSP2 route.

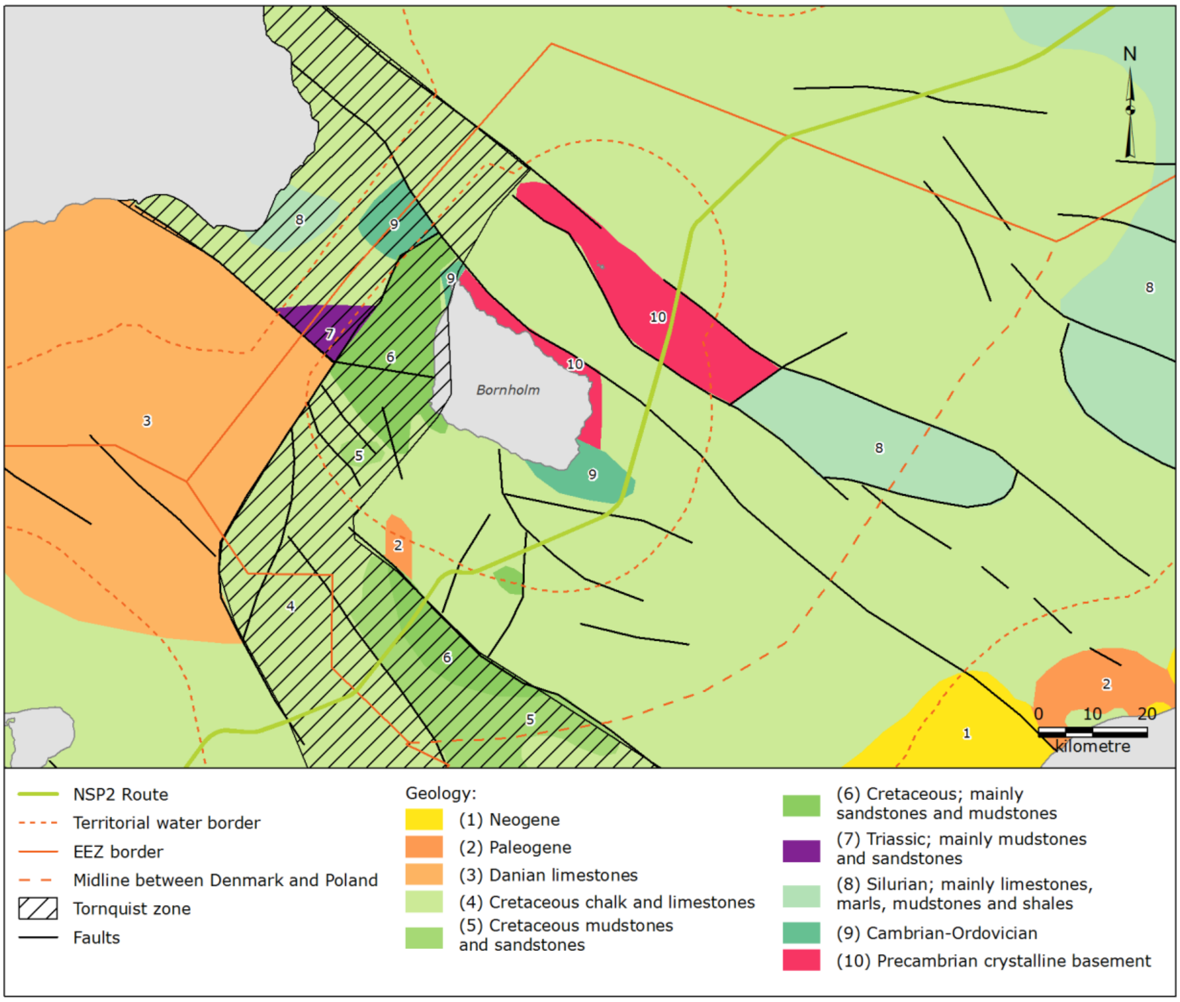


Figure 7-8 Bedrock geology along the proposed NSP2 route in Danish waters.

A review of seismic events in the Danish waters around Bornholm shows very low activity, with only two registered earthquakes in the period 2000-2012: a magnitude 2.0 earthquake in 2006 and a magnitude 0.6 earthquake in 2011 /75/. More recently, on 16 August 2014, an earthquake measuring 2.6 on the Richter scale with an epicentre approximately 10 km off the south coast of Bornholm was registered /76/. Atlas map GE-04-D and Figure 7-9 show the position of seismic events detected around Bornholm in the period 2000-present (March 2016). It should be noted that a number of the events recorded on the figure are likely related to man-made events, such as detonations of munitions left from WWII /76/.

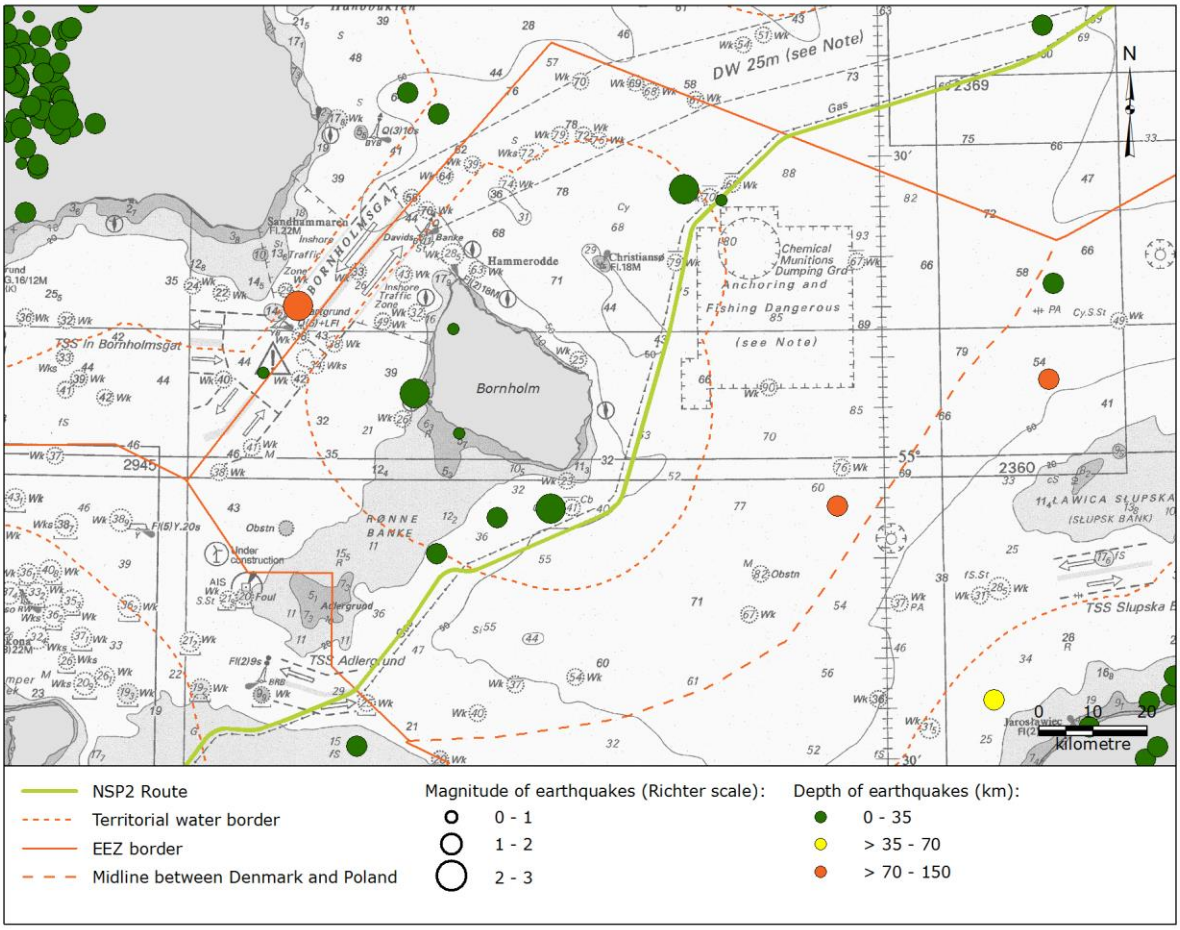


Figure 7-9 Recordings of earthquake-like seismic events in the area around Bornholm in the period 2000 to March 2016 /76/.

During the planning of NSP, a probabilistic seismic hazard analysis was prepared for the entire route and region and seismic design parameters were defined at selected points at approximately 100 km intervals along the route /77/. The design data were produced for return periods of 100, 200, 475, 1,000, 2,000 and 10,000 years. It was concluded that seismicity in the region, and hence along the route, is "very low to low", also compared with other regions in Europe. The same was concluded for the risk of seismic hazard. This conclusion can also be shown graphically by comparing a seismic hazard map for other regions in Europe (Figure 7-10) /78/.

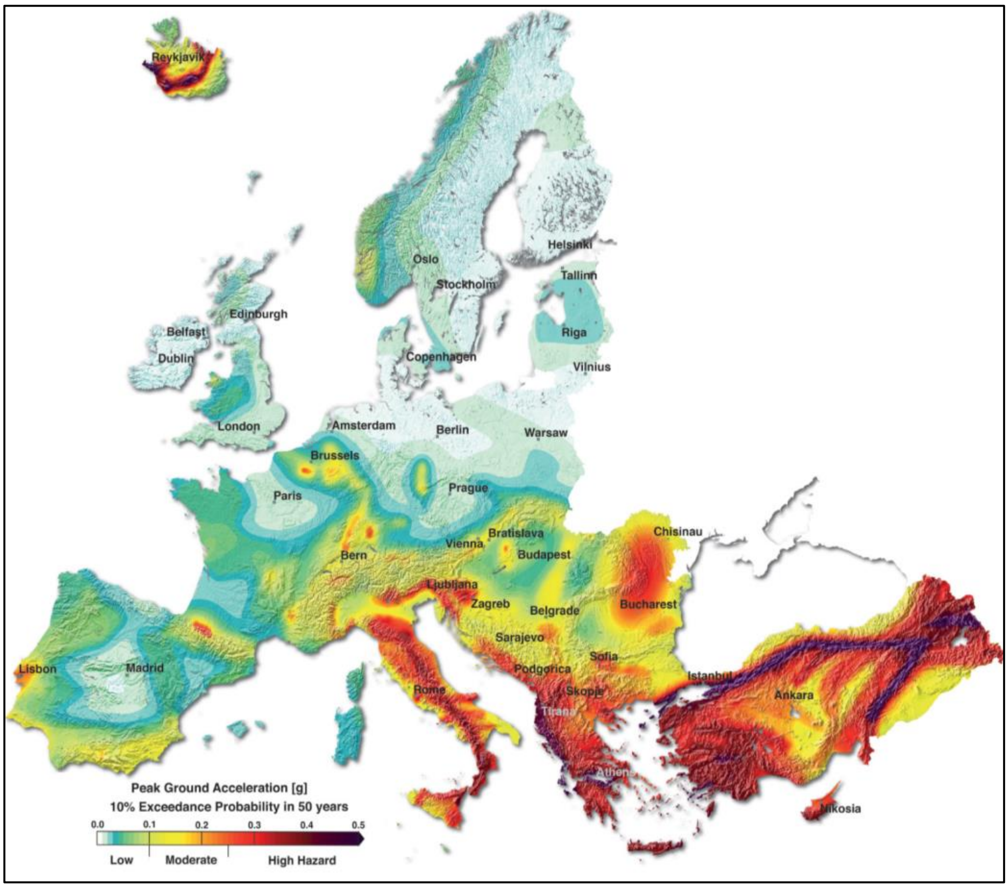


Figure 7-10 European Seismic Hazard Map (ESHM13) displaying the 10% exceedance probability in 50 years for peak ground acceleration (PGA) in units of gravity (g) /78/. Blue-green colours indicate comparatively low hazard areas (PGA ≤ 0.1 g), yellow and orange indicate moderate hazard areas (0.1 g < PGA ≤ 0.25 g) and red colours indicate high hazard areas (PGA ≥ 0.25 g).

The results and conclusions from the probabilistic seismic hazard analysis carried out during NSP were recently reviewed as part of NSP2 and deemed to be adequate and valid for NSP2 as well /79/.

7.3.2 Seabed sediments

Quaternary sedimentary deposits cover the sea floor of the Baltic Sea almost completely. These deposits were formed during the last ice age and during different post-glacial Baltic Sea development stages. The distribution of sediments is a result of the Quaternary geological history of the Baltic Sea until the present day distribution of areas of sedimentation or erosion. Bedrock without a cover of younger sediments is found only in near-shore areas in the northern Baltic Proper and Gulf of Finland or where steep slopes are present on the seabed.

The glacial deposits are dominated by glacial till comprised of a mixture of grain sizes, from clay to boulders. The majority were deposited under glaciers and are consolidated and possess high strengths as a result of the pressure of the overlying ice. The thickness of till deposits varies from a few metres to several tens of metres. Exposed till is found on top of or at the sides of topographical heights and on steep slopes at the seabed. Late-glacial and post-glacial sediments occur upon the glacial deposits. The late-glacial sediments are mainly clay, silt and sand. These deposits are covered by even younger deposits of mainly clay and silt.

The distribution of sediments on the Baltic Sea floor is governed by a number of factors, such as water depth, wave size, current pattern, etc. Two general zones can be outlined: a zone of sedimentation and a zone of erosion or non-deposition. Zones of sedimentation include areas such as deep basins or sheltered areas, whereas zones of erosion or non-deposition include areas exposed to wave- or current-induced water motion. Sedimentation rates in the Arkona and Bornholm basins, both zones of sedimentation, are in the range of 3-4 mm/year /79/.

Figure 7-11 shows the seabed sediments present in Danish waters. Along the Danish section of the proposed NSP2 route, the seabed mainly consists of soft clay with organic content (mud), sandy mud, sand and coarser sediments. The soft deposits are mainly in deep accumulation areas, i.e. zones of sedimentation, whereas the coarser sediments are in general situated in shallower areas more exposed to the action of waves and currents.

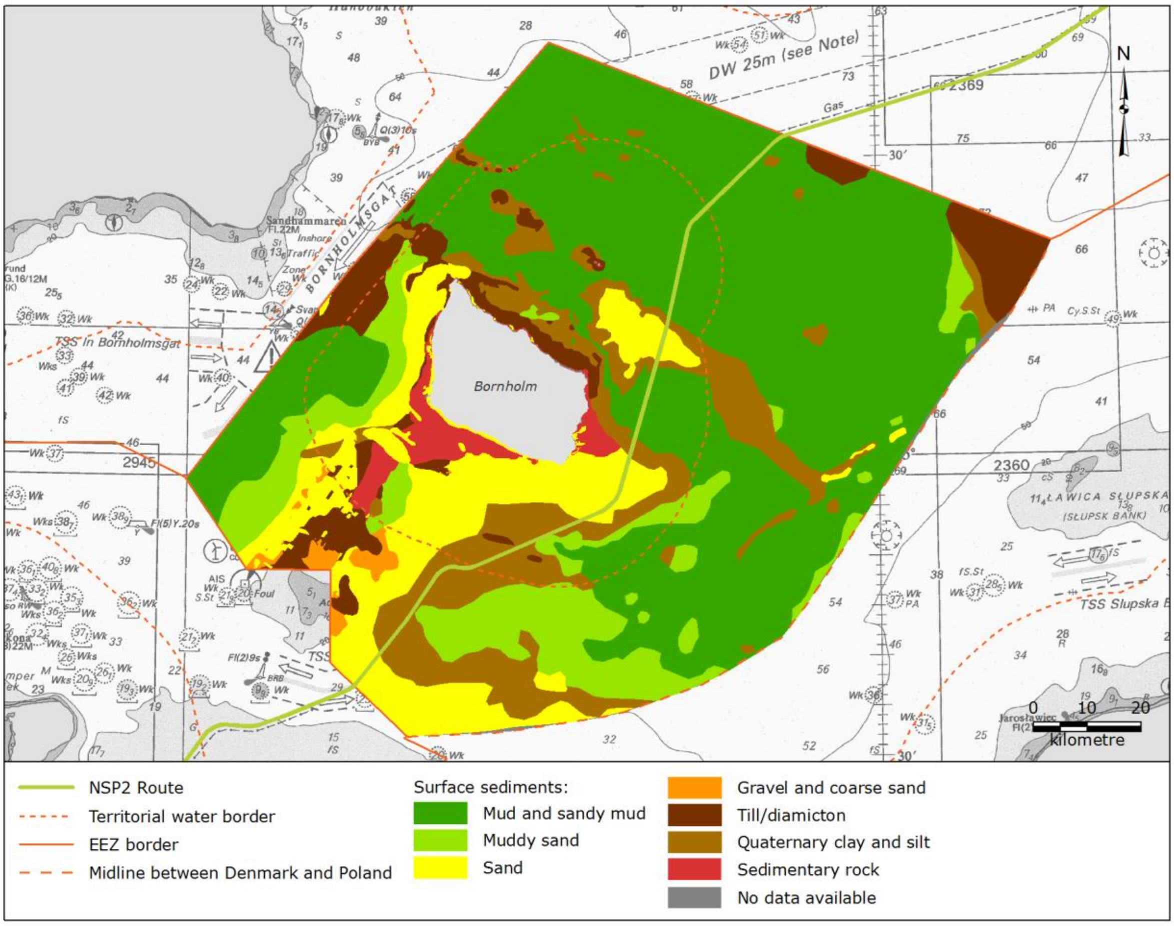


Figure 7-11 Seabed surface sediment types in the Danish Baltic Sea.

Sediment properties along the proposed NSP2 route were investigated during the geophysical survey carried out in 2015-2016 /61/. The northern stretch of the NSP2 route, from the Swedish EEZ border travelling south, passes through the Bornholm Basin, where water depth reaches 95 m. The basin is characterised by a thick sequence of sediment deposits (varying between 45-60 m thick) with very soft clay at the top and a base of is sedimentary bedrock.

Following the proposed NSP2 route as it passes east and south of Bornholm, the seabed becomes more undulating, with water depths ranging from 40-75 m. The seabed in the shallower areas is dominated by coarser sediments, sand and boulders. In the deeper sections, the seabed mainly consists of soft clay. In some areas, the bedrock is close to the seabed surface /61/.

An overview of the sediment types observed during the geophysical survey is illustrated in Figure 7-12 and are broadly in line with Figure 7-11 above.

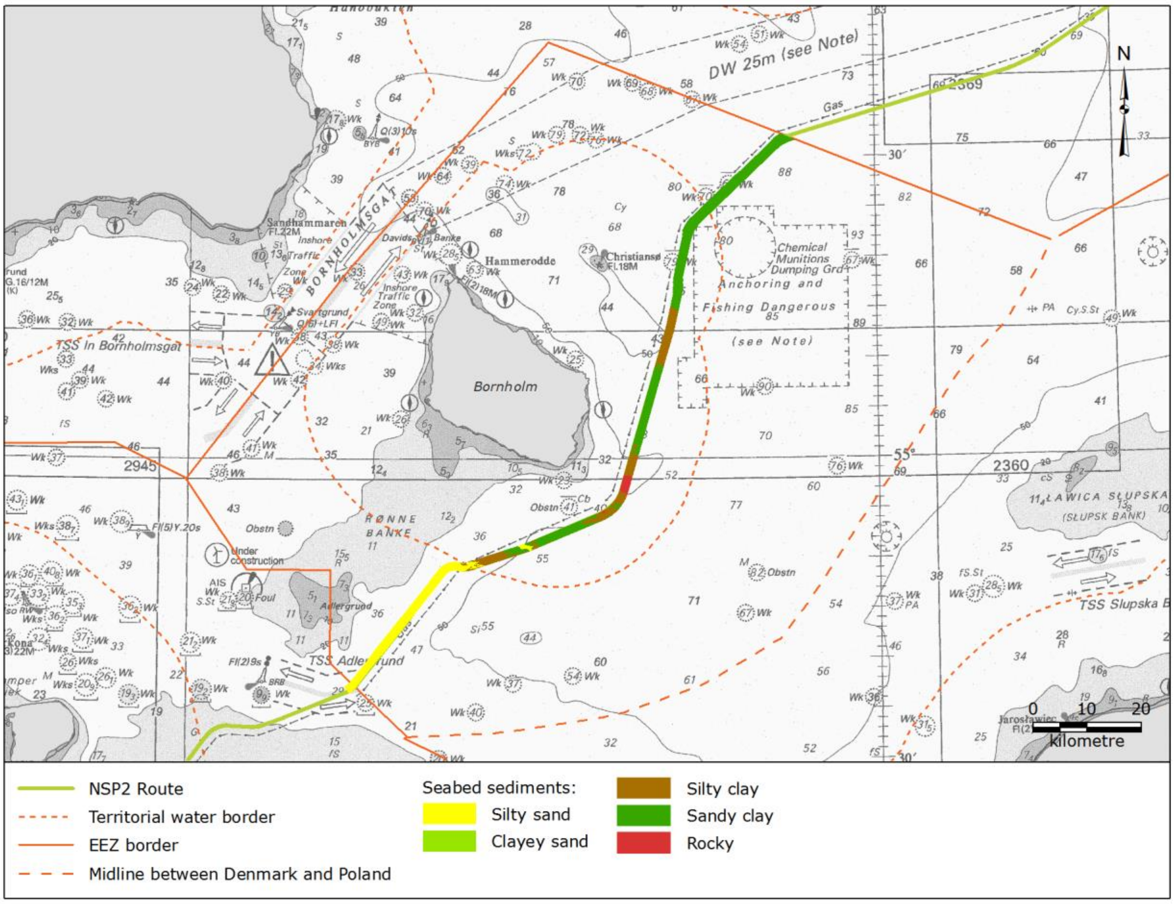


Figure 7-12 Types of seabed sediment along the NSP2 route, observed during the field survey in October 2015.

7.3.3 Physical and chemical characteristics of seabed sediments

Inorganic and organic chemical contaminants enter the Baltic Sea via several routes /80/. The main means are atmospheric deposition, advective supply from rivers and exchange with the surrounding seas through the Danish straits. In addition, hazardous substances from shipping reach the environment through atmospheric emissions from combustion, leakage from anti-fouling paints and intentional or accidental spills of oil and hazardous substances /81/. Chemical warfare agents (CWA) were dumped in designated areas of the Baltic after the Second World War (WWII) and are now present in the sediment along parts of the proposed NSP2 route.

The general distribution patterns of contaminants in the Baltic Sea are complex. Many of the contaminants are hydrophobic, i.e. they tend to be adsorbed by particulate matter and settle on the seabed. This adsorption takes place especially with fine-grained sediments and particulate organic matter.

Settled sediments with their associated contaminants may be resuspended by currents/waves, bioturbation, trawling, etc. The resuspension events mix the top sediment and facilitate its long-distance transport, depending on the physical settings, sediment conditions, etc. Eventually, the majority of the transported fine-grained sediments and their associated contaminants end up in accumulation areas for fine-grained sediments, primarily in the deep parts of the Baltic Sea.

7.3.3.1 Seabed conditions

As discussed in section 7.1, sampling and biological/chemical analyses of the surficial sediment along the proposed NSP2 route in Danish waters were carried out in October 2015 /65/, survey stations are shown in Figure 7-1. The amount of nutrients (N and P), heavy metals and organic contaminants in the top 2 centimetres (cm) of sediment were measured.

The depth at the sampling stations ranges between 28 m and 95 m, to the south-west of Bornholm and north-east of Christiansø respectively. The substrate varies with depth as summarised in Figure 7-13.

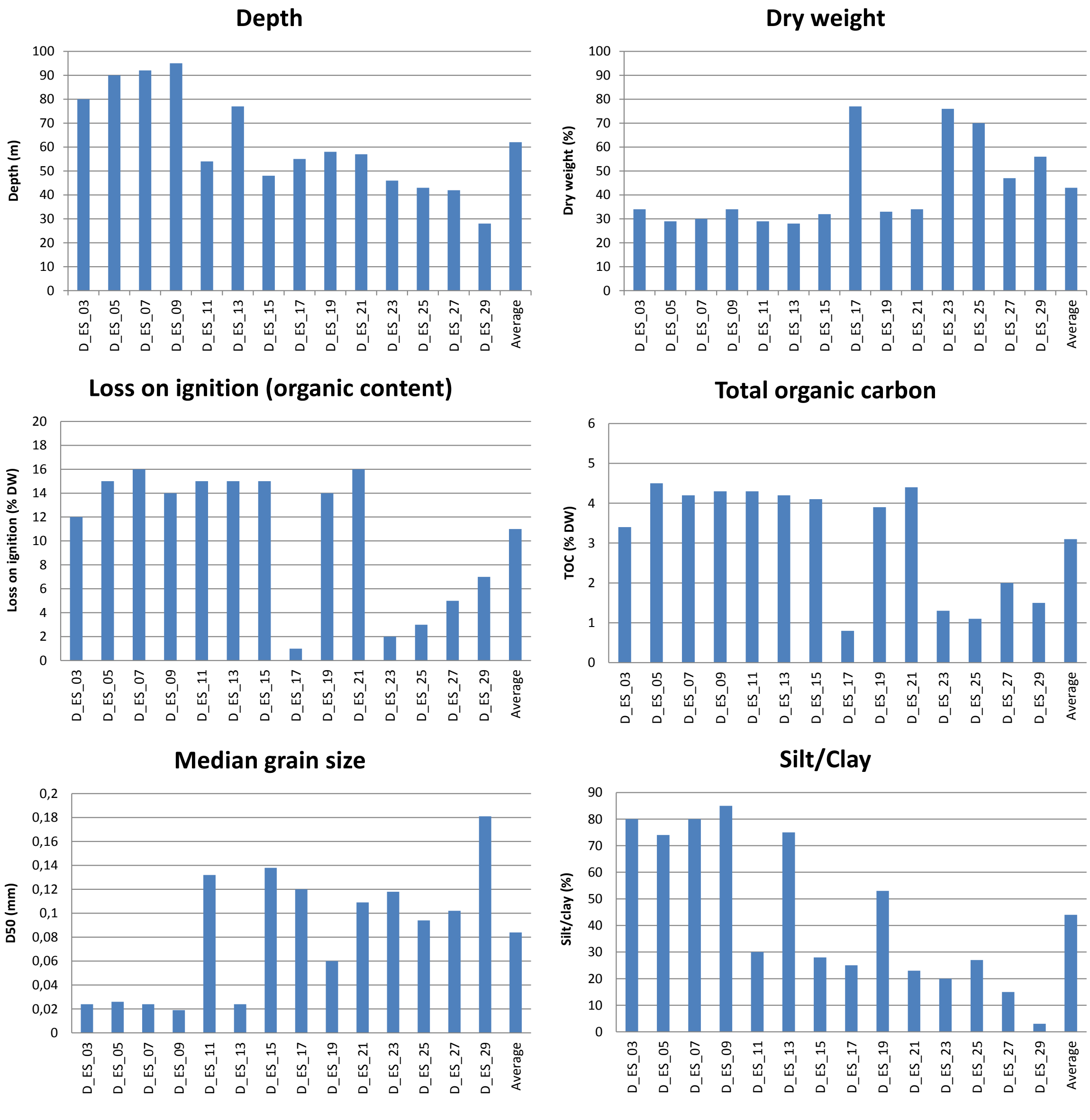


Figure 7-13. Water depth and sediment properties (upper 2 cm) in October 2015 of the stations following the proposed NSP2 route. D50 represents the median grain size. Loss of ignition (LOI) and TOC (total organic carbon) are both expressions for the content of organic matter. The inverse to dry weight (DW) reflects the water content of the sediment.

Sediment with a median grain size (D50) below or equal to 0.063 mm and consisting mainly of silt and clay particles is observed at the stations at water depths of approximately 60 m or more. For the stations at water depths between 40 m and almost 60 m, the D50 is approximately 0.10 – 0.14 mm, which corresponds to the median grain size for the fine sand fraction. The shallowest station, D_ES_29, has a D50 of 0.18 mm and a very low silt/clay fraction.

The content of organic matter expressed as LOI, TOC and the inverse of DW shows only a slight correlation with water depth compared to grain size distribution. This is likely due to the sediments being frequently resuspended as a result of mechanical impact (i.e. water turbulence or trawling activity). At some of survey stations residual sediments originating from the latest ice age in the form of gravel and stones are observed, reflecting that net erosion is higher than net sedimentation. These areas are often located on vast slopes of the submersed landscape.

7.3.3.2 Metals

Heavy metals are transported to the Baltic Sea via rivers, run-off in coastal areas, direct water-borne discharges to the sea or by wet or dry atmospheric deposition. Excessive metal levels may pose a health risk to biota in the environment. For example, mercury may damage nervous systems and kidneys and cause reproductive problems in birds and mammals. Mercury is also strongly bioaccumulated and biomagnified through the food chain, posing a risk to top predators such as marine mammals, fish-eating birds, and humans. Cadmium accumulates in many organisms, such as micro-organisms, molluscs and other invertebrates, and may cause a wide variety of acute and chronic effects such as kidney damage and lung emphysema in top predators such as marine mammals and humans /82/.

Sediment characteristics, including grain size and organic content, play an important role in the concentration and distribution of heavy metals in marine sediment. The concentration of heavy metals is typically enriched in the fine-grained fraction, compared with sand-sized particles, because fine-grained sediment better adsorbs heavy metals from water due to the large surface-to-volume ratio. In most sedimentary environments, there is a linear relationship between trace elements and the fine particle-size fractions (silt and clay) of the samples. Therefore measurable concentrations of heavy metals do not automatically infer an anthropogenic enrichment, but can be caused by a high fraction of silt and/or clay in sediment.

In the following, the background assessment criterion (BAC) and effect-range low (ERL) for metals are used to evaluate the concentrations found in sediments along the NSP2 route. Both are developed by OSPAR, and BAC is thought to represent the natural background concentration of metals that could be expected without any anthropogenic influence, whereas ERL indicates the limit above which negative effects may be expected /83//84/. The Helsinki Commission, the Baltic Marine Environment Protection Commission (HELCOM) has implemented assessment criteria for cadmium, lead and mercury in marine sediments. In general, the threshold for "good environmental status" (GES) and "moderate environmental status" (MES) is the same as the BAC developed by OSPAR, and the threshold concentration indicating "bad environmental status" (BES) is the same as the ERL developed by OSPAR. Other assessment criteria that can be used for comparison of environmental measurements of metals in sediment include the lower action levels (LAL) that are established by the Danish Nature Agency. These concentrations are considered natural background concentrations or concentrations at which no negative effects are observed, and are generally comparable to BAC /85/.

Table 7-1 summarises the content of heavy metals in the sediment along the NSP2 route in Denmark (2015) along with concentrations corresponding to BAC and ERL as given by OSPAR. For context, results from the previous survey carried out in a parallel transect for NSP in 2008 are also included. The subsequent text compares the concentrations with the LAL, as given by the Danish authorities.

Table 7-1 Content of heavy metals (mg/kg DW) along the proposed NSP2 route in Danish waters/65/. If values exceed ERL they are indicated in bold.

Station	As	Pb	Cd	Cr	Cu	Co	Hg	Ni	V	Zn
BAC[3]	25	38	0.310	81	27	-	0.070	36	-	122
ERL	-	47	1.200	81	34	-	0.150	-	-	150
NSP results[1]	0.5-21	2.6-86.4	0.02-1.17	0.5-61.0	0.3-53.6	-	<0.01 – 0.14	0.5-45.9	-	2.8-266
NSP2 maximum value[2]	19.1	80.8	0.480	50.1	57.8	20.70	0.140	43.5	77.3	207
ES_03	12.6	**60.8**	0.170	48.0	**50.1**	16.60	0.081	38.5	65.6	**170**
ES_05	16.5	**56.0**	0.160	49.5	**53.2**	20.30	<0.010	43.5	76.6	**171**
ES_07	14.8	**68.0**	0.480	50.1	**57.8**	20.70	0.120	42.3	77.3	**207**
ES_09	17.1	**56.3**	0.140	48.6	**52.5**	19.00	0.140	42.8	75.5	**159**
ES_11	11.4	**78.1**	0.210	47.1	**54.3**	18.00	0.015	38.0	69.4	**186**
ES_13	17.0	**80.4**	0.110	46.3	**52.8**	19.10	0.120	37.5	67.4	**182**
ES_15	17.8	**51.7**	0.065	48.4	**46.2**	19.20	0.015	41.4	74.8	128
ES_17	9.3	8.2	0.073	16.7	8.8	8.49	0.020	14.4	21.0	34.3
ES_19	14.6	**80.8**	0.180	47.3	**48.0**	17.70	0.047	39.1	64.7	**173**
ES_21	10.7	**79.1**	0.180	47.0	**54.0**	19.70	0.015	38.3	71.1	**190**
ES_23	7.8	13.1	0.061	11.1	8.54	4.28	0.011	9.0	13.5	27.2
ES_25	3.6	14.2	0.060	20.3	11.6	5.57	0.012	13.7	22.2	39.7
ES_27	19.1	35.1	0.074	40.5	29.6	14.90	0.015	29.0	57.9	106
ES_29	5.1	28.4	0.019	20.7	15.9	4.51	<0.010	12.4	23.4	46.4

[1]Range measured during NSP survey in 2008; [2]The highest value measured along the NSP2 route in Denmark /65/. [3]Values of BAC are normalised to 5% Aluminium.

Although the lower range of metals measured during the NSP2 survey was somewhat higher than the lower range measured during NSP survey, the maximum levels were similar /86/.

The following exceedances were observed:

- Nine of the samples had lead concentrations exceeding BAC and/or LAL.
- One of the samples (ES_07) had cadmium concentrations exceeding the BAC. This sediment sample had a very high content of silt/clay and a very low median grain size, implying that the clay fraction was very high. Hence, the relatively high content of cadmium is likely a result of high clay content. No samples exceeded the ERL for cadmium /83/.
- Nine of the samples had nickel concentrations which exceeded BAC (no ERL value is given for Ni).
- Nine of the samples had copper concentrations which exceeded ERL.
- Four of the samples, all of which were at water depths of 77 m or higher, had mercury concentrations exceeding BAC, but none exceeded the ERL /83/).
- Eight of the samples had zinc concentrations which excessed BAC and ERL

In addition to the results shown in Table 7-1, concentrations of metals were measured in sediment cores down to 1 m below the sediment surface to determine whether the concentration varied with depth. The results indicated only little variation at the individual stations, and no consistent trends were observed /88/.

7.3.3.3 Polycyclic aromatic hydrocarbons (PAHs)

PAHs are environmental contaminants that are primarily formed by incomplete combustion of organic materials such as coal, oil or wood. PAH molecules consist of three or more benzene rings, at least two of which are fused with two neighboring rings. PAHs comprise a large and heterogeneous group, the most toxic of which are PAH molecules with four to seven rings. The lower molecular weight PAHs can be acutely toxic to aquatic organisms, and some PAHs form carcinogenically-active metabolites (benzo[a]pyrene is the prime example) and PAH concentrations in sediments have been linked with liver neoplasms and other abnormalities in bottom-dwelling fish /87/. Elevated PAH concentrations may therefore pose a threat to aquatic organisms and potentially also to human consumers of fish and shellfish. Because of their lipophilic nature and high affinity to particles, PAH compounds in the marine environment tend to accumulate in organic-rich sediments.

The threshold concentrations between GES and MES set by HELCOM for a range of PAHs are equal to their respective ERL values /89/. These are listed in the tables below, together with BAC values, the results of PAH measurements during the NSP2 baseline survey /65/ and the results from 2008 survey carried out for NSP.

Table 7-2 Content of PAHs (mg/kg DW) along the proposed NSP2 route. If values exceed ERL they are indicated in bold.

Station	Naphthalene	Acenaph-thylene	Acenaph-thene	Phen-anthrene	Anthracene	Fluorene
BAC[2]	0.008	-	-	0.032	0.005	-
ERL	0.160	0.044	0.016	0.240	0.085	0.019
Range measured during NSP	-	-	-	<0.002 - 0.13	-	-
NSP2 maximum value[1]	0.046	0.010	0.009	0.110	0.029	0.016
ES_03	0.025	0.009	0.004	0.054	0.015	0.008
ES_05	0.027	0.009	0.006	0.056	0.015	0.011
ES_07	0.033	0.010	0.008	0.080	0.023	0.013
ES_09	0.040	0.009	0.009	0.110	0.029	0.016
ES_11	0.004	<0.002	<0.002	0.006	<0.002	<0.002
ES_13	0.046	0.010	0.009	0.099	0.028	0.015
ES_15	0.032	<0.002	<0.002	0.009	0.002	<0.002
ES_17	0.005	<0.002	<0.002	0.013	0.003	<0.002
ES_19	0.012	0.003	0.002	0.034	0.009	0.005
ES_21	0.003	<0.002	<0.002	0.007	<0.002	<0.002
ES_23	0.003	<0.002	<0.002	0.007	<0.002	<0.002
ES_25	0.004	<0.002	<0.002	0.008	<0.002	<0.002
ES_27	0.003	<0.002	<0.002	0.009	0.002	<0.002
ES_29	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

[1] Highest value measured along the NSP2 route in Denmark /65/ . [2]The BAC concentrations are normalized to 2.5% TOC.

Table 7-3 Content of PAHs (mg/kg DW) along the proposed NSP2 route. If values exceed ERL they are indicated in bold.

Station	Fluor-anthene	Pyrene	Benz(a) anthracene	Chrysene	Benzo(b) fluoranthene	Benzo(k) fluoranthene
BAC[2]	0.039	0.024	0.016	0.020	-	-
ERL	0.600	0.665	0.261	0.384	-	-
Range measured during NSP	<0.002 - 0.26	<0.002 - 0.19	<0.002 - 0.10	<0.002 - 0.089	<0.002 - 0.024	<0.002 - 0.096
NSP2 maximum value[1]	0.280	0.250	0.140	0.120	0.340	0.180
ES_03	0.130	0.130	0.076	0.057	0.230	0.120
ES_05	0.150	0.130	0.072	0.058	0.170	0.100
ES_07	0.240	0.180	0.100	0.088	0.320	0.170
ES_09	0.280	0.250	0.140	0.120	0.340	0.180
ES_11	0.013	0.010	0.005	0.005	0.014	0.005
ES_13	0.280	0.220	0.120	0.110	0.340	0.180
ES_15	0.024	0.018	0.009	0.009	0.019	0.009
ES_17	0.028	0.020	0.009	0.009	0.022	0.010
ES_19	0.094	0.074	0.039	0.034	0.093	0.046
ES_21	0.016	0.013	0.007	0.006	0.016	0.008
ES_23	0.015	0.013	0.007	0.006	0.017	0.009
ES_25	0.002	0.016	0.008	0.007	0.023	0.011
ES_27	0.018	0.014	0.007	0.007	0.021	0.009
ES_29	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

[1] Highest value measured along the NSP2 route in Denmark /65/. [2]The BAC concentrations are normalized to 2.5% TOC.

Table 7-4 Content of PAHs (mg/kg DW) along the proposed NSP2 route. The BAC and ERL concentrations are also shown (normalized to 2.5% TOC). If values exceed ERL they are indicated in bold.

Station	Ben-zo(A)pyrene	indeno-(1,2,3-cd)pyrene	Dibenz(a,h)-anthracene	Ben-zo(ghi)-perylene	Sum of 9 PAHs[2]	Total PAH
BAC[3]	0.030	0.103	-	0.080	-	-
ERL	0.430	0.240	0.063	0.085	-	-
Range measured during NSP	<0.002 - 0.073	<0.002 - 0.15	-	<0.002 - 0.091	-	<0.002 - 1.37
NSP2 maximum value[1]	0.190	0.550	0.075	0.460	1.865	2.798
ES_03	0.100	**0.430**	0.061	**0.320**	1.190	1.769
ES_05	0.100	**0.400**	0.059	**0.290**	1.132	1.653
ES_07	0.170	**0.530**	0.063	**0.400**	1.584	2.428
ES_09	0.190	**0.550**	**0.075**	**0.460**	1.865	2.798
ES_11	0.006	0.016	0.002	0.013	0.061	0.099
ES_13	0.190	**0.550**	**0.073**	**0.430**	1.762	2.700
ES_15	0.011	0.025	0.003	0.020	0.103	0.19
ES_17	0.013	0.028	0.004	0.020	0.115	0.184
ES_19	0.055	**0.150**	0.020	**0.110**	0.51	0.780
ES_21	0.009	0.026	0.003	0.019	0.087	0.133
ES_23	0.008	0.025	0.003	0.020	0.086	0.133
ES_25	0.010	0.028	0.004	0.023	0.100	0.144
ES_27	0.009	0.024	0.003	0.019	0.091	0.145
ES_29	<0.002	0.002	<0.002	<0.002	0.002	0.002

[1] Highest value measured along the NSP2 route in Denmark /65/. [2] Sum of the following nine PAHs: anthracene, benz(a)anthracene, benz(ghi)perylene, benz(a)pyrene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, pyrene, and phenanthrene. [3]The BAC concentrations are normalized to 2.5% TOC.

Concentrations of some of the PAH compounds along the NSP2 route were somewhat higher than the concentrations measured during the 2008 NSP survey /86/. The largest deviations between NSP and NSP2 results were observed for benzo(b)fluoranthene and benzo(ghi)perylene. Both benzo(b)fluoranthene and benzo(ghi)perylene are complex, organic molecules that may be formed during incomplete burning of organic material such as gasoline exhaust or cigarette smoke. Other sources include industrial effluents and emissions generated during municipal waste water treatment or waste incineration. Concentrations of PAHs measured in sediment cores down to 1 m below the sediment surface indicated only slight variations with depth /88/.

PAHs were most abundant at the deep stations where sediment is rich in clay and the bottom water has low or no oxygen.

7.3.3.4 Polychlorinated biphenyls (PCBs)

PCBs are persistent organic pollutants (POPs) that can cause long-term impacts on ecosystems and affect human health. PCB congeners are persistent and hydrophobic and accumulate in sediments and organisms in the aquatic environment. PCBs consist of two benzene rings with various numbers of chlorine atoms substituted for one or more hydrogen atoms. Up to 130 different congeners are found in commercial mixtures. Some PCBs are called dioxin-like (dl-PCBs) because of their structure and dioxin-like effects. Accumulation of PCBs in sediments poses a potential hazard to sediment-dwelling organisms. However, the main concern over PCBs is their high bioaccumulation capacity which may result in relatively high PCB levels in biota even in areas with relatively low concentrations of PCBs in the aquatic environment. The presence of elevated concentrations of PCBs or their residues in marine mammals have been suggested as the cause of reproductive failures, increased susceptibility to disease, and developmental instability. The effects on birds also include egg-shell thinning /87/.

HELCOM has established threshold concentrations of PCB-118 and PCB-153 as indicators of GES. Both of these thresholds are equal to the OSPAR environmental assessment criteria (EAC) values, which are normalised to the TOC content of the sediment /93/. BAC values are also given by OSPAR /83/. EAC values are intended to represent the contaminant concentration in sediment and biota below which no chronic effects are expected to occur in marine species, including the most sensitive species. The Danish Nature Agency has implemented an LAL value of 20 µg/kg DW for the sum of PCB congeners 28, 52, 101, 118, 138, 153 and 180.

In Table 7-5, the values measured in sediments along the proposed NSP2 route are shown together with the OSPAR EAC values for each PCB, and the results from the 2008 NSP survey. All measured values are normalised according to the EAC standard of 2.5% TOC.

The concentrations of all PCB congeners measured in the sediment along the NSP2 route were below the detection limits of the measurements performed during NSP /86/. None of the measured congeners exceeded the value indicating GES, and the sum of the concentrations was below the LAL.

All measurements were below EAC boundary levels, and in 6 of the 14 samples, all PCBs were below detection limit (0.1 µg/kg DW).

Table 7-5 Content of PCB congeners (µg/kg DW) along the proposed NSP2 route. If values exceed EAC they are indicated in bold.

Station	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	Total
BAC	0.22	0.12	0.14	0.17	0.15	0.19	0.10	-
EAC	1.7	2.7	3.0	0.6	7.9	40	12	-
Range measured during NSP[1]	<3	<3	<3	<3	<3	<3	<3	<3
NSP2 maximum value[2]	0.2	0.2	0.5	0.4	0.8	1.0	0.5	3.6
ES_03	<0.1	0.1	0.4	0.2	0.3	0.5	0.2	1.7
ES_05	0.1	0.2	0.3	0.2	0.3	0.5	0.2	1.8
ES_07	0.1	0.2	0.4	0.3	0.5	0.7	0.4	2.6
ES_09	0.1	0.2	0.5	0.3	0.6	0.8	0.3	2.8
ES_11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ES_13	0.2	0.2	0.5	0.4	0.8	1.0	0.5	3.6
ES_15	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	0.2
ES_17	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.3
ES_19	<0.1	<0.1	0.2	0.1	0.3	0.3	0.2	1.1
ES_21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ES_23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ES_25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ES_27	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
ES_29	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

[1]Detection limit during NSP measurements. [2]Highest value measured along the NSP2 route in Denmark /65/.

7.3.3.5 Organochlorine pesticide (chlordane, HCH, DDT, and HCB)

Organochlorine pesticides have a low water solubilities and tend to be persistent and sorb strongly to suspended solids and sediments. They are generally highly toxic to aquatic life, and accumulation in sediments poses a potential hazard to sediment dwelling fauna. Furthermore, bioaccumulation in marine organisms and biomagnification through the food chains poses a threat to fish, sea birds and marine mammals. The presence of elevated concentrations of organochlorines in marine mammals have been suggested as the cause of reproductive failures, increased susceptibility to disease, developmental instability, and premature pupping /87/.

Persistent organochlorine pesticides are banned, and concentrations of most compounds in Baltic Sea sediments have been declining since the 1970s. Chlordane (with limited use in the Baltic area) was banned at the Stockholm Convention on Persistent Organic Pollutants in 2001. Diclhordiphenyltrichlorethane (DDT), which is a persistent organochlorine insecticide, was phased out in Scandinavia and the former West Germany in the 1970s, and 10 to 20 years later in the other Baltic States. DDT degrades primarily to dichlorodiphenyldichloroethylene (DDE) or dichlorodiphenyldichloroethane (DDD). Lindane, or hexachlorocyclohexane (HCH), was used as an insecticide and wood preservative until it was phased out in most Baltic States during the 1970s and in Russia somewhat later. Technical HCH contains several isomers: α-HCH (70%), γ-HCH (15%), β- HCH (8%) and δ-HCH (7%). Of these, γ-HCH is the most toxic. Hexachlorobenzene

(HCB) is a fungicide previously used in seed protection and wood preservation. It is also a by-product in the chemical industry. The use of HCB as a pesticide in the Baltic States ceased in the early 1990s.

The results of the measurements of organochlorine pesticides in sediment samples from the stations indicated in Figure 7-1 are summarised in Table 7-6, together with the EAC values for HCH and DDE /81/, and the results from the NSP survey carried out in 2008.

The concentrations measured along the NSP2 route were generally somewhat higher than the concentrations measured during the NSP route survey in 2008 /86/. One explanation could be that the difference is caused by inherent and natural variation in the distribution of contaminants in the sediment.

Overall, the concentrations of organochlorine pesticides in sediment sampled along the proposed NSP2 route in Danish waters were low, with many results being below detection limits. DDT and degradation products (DDE and DDD) were the pesticides that were found in the highest concentrations in the sediment samples. Exceedance of the EAC threshold for DDE was found at four stations.

Table 7-6 Content of organochlorine pesticides in sediment from the 14 stations along the proposed NSP2 route. The unit in all columns is µg/kg DW. If values exceed EAC they are indicated in bold.

Station	Cis-chlordane	Trans-chlordane	HCH	DDE	DDD	DDT	Trans-nona Chlor	HCB
ERL	-	-	3.0 (γ-HCH)	2.2	-	-	-	20
Range measured during NSP[1]	< 0.05	< 0.05	<0.15	< 0.05	< 0.05	< 0.05	-	-
Maximum value[2]	0.132	0.148	0.37	3.29	10.1	0.43	0.11	0.23
ES_03	<0.10	<0.10	0.28	2.19	10.1	0.23	<0.10	0.13
ES_05	0.119	0.122	0.35	**2.97**	6.8	0.19	<0.10	0.18
ES_07	0.132	0.148	0.27	**2.98**	9.5	0.27	0.11	0.17
ES_09	<0.20	<0.20	0.31	**2.88**	5.9	0.39	<0.20	0.3
ES_11	<0.10	<0.10	<0.10	0.29	0.12	0.17	<0.10	<0.10
ES_13	<0.10	<0.10	0.37	**3.29**	7.4	0.43	0.1	0.23
ES_15	<0.10	<0.10	<0.10	0.20	0.24	<0.10	<0.10	<0.10
ES_17	<0.10	<0.10	<0.10	0.21	0.21	<0.10	<0.10	<0.10
ES_19	<0.10	<0.10	<0.10	0.89	0.50	0.1	<0.10	0.1
ES_21	<0.10	<0.10	<0.10	0.13	0.18	<0.10	<0.10	<0.10
ES_23	<0.10	<0.10	<0.10	0.13	0.21	<0.10	<0.10	<0.10
ES_25	<0.10	<0.10	<0.10	0.28	0.24	0.13	<0.10	<0.10
ES_27	<0.10	<0.10	<0.10	0.12	0.23	<0.10	<0.10	<0.10
ES_29	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

[1]Detection limit during NSP measurements. [2]The highest value measured along the NSP2 route in Denmark /65/

7.3.3.6 Organotin

Tributyltin (TBT) belongs to the organotin compounds used as biocides, such as antifouling paints. TBT compounds are hydrophobic and bind to particles, especially organic matter, and ultimately deposit in sediments. Depending on the availability of light and oxygen, the half-life of TBTs in natural waters may range from a few days to several years, with the slowest degradation occurring in anoxic sediments. TBT is very toxic to algae, molluscs, crustacea and fish, and adverse effects have been observed in benthic fauna at a water concentration of about 2 ng/l /87/. It has been reported that TBT affect endocrine system of marine gastropods causing e.g. imposex in red whelk (*Neptunea antiqua*) and common whelk (*Buccinum undatum*) /110/.

Since the use of TBT was banned under international law in 2003, its concentration has been decreasing in the Baltic Sea /81/. TBT compounds associated with sediments appear to be much less available to sediment-living organisms compared with TBT in the water column /94/. Therefore the recommended impact monitoring is focused on imposex in gastropods (being a specific effect of dissolved TBT) rather than sediment monitoring. OSPAR suggests an EAC concentration in sediment of 0.01 µg TBT/kg DW /95/. However, very few commercial laboratories can meet such low detection limits /95/. The Danish Nature Agency operates with an LAL of 7 µg TBT/kg DW. The results measured in relation to the NSP2 project are summarised in Table 7-7, and compared with measurements from the NSP survey 2008.

Most of the sediments sampled along the proposed NSP2 route contained levels of TBT and/or the degradation products dibenzothiophene (DBT) and 2-mercaptobenzothiazole (MBT) above the detection limit, and hence also above the EAC. The TBT concentration did not exceed the LAL (7 µg/kg TBT), and the levels did not exceed the levels detected during the NSP survey in 2008 /86/.

Table 7-7 Content of organotin (µg/kg DW) in sediment from the 14 survey stations. If values exceed EAC they are indicated in bold.

Station	Tributyltin-cation	Dibutyltin-cation	Monobutyltin-cation
EAC	0.01	-	-
Range measured during NSP	<1 - 16	<1 – 9.3	<1 - 13
Maximum value[1]	5.79	5.47	7.26
ES_03	**1.71**	2.29	2.99
ES_05	**5.79**	5.26	5.64
ES_07	**2.59**	2.70	7.26
ES_09	**4.26**	4.72	4.97
ES_11	<1*	<1	1.52
ES_13	**2.52**	5.47	5.50
ES_15	<1*	<1	1.81
ES_17	<1*	<1	4.97
ES_19	**2.80**	2.61	4.66
ES_21	<1*	<1	1.33
ES_23	<1*	<1	<1
ES_25	<1*	<1	1.18
ES_27	<1*	<1	<1
ES_29	<1*	<1	<1

[1] The highest value measured along the NSP2 route /65/. * Detection limit > EAC

7.3.3.7 Nitrogen and phosphorus

Nitrogen and phosphorous occur in the Baltic Sea water column and sediment. Although not directly harmful to biological receptors, enhanced concentrations of N and P in the water column (either through additional input or resuspension of sediment) are the main cause of the observed eutrophication in the Baltic Sea. The issue of eutrophication is further discussed in section 7.5.3.

The concentrations of N and P measured in the sediments along the proposed NSP2 route in Danish waters fall within the range of the concentrations measured along the NSP route in 2008 /86/, as summarised in Table 7-8.

Table 7-8 Content of N and P (mg/kg DW) in sediment from the 14 survey stations.

Station	Total nitrogen	Total phosphorus
Range measured during NSP	100-44,000	100-3,400
Maximum value[1]	3,110	1,220
ES_03	2,840	1,030
ES_05	2,710	1,220
ES_07	2,600	1,200
ES_09	516	1,050
ES_11	735	1,060
ES_13	366	1,140
ES_15	521	1,050
ES_17	345	780
ES_19	3,110	1,050
ES_21	2,740	1,030
ES_23	2,660	600
ES_25	1,540	890
ES_27	2,320	650
ES_29	1,200	1,130

[1] The highest value measured along the NSP2 route /65/.

Concentrations of N and P measured in sediment cores down to 1 m below the sediment surface indicated only slight variations with depth, and no consistent trends were observed /88/.

7.3.3.8 Chemical warfare agents (CWA)

Chemical munitions were dumped in areas of the Baltic Sea, including the Bornholm Basin, after the end of WWII. Since then, shell cases of many chemical munitions have corroded and chemical warfare agents (CWA) have been released into the surrounding marine environment, where they have been accumulating in the seabed sediments.

CWA break down at varying rates into less toxic, water-soluble substances. Some CWA, however, have extremely low solubility and degrade slowly (e.g. mustard gas, Clark I and II, and Adamsite). Given their low solubility, these compounds cannot occur in higher concentrations in water, and wide-scale threats to the marine environment from dissolved CWA can be ruled out. However, direct contact with CWA in sediments is dangerous for many forms of life, including humans, other mammals, birds and fish. Knowledge of the interactivity of CWA with microorganisms is still fragmentary /89/.

The most frequently occurring CWA in the chemical munitions dumped east of Bornholm and the consequences should humans be exposed to them are shown in Table 7-9.

Table 7-9 Examples of CWA contained within chemical munitions dumped in the Bornholm Basin /89/

Name	Composition	CAS no.	Dumped (tonnes)	Consequences
Sulphur mustard	$C_4H_8Cl_2S$	505-60-2	6,713	Blisters on exposed skin and lungs
Clark types	Type I: $C_{12}H_9AsCl$ Type II: $C_{13}H_{10}AsN$	Type I: 712-48-1 Type II: 23525-22-6	2,033	Nausea, vomiting, headaches
Adamsite	$C_{12}H_9AsClN$	578-94-9	1,363	Affects the upper respiratory system
α-chloroacetophenone	C_8H_7ClO	1341-24-8	515	Tear gas, irritating eyes

As discussed in section 7.1.3, a survey to determine CWA concentrations in seabed sediments along the proposed NSP2 route in Danish waters was conducted in October 2015 (Figure 7-4). During 2016, a supplementary survey was undertaken and sediment samples were collected in the areas where post-lay trenching is proposed (section 6). Seabed samples at these stations were taken at three depths (surface, 0.5 m and 1 m) to evaluate if CWA concentrations vary with the depth. A number of CWA and CWA degradation products were measured as summarised in Table 7-10.

Table 7-10 CWA analysed in seabed sediments /67/

Chemical	Description	CAS number
Sulphur Mustard (SM)	Dumped CWA	506-60-2
Thiodiglycol	Degradation product of SM	111-48-8
Thiodiglycol Sulfoxide	Degradation product of SM	3085-45-8
1,4-Dithiane	Degradation product of SM	505-29-3
1,4-Dithiane Oxide	Degradation product of SM	19087-70-8
1,4-Oxathianine	Degradation product of SM	15980-15-1
1,4,5-Oxadithiepane	Degradation product of SM	3886-40-6
1,2,5-Trithiepane	Degradation product of SM	6576-93-8
Adamsite,	Dumped CWA	578-94-9
5,10-Dihydrophenarsazin-10-oxide	Degradation product of Adamsite	4733-19-1
Clark I (C1)	Dumped CWA	712-48-1
Clark II (C2)	Dumped CWA	23525-22-6
Diphenylarsinic Acid	Degradation product of C1/C1	4656-80-8
Diphenylpropylthioarsine	Degradation product of C1/C2	17544-92-2
Triphenylarsine (TPA)	Dumped CWA	603-32-7
Triphenylarsine Oxide	Degradation product of TPA	1153-05-5
Phenyldichloroarsine (PDCA)	Dumped CWA	696-28-6
Phenylarsonic Acid	Degradation product of PDCA	98-05-5
Dipropyl Phenylarsonodithionite	Degradation product of PDCA	1776-69-8
α-Chloroacetophenone (CN)	Dumped CWA	532-27-4
Lewisite I (L1)	Dumped CWA	541-25-3
Dipropyl(2-Chlorovinyl) Arsonodithionite	Degradation product of L1	677354-97-1
Lewisite II (L2)	Dumped CWA	40334-69-8
Bis(2-chlorovinyl)Arsinic Acid	Degradation product of L2	157184-21-9
Bis(2-chlorovinyl) Propylthioarsine	Degradation product of L2	677355-04-3
Tabun	Dumped CWA	77-81-6
Trichloroarsine	Component in dumped arsine oil	8011-67-4

A total of 61 sediment samples collected along the proposed NSP2 route were analysed during the 2015 survey /67/. A summary of the results are presented in Table 7-11, along with results of the previous NSP surveys in Danish waters (shown as maximum concentrations found during 2008–2012). The intact CWA Clark I/II, phenyldichloroarsine, lewisite I/II, tabun, trichloroarsine as well as a number of degradation products were not detected during NSP2 survey, and are therefore not included in Table 7-11. Of note, two degradation products of lewisite II (bis(2-chlorovinyl)arsinic acid and bis(2-chlorovinyl)propylthioarsine) were found during NSP surveys but not during the NSP2 survey.

Table 7-11 Results of CWA measurements performed during the 2015 survey. Concentrations are shown in µg/kg DW.

Station	Intact CWA				CWA degradation products and derivatives[3]									
	Sulphur mustard	Adam site	TPA	CN	1,4-D	1,4,5-O	1,2,5-T	5,10-D	DPAA	DPPT	TPAO	PAA	DPPA	TPAT
NSP[1]	ND	ND	ND	ND	NM	NM	NM	200	140	NM	NM	327	310	39
NSP2[2]	0.6	2000	13	2.3	0.34	0.44	1.6	576	1764	59	234	145	98	3.5
ES_01	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_02	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_03	-	27*	0.56*	-	-	-	0.27*	6.1*	-	-	4.7*	-	-	-
ES_04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_05	-	35*	13*	-	-	0.25*	0.66*	19	17*	-	234*	-	-	-
ES_06	-	34	9,6*	2.3	0.34	0.36*	1.6*	26	38*	1.3*	23*	11	4.4	-
ES_07	-	32	5.4	-	-	0.21	1.5	6	12	3.4	8.6	-	2.7	-
ES_08	-	58*	0.87*	-	0.27*	0.44*	1.4*	10*	9.2*	1.2*	7.5*	-	-	-
ES_09	-	68	10	-	-	-	-	57	32	-	98	22	-	-
ES_10	0.6*	52	13*	-	-	-	-	136*	119*	57*	10*	145	98*	3.5*
ES_11	-	2000*	1	-	-	-	-	576*	1764*	59*	4.2	78	6.4	-
ES_12	-	310	-	-	-	-	-	114*	16.5*	3*	11*	27*	10*	-
ES_13	-	250	-	-	-	-	-	19	27	3.7	-	23	5.1	-
ES_14	-	30*	-	-	-	-	-	5.6	38*	5.2*	7.3	8.8*	5.7*	-
ES_15	-	-	-	-	-	-	-	-	4.1	-	-	3.7	-	-
ES_16	-	17	-	-	-	-	-	-	-	-	-	-	-	-
ES_17	-	23	-	-	-	-	-	23	-	1.3	-	-	5.6	-
ES_18	-	-	-	-	-	-	-	-	-	-	-	-	1.2	-
ES_19	-	-	-	-	-	-	-		-	-	-	-	-	-
ES_20	-	-	-	-	-	-	-	2.9	-	-	-	-	-	-
ES_21	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_23	-	35	-	-	-	-	-	4.1	-	-	-	-	-	-
ES_24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_26	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ES_28	-	-	-	-	-	0.39	-	-	-	-	-	-	-	-
ES_29	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] - Maximum value measured during NSP. [2] Maximum value measured during NSP2. [3] 31,4-D = 1,4-Dithiane; 1,4,5-O = 1,4,5-Oxadithiepane; 1,2,5-T = 1,2,5-Trithiepane; 5,10-D = 5,10-Dihydro-phenarsazin-10-ol 10-oxide; DPAA = Diphenylarsinic acid; DPPT = Diphenylpropylthioarsine; TPAO = Triphenylarsine oxide; PAA = Phenylarsonic acid; DPPA = Dipropyl phenylarsonodithioite; TPAT = Tripropyl arsenotrithioite. *Concentration at a transect station (250m or 500m from the route station) since CWA is not detected at the route station or higher concentration is measured at the transect station. ND: not detected. NM: not measured

The highest detection frequencies and the highest maximum concentrations were found along the middle and northern parts of the NSP2 route. The southern part of the NSP2 route had a comparatively low degree of contamination associated with CWA.

Degradation products were found for sulphur mustard, Adamsite, and Clark I or II. No traces of degradation products were found for Tabun, Lewisite I or Lewisite II.

Seabed sediment samples collected during the 2016 survey contained neither intact CWA nor their degradation products in concentrations higher than the detection limits /88/.

Comparison of results from NSP2 with previous results
The frequency of CWA-positive samples was higher during NSP2 surveys (2015) compared to NSP surveys (2008-2012) /89/. However, the findings of NSP2 are similar to the more recent results from CHEMSEA project (Chemical Munitions Search and Assessment), where 86% of the samples from the Bornholm Basin contained one or more of the CWA or their degradation products /91/. Similar to the findings of the 2015 NSP2 survey, CHEMSEA also reports a low frequency of intact mustards gas detections, whereas arsenic-containing compounds are more frequent.

To evaluate differences in the results from the NSP and NSP2 surveys, VERIFIN (Finnish Institute for Verification of the Chemical Weapons Convention) conducted an evaluation of changes in test methods for chemical analyses of CWA between 2008 and 2016 and compared four projects in the Baltic Sea where CWA were analysed/89/: MERCW (2006-2008), NSP (2008-2012), CHEMSEA (2011-2014), and the current study (NSP2, 2015-2016). The following conclusions were reached:

- The introduction of a new extraction solvent in 2011 has improved the extraction efficiency of several CWA-related compounds, in particular adamsite, 5,10-dihydrophenarsazin-10ol 10 oxid, diphenylarsinic acid, and phenylarsonic acid
- The lowest limits of quantitation (LLOQ) have improved during the period since 2008 due to the introduction of a new GC-MS method; and
- A number of new chemical compounds have been introduced in the analytical methods since 2010 (e.g. cyclic degradation products for sulphur mustard and oxidation product for triphenylarsine).

Thus, it is likely that the higher frequency of positive samples compared to the NSP survey is a result of improved analytical methods, including both a more efficient extraction of CWA and degradation products and a lowering of the LLOQ.

In addition, it is noted that the distribution of dumped munitions and consequently CWA-related contaminants is inconsistent, patchy and localized. As a result, the results from localised sampling stations, and in some cases even replica from the same sediment sample, may vary greatly in their content of CWA and degradation products.

7.4 Hydrography

The Baltic Sea constitutes a complex mix of environments, where water characteristics vary from freshwater to marine and from oxygenated (aerobic) to hypoxic/anoxic (anaerobic). These characteristics, and their spatial and temporal variations are controlled by the hydrography of the Baltic Sea, as discussed in this section. The hydrography in the Baltic Sea is therefore considered an important receptor.

7.4.1 Hydrography

The semi-enclosed Baltic Sea forms a large estuary. The area is permanently stratified because it receives freshwater from rivers and saltwater from the North Sea, which flows into the Baltic Sea via the Danish straits. The inflow of saltwater from the Kattegat to the Baltic Sea causes a horizontal salinity gradient from almost oceanic conditions in the northern Kattegat to almost freshwater conditions in the innermost Gulf of Finland /96/.

The temperature in the bottom water in the Bornholm Basin is typically within the range of 5-7 °C throughout the year, and it is sensitive to inflows from the Kattegat and the North Sea. In winter, the temperature of the bottom water is warmer than the overlaying water due to the inflow of warm but dense saline water through the Danish straits. The average temperature of the surface water in the Bornholm Basin is 15 °C during summer and 4 °C during winter.

In general, the currents in the Baltic Sea are weak, except for the transition area, i.e. the Belt Sea. On average, the surface current may be described as cyclonal horizontal, with a speed of a few cm/s. Wind-driven currents of higher velocities appear in the upper layers. At deeper levels, small-scale vortices may appear due to the influence of bathymetric variations /97//98/.

The deep water renewal processes in the Baltic Sea depend on specific meteorological circumstances that force substantial amounts of salt- and oxygen-enriched seawater from the Kattegat through the Danish straits into the western Baltic. From there, it slowly moves as a thin bottom layer into the central Baltic basins, replacing aged water masses. The saltwater inflows from the Kattegat are sporadic but ecologically important. The principle of a major inflow is shown in Figure 7-14. Before 1980, such events were relatively frequent and could be observed on average once a year. In the last two decades, however, the frequency has decreased.

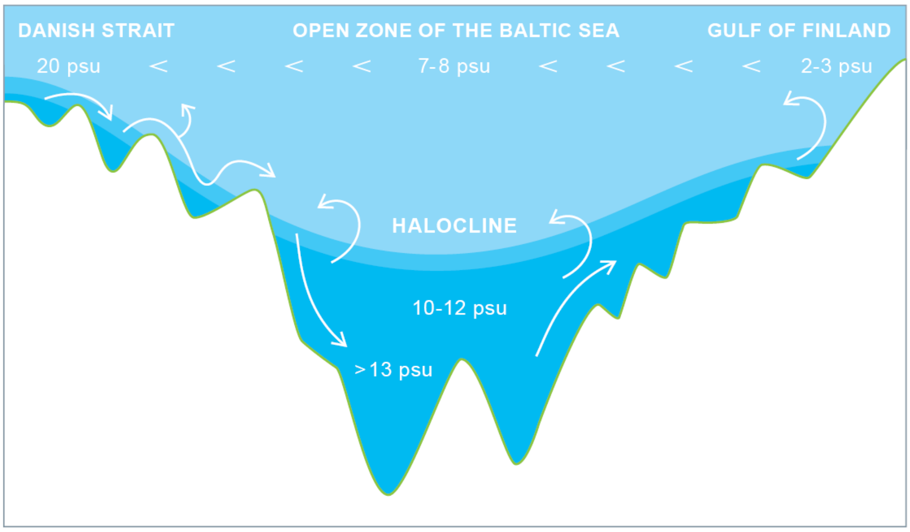


Figure 7-14 The heavy, saline water flows along the bottom, and the less saline surface water flows out of the Baltic Sea. The water becomes stratified, and a halocline separates the layers of varying salinity /99/.

The Arkona Basin is the first basin that new deep water flowing into the Baltic Proper encounters after crossing the entrance sills in Øresund (Drogden Sill) and Fehmarn Belt (Dars Sill). The deep water flows along the bottom as a gravity-forced dense bottom current that mixes with resident Baltic surface water. The salinity of the inflowing deep water therefore decreases as the flow proceeds into the basin, and at the same time the volume flow increases due to mixing with the ambient water.

Dense bottom currents build up a deep water pool in the Arkona Basin that loses water via a dense bottom current carrying water through the Bornholm Strait and into the Bornholm Basin. This builds up the deep water pool in the Bornholm Basin, which is drained through the Stolpe Channel. This water sustains the deep water in the large basins in the interior of the Baltic Proper.

Average wave heights in the Arkona Basin are in the range 0.5-1 m during the summer and 1-1.5 m during the winter. Higher waves up to >4 m occur during storm events /123/. The frequencies of storms resulting in wave heights above 4 m in the Baltic Sea in the years 1948-2011 have been modelled on the basis of historical weather data, and the results are shown in Figure 7-15 /124/. Such storm events occur mainly during the winter months (November to February) and are very rare in the months May to August.

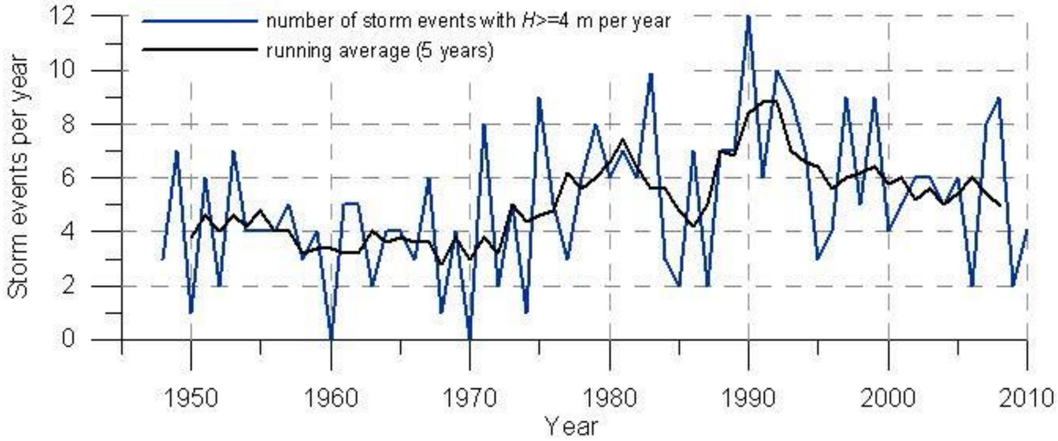


Figure 7-15 Annual number of storm events with significant wave heights of 4 m or more in the Baltic Sea /124/.

The mean and extreme significant wave heights at the end of the twenty-first century are anticipated to increase compared with present conditions. The changes are expected to be greatest in the Bothnian Bay and Bothnian Sea because of reduced ice coverage causing unstable marine atmospheric boundary layers with increased surface speed /130/.

7.4.2 The effect of hydrography on oxygen and hydrogen sulphide in the water

The surface waters of the Baltic Sea are aerated by wind mixing, and oxygen is further supplied by photosynthesis. The intermediate waters are also relatively well oxygenated because most of the water from the Kattegat and the Great Belt is supplied to this depth range. The deep basins, however, frequently experience oxygen depletion and a build-up of hydrogen sulphide (H_2S) due limited water renewal (the water is renewed only by major saline inflows from the North Sea).

Bacterial decomposition of detritus at the seabed can result in decreased oxygen levels and production of H_2S in bottom waters, particularly towards the end of summer between August and October. The deep water basins in the Baltic Proper (e.g. the Bornholm Basin) suffer severely from long-term oxygen depletion (anoxia), and as a result the benthic environment is often unsuitable for higher life forms (animals and plants).

A relatively large saltwater inflow was detected in the western Baltic during the winter 2011-2012. This event ventilated the Bornholm Basin and could be traced as far as the southern part of the eastern Gotland Basin. In the period November 2013 to February 2014, three subsequent inflow events caused a large seawater inflow to the Bornholm Basin and further east to the Gotland Basin. On this occasion, bottom water hydrogen sulphide was displaced as far east as the southern and central part of the eastern Gotland Basin. In December 2014, a large amount of well-oxygenated, saline water entered the Baltic Sea during a very strong inflow event /100/. While such major inflows of saline and oxygen-rich water may cause major changes to the hydrographical conditions in the deep basins between Arkona Basin and the east Gotland Basin, their effect appears to be short-lived, as oxygen is consumed in the bottom waters and hydrogen sulphide returns /101/.

Salinity, temperature and oxygen were measured in the water column along the proposed NSP2 route at the 14 stations shown in Figure 7-1 /65/. The measured depths of haloclines and thermoclines in the water column at each station as well as the bottom water oxygen content are listed in Table 7-12, and an example of the profiles is shown in Figure 7-16.

Table 7-12 A summary of water depth, the depth range with the major halocline and thermocline, and the bottom water oxygen content, temperature, and salinity measured at the recording depth given in column 3.

Station	Water depth (m)	Recording depth (m)	Depth of halocline (m)	Depth of thermo-cline (m)	Oxygen con-centration in bottom water (mg/l)	Tempera-ture in bottom water (°C)	Salinity in bottom water (psu)
ES_03	80	77	42-70	38-40	1.8	7.0	18.5
ES_05	90	88	40-70	38-40	0.5	7.0	19.2
ES_07	92	87	40-70	41-43	0.1	7.0	19.3
ES_09	95	93	38-70	36-38	0.3	7.0	19.2
ES_11	54	54	40-55	34-40	4.7	11.3	11.5
ES_13	77	69	40-70	33-36	1.6	7.3	17.7
ES_15	48	48	39-48	32-35	5.4	10.1	9.8
ES_17	55	54	48-55	35-41	3.2	9.8	13.0
ES_19	58	59	38-58	32-38	3.7	8.6	14.3
ES_21	57	49	38-57	34-38	5.9	8.9	10.5
ES_23	46	45	40-46	31-34	5.6	7.4	9.3
ES_25	43	42	40-43	32-36	6.8	7.4	8.7
ES_27[1]	42	43	-	37-42	6.8	8.2	8.4
ES_29[1,2]	28	-	-	-	-	-	-

[1]Station is above halocline; [2]Measurements of salinity, temperature and oxygen were not performed due to instrument error.

The water column is strongly stratified and divided into a mixed surface layer and a distinct bottom layer at depths of more than 60 m (Figure 7-16). These two layers are separated by a wide layer of quite variable conditions of salinity, temperature and oxygen. The salinity of the bottom water along the NSP2 route varies between 8 psu and 20 psu depending on the water depth.

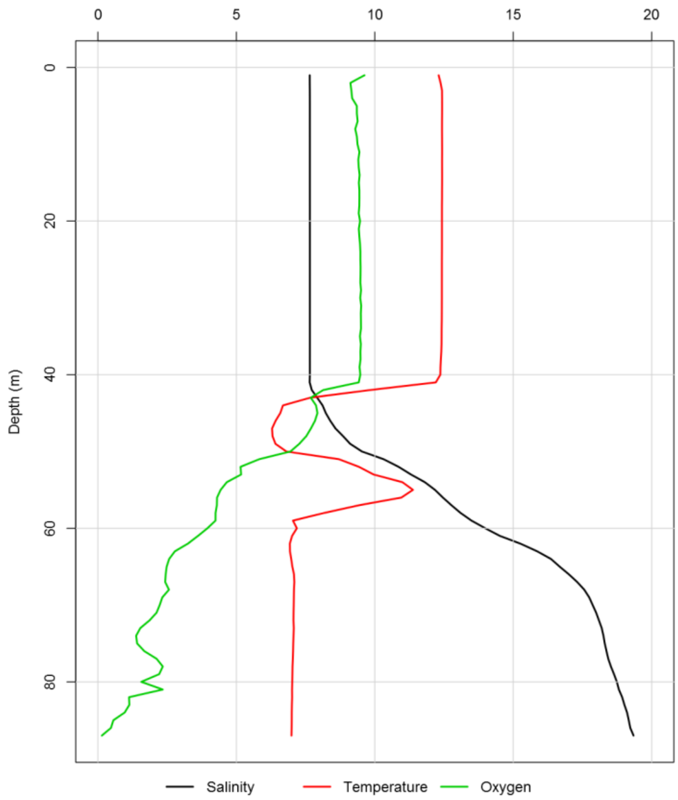


Figure 7-16 Profiles of salinity (psu), temperature (°C) and oxygen (mg/l) in the water column at station ES_07 /65/

At the time of the most recent survey (October 2015), the salinity in the bottom water ranged from 15 psu to 19 psu, with oxygen concentrations below 3 mg/l. At the stations with depths of

40-60 m, the salinity varied between 8 psu and 15 psu, with oxygen concentrations usually well above 3 mg/l. The temperature generally remained at approximately 8^{0}C.

The profiles from station ES_07 (water depth 92 m) shown in Figure 7-16 illustrate the complex hydrology of the Baltic Sea. The upper 40 m of the water column consist of well-mixed, oxygenated and relatively low-salinity water. At depths below 41 m, the water column is less mixed and a significant stratification in salinity, temperature and oxygen is present. A cold layer of water at approximately 41-50 m depth represents so-called 'winter water', which is water that remains cold throughout the summer period because the wind- and current-driven mixing does not reach down to that depth. A warmer, slightly more saline layer of water is present approximately 50-59 m below the surface. This layer was also observed at the other stations in the Bornholm Basin (ES_03, ES_05 and ES_09) and likely represents an event of seawater inflow with medium salinity during the summer months when the water temperature was higher. The bottom water below approximately 61 m depth has high salinity, low temperature and low oxygen content.

The primary thermocline marking the lower boundary of the well-mixed surface water was present at depths between 30 m and 40 m at all 14 stations. As a result of the water column stratification, shallow stations with water depths less than 50 m tend to have oxygenated bottom water of relatively low salinity, whereas deep stations are characterised by little or no oxygen in the water and higher salinity. These results are similar to the results of surveys carried out in relation to NSP.

7.5 Water quality

The water quality in the Baltic Sea is an important factor which influences the environment and the living conditions for the associated fauna and flora. On this basis, and demonstrated by the requirements outlined in the WFD and the MSFD (sections 4.2.5 and 4.2.6), water quality is considered an important receptor. This section describes the current water quality in the Baltic Sea, particularly in respect to the turbidity and concentrations of contaminants and nutrients.

7.5.1 Metals

The main sources of heavy metals in the Baltic Sea are diffuse sources (e.g. leakage from forest and agricultural soils) and industrial and municipal point sources /80/. Heavy metals are discharged directly, transported via river or supplied from the air. Significant amounts of the airborne heavy metal pollution originate from sources outside the Baltic Sea catchment area.

Levels of annual inputs of heavy metals, both riverine and atmospheric, to the Baltic Sea have substantially decreased in the period from 1990 to the present /REF46/. The estimated yearly inputs of heavy metals to the Baltic Sea in 2006 (most recently available data) are shown in Table 7-13.

Table 7-13 Waterborne heavy metal inputs (tonnes) to the Baltic Sea in 2006. Inputs of mercury from Polish rivers are not included /80/. The areas in Denmark which are crossed by the NSP2 route are indicated in bold.

Area	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Archipelago Sea	0.30	11.32	12.61	0.02	9.13	3.76	88.60
Baltic Proper	**10.42**	**12.60**	**200.62**	**0.11**	**62.38**	**47.59**	**445.90**
Bothnian Bay	1.33	43.62	136.74	0.22	136.88	20.84	404.45
Bothnian Sea	2.91	39.87	106.03	0.19	109.66	27.30	698.24
Gulf of Finland	29.49	20.29	290.31	0.19	185.33	145.91	918.88
Gulf of Riga	2.71	0.20	92.35	0.01	62.63	20.84	439.49
The Kattegat	0.44	21.83	39.79	0.07	23.38	13.75	138.35
The Sound	0.03	1.65	2.83	0.01	1.67	1.10	8.00
Western Baltic	0.05	0.24	5.0	0.01	0.90	1.02	15.35
Total Baltic Sea	47.7	151.6	886.3	0.8	592.0	282.2	3157.3

As a consequence of the reduced inputs, the concentration of heavy metals in the Baltic Sea water and surface sediment has generally decreased /102//103//104/. Nevertheless, heavy metal concentrations in the Baltic Sea remain higher than the concentrations in Atlantic waters, which are considered less influenced by human activities (Table 7-14) /104/.

Table 7-14 Content of dissolved heavy metals (ng/kg) in the waters of the North Atlantic and the Baltic Sea measured in the period 1993-2005 /105//106//107//108/.

Metal	North Atlantic	Baltic Sea
Mercury (Hg)	0.15–0.3	0.5–1.5
Cadmium (Cd)	4±2	12–16
Lead (Pb)	7±2	12–20
Copper (Cu)	75±10	500–700
Zinc (Zn)	10–75	600–1000

It is noted that more recent data, since 2005, regarding metal concentrations in the water column are scarce; this is because it has become standard to measure metals in sediment (see section 7.3).

Notwithstanding this, recent research indicates that deep pockets of methylated heavy metals from the anaerobic basins in the Baltic Sea may serve as an intrinsic pool and source of heavy metals for the surface waters /109/.

7.5.2 Organic pollutants

There have been substantial inputs of organic pollutants in the Baltic Sea from numerous sources over the past 50 years. These sources include industrial discharges, such as the organochlorines in effluent from pulp and paper mills, run-off from farmland, special paints used on ships and boats and dumped wastes. Several organic pollutants, such as DDT and technical-grade hexachlorocyclohexanes (HCH isomers), have been completely banned since the 1980s.

Organic pollutants can reach the Baltic Sea via river run-off, atmospheric deposition, and direct discharge of effluents or via inflowing water from the North Sea. Organic pollutants are usually adsorbed onto fine-grained particles in the water mass and carried to the seabed by sedimentation. The concentrations of organic contaminants in the sediment are therefore generally several orders of magnitude higher than in the overlying water mass /110/.

Recent data regarding organic pollutants in the water are scarce, because it has become standard to measure organic pollutants in sediment rather than in the water column (see section 7.3.3). The data presented in Table 7-15 are concentrations and trends for organic contaminants in the central and western Baltic Sea from HELCOM for the period 1994-1998. Annual Average Environmental Quality Standards (AA-EQS) in marine waters have been developed by the EU for some of these compounds, and are listed in the table for comparison.

Table 7-15 Surface seawater concentrations during the period 1994–1998 /110/.

Organic contaminants in surface seawater
PCBs
Surface seawater PCB concentrations were rather low. Thus, the concentration of PCB 153 (one of the main congeners) ranged from 10-24 pg/l (median values for the period 1994-1998). It was not possible to identify a temporal or geographical trend for the period 1994-1998, except for a general increase in concentration towards the coasts. Due to the high lipophilicity of PCBs, they are enriched in suspended matter and sediments.
DDT, DDD and DDE
Surface seawater DDT concentrations ranged from 2-77 pg/l. The highest concentrations were observed in the Pomeranian Bight, where the values for DDD and DDE ranged from 30-77 pg/l. In the rest of the southern and western parts of the Baltic Marine Area, the concentration range was 2-30 pg/l. Due to the low concentrations, the data set is rather limited and variability is high. The AA-EQS for total DDT is 25 pg/l.
HCB
Surface seawater HCB concentrations ranged from <5-10 pg/l. Due to the low concentrations, no evidence of any geographical variation within the Baltic Marine Area could be found. The AA-EQS for total HCB is 10 pg/l.
HCH isomers
Surface seawater concentrations of the HCH isomers exhibited distinct geographical variation. In 1997 and 1998, the concentration of α-HCH ranged from 0.43 ng/l in the Bights of Kiel and Flensburg to 1.1 ng/l in the Baltic Proper. A clear concentration gradient was observed from east to west. The surface seawater concentration (outflow from the Baltic Marine Area) ranged from 0.54-0.75 ng/l, and the concentration in the deep water (inflow from the North Sea) was 0.25-0.31 ng/l.The AA-EQS for HCH is 20 ng/l.
Petroleum and other hydrocarbons
Total hydrocarbon concentrations were 0.5-1.6 µg/l in the summer months of 1997 and 1998 in the western and central parts of the Baltic Sea. In winter, the concentrations were significantly higher, ranging from 1.1-3 µg/l. The concentrations in the Gulf of Bothnia and the Gulf of Finland were similar, with the yearly average ranging from 0.2-2.1 µg/l. The concentrations in the Gulf of Finland were slightly higher than those in the adjacent waters.
PAHs
In the western and central parts of the Baltic Marine Area, the surface seawater concentrations of single PAHs ranged from <2-4.5 pg/l. The median concentration of the two- to four-ring aromatics (naphthalene to chrysene) in the open sea ranged from 0.02-2.1 ng/l. The mean concentrations of the more lipophilic five- to six-ring PAHs (benzofluoranthene to benzo[ghi]perylene) were <0.005- 0.15 ng/l. Significantly higher concentrations are observed in winter, due to higher inputs from combustion sources, slower degradation and a higher content of suspended matter in shallow areas. There is no established AA-EQS for total PAH, but is values are given for individual compounds, such as naphthalene (5 µg/l), Benzofluoranthene (30 ng/l), and the sum benzo[ghi]perylene + indeno(1,2,3-cd)pyrene (2 ng/l).

7.5.3 Nutrients

As discussed in section 7.3.3.7, increased concentration of nutrients mainly relating to nitrogen (N) and phosphorus (P) compounds, can cause eutrophication. Eutrophication is considered one of the major pressures on the Baltic Sea ecosystem/115/ and is discussed in more detail in section 7.5.3.2.

7.5.3.1 Nutrient sources and input

Land-based nutrient inputs to the Baltic Sea are both air- and waterborne, as illustrated in Figure 7-17. Typical pathways of nutrient inputs to the offshore environment are discussed in /111/ and summarised below:

- Direct atmospheric deposition on the water surface. Atmospheric emissions of airborne nitrogen compounds emitted from traffic or combustion of fossil fuels (heat and power generation) and from animal manure and husbandry, etc. A significant part of this load originates in areas outside the Baltic Sea catchment area.
- Riverine inputs of nutrients to the sea. Rivers transport nutrients that have been discharged or lost to inland surface waters within the Baltic Sea catchment area.
- Exchange with the North Sea via transport through the Danish straits.
- Point sources discharging directly to the sea. Point sources include inputs from municipalities, industries and fish farms discharging into inland surface waters and discharging directly into the Baltic Sea.
- Diffuse sources. These mainly originate from agriculture but also include nutrient losses from, e.g., managed forestry and urban areas.
- Natural background sources. These mainly refer to natural erosion and leakage from unmanaged areas and the corresponding nutrient losses from, e.g., agricultural and managed forested land that would occur irrespective of human activities.

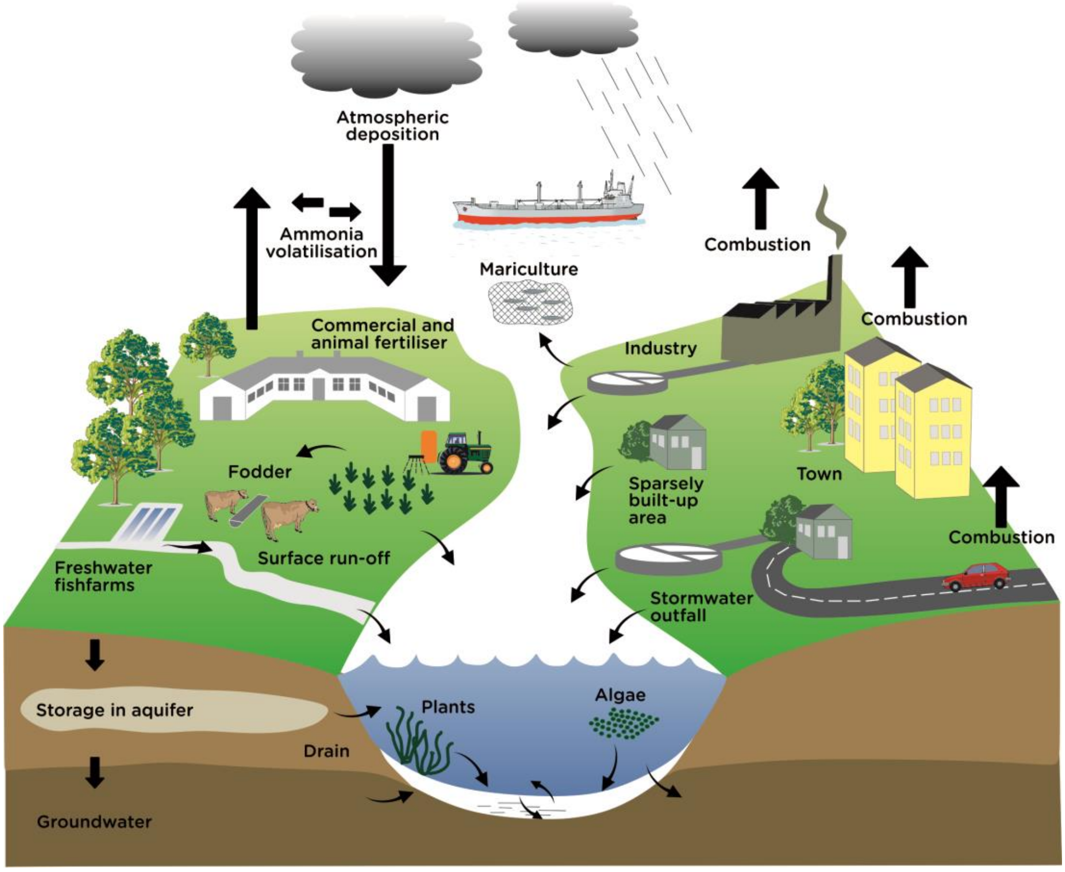


Figure 7-17 Typical sources of nutrients to the sea /112/.

The nitrogen and phosphorus loads supplied to the different sub-regions in the Baltic Sea in the period 2010-2012 are summarised in Table 7-16 /113/.

Table 7-16 Averaged normalised annual inputs of nitrogen (N_{tot}) and phosphorus (P_{tot}) during the years 2010-2012 in the different sub-basins to the Baltic Sea /113/. Units are in tonnes per year. The areas in Denmark which are crossed by the NSP2 route are indicated in bold.

Baltic Sea Sub-basin	N_{tot}	P_{tot}
Bothnian Bay	56,962	2,824
Bothnian Sea	72,846	2,527
Baltic Proper	**370,012**	**14,651**
Gulf of Finland	116,568	6,478
Gulf of Riga	91,257	2,341
Danish Straits	53,545	1,514
Kattegat	63,685	1,546
Total Baltic Sea	824,875	31,883

A number of measures have been implemented by Baltic countries to reduce the input of nutrients into the Baltic Sea and the data in Table 7-16 represent a significant reduction from the levels entering the Baltic Sea during earlier decades. Table 7-17 summarises the reduction in yearly N and P influx to the Baltic Sea compared with the reference period 1997-2003.

Table 7-17 Changes in nitrogen and phosphorus inputs to the different Baltic Sea sub-basins since the reference period (1997-2003). Inputs are calculated as average normalised inputs during 2010-2012 /113/. The areas in Denmark which are crossed by the NSP2 route are indicated in bold.

Sub-region	Changes in normalized N input in 2010-2012 compared with the reference period 1997-2003 (%)	Changes in normalised P input in 2010-2012 compared with the reference period 1997-2003 (%)
Bothnian Bay	-1.1	5.6
Bothnian Sea	-8.2	-8.9
Baltic Proper	**-12.7**	**-20.0**
Gulf of Finland	0.3	-13.7
Gulf of Riga	3.2	0.5
Danish Straits	-18.9	-5.4
Kattegat	-19.1	-8.3
Total Baltic Sea	-9.4	-13.6

7.5.3.2 Eutrophication in Danish waters

Eutrophication is a condition in an aquatic ecosystem where high nutrient concentrations stimulate growth of algae, leading to imbalanced functioning of the system. Nitrogen and phosphorus are the main growth-limiting nutrients in the Baltic Sea, and therefore an increased inflow of N and P can result in an increase in the growth of algae in the water. When the algae die and the biomass sinks to the bottom, a process of decomposition occurs and the nutrients contained within the organic matter are converted into inorganic salts. This decomposition consumes oxygen and can result in oxygen deficiency. Hypoxic conditions at the seabed may in turn result in loss of important ecosystem functions carried out by the benthic fauna, e.g. biogeochemical feedback loops and biomass production /114/.

Although eutrophication is often caused by human activities resulting in an increased flow of nitrogen and phosphorus into water bodies, it can also occur naturally. The main difference between natural and anthropogenic eutrophication is that the natural process is very slow, occurring on geological time scale, whereas anthropogenic eutrophication occurs over a far shorter timeframe.

HELCOM has presented the eutrophication status of the Baltic Sea 2007-2011 (Figure 7-18 and Figure 7-19), which shows that the status of the Danish waters is below good environmental status (GES) /115/.

Concentrations of dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) in seawater from the Arkona and Bornholm basins are summarised in Table 7-18. Also shown in the table are the target concentrations corresponding to GES as agreed by HELCOM /80//115/.

Table 7-18 Present concentrations and GES target concentrations (as average 2007-2011 of DIN and DIP in the open-sea Arkona and Bornholm Basins /115/.

Sub-region	DIN	GES target (DIN)	DIP	GES target (DIP)
Arkona Basin	3.73	2.90	0.62	0.36
Bornholm Basin	2.97	2.50	0.61	0.30

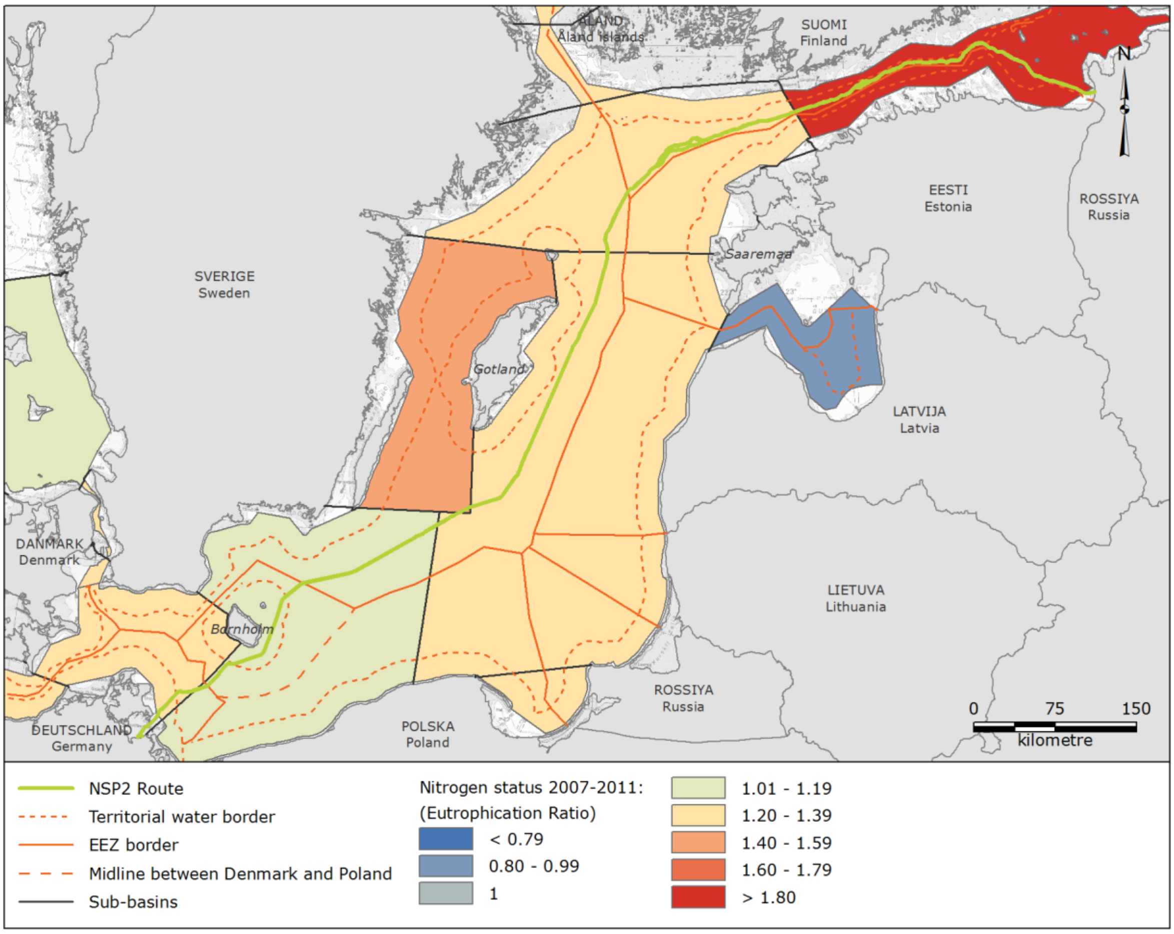


Figure 7-18 Status of the nitrogen indicator presented as eutrophication ratio (ER). ER shows the present concentration in relation to the GES threshold, increasing along with increasing eutrophication. The GES threshold is set at ER 1 /80/.

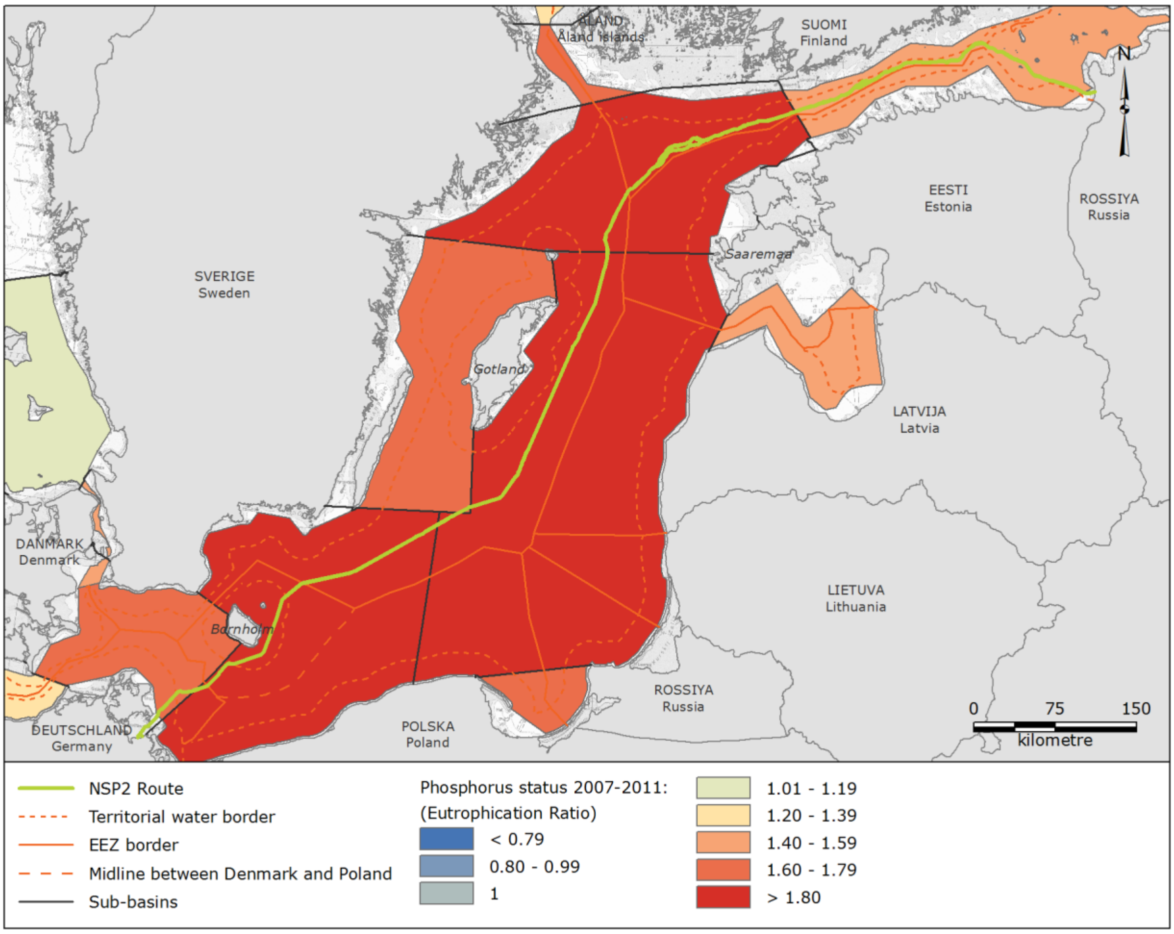


Figure 7-19 Status of the phosphorus indicator presented as eutrophication ratio (ER). ER shows the present concentration in relation to the GES threshold, increasing along with increasing eutrophication. The GES threshold is set at ER 1 /80/.

7.5.4 Water turbidity

Water turbidity depends on the amount of particulate matter and dissolved substances in the water column. This may include suspended solids, plankton, humic acids and other dissolved coloured substances. Water turbidity varies naturally due to mobilisation and resuspension of seabed sediments by waves and currents in shallow areas. Fine-grained sediments (with diameter <0.063 mm), e.g. silt and clay, are often cohesive and tend to flocculate and form aggregates in seawater. When sediments are re-suspended, the grains are transferred away from the seabed into the water column by turbulent mixing, with the lowest concentration in the upper part of the water column and the highest concentration near the seabed. In general, fine-grained sediments remain in suspension for a longer period and have the potential to travel relatively long distances before depositing, due to their low settling velocity.

The suspended solids usually settle to the seabed and accumulate at the seabed in accumulation areas, possibly after having been temporarily deposited and subsequently resuspended in shallow-water areas. As particles with a high organic content settle onto the seabed, they may form a very loose surface sediment layer with considerably low dry weight content (a so-called 'fluff-layer'). These surface sediments are easily resuspended due to erosion caused by the shear stress imposed by wave and current action /119//120/. Resuspension of the loosest surface sediments may occur even at relatively large depths due to storm wave action. Large waves have been found to be able to move sand, gravel and even cobbles up 20 cm in diameter at depths below 20 m /121/.

Furthermore, the turbidity increases during summer throughout the Baltic Sea due to the increased growth of phytoplankton, see section 7.7.

The water turbidity in the Bornholm Basin and the Arkona Basin has improved during the last two decades, and compared with most other sub-regions of the Baltic Sea, the Danish waters have a relatively low turbidity level /116/. As noted above, turbidity is strongly linked to the suspended sediment concentration (SSC) in the water column. The SSC in the saline bottom water in the Baltic Sea is typically 1-2 mg/l /118/ though during stormy periods, SSC has been shown to increase locally to 30-40 mg/l /118/.

Results of Secchi depth measurements (a measure of the clarity of the water) in the Bornholm and Arkona Basins are shown in Figure 7-20 /115/. Secchi depths were also measured at several stations around Bornholm as part of the monitoring performed during NSP, and the results were in the range indicated in Figure 7-20 /117/.

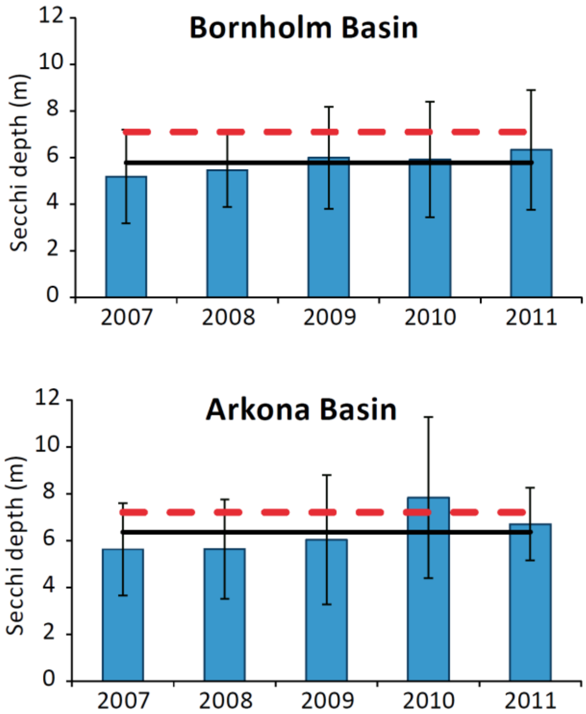


Figure 7-20. Summer (June-September) Secchi depth yearly average in surface water from Bornholm and Arkona basins (blue columns). Also shown are averages for the years 2007-2011 (black line) and target levels as agreed by HELCOM HOD 39/2012 (red broken line).

7.6 Climate and air

The climate and air quality in the Baltic region is an important factor which influences the environment and the living conditions for the associated fauna and flora, as well as humans. Therefore climate and air quality is considered an important receptor. In this section, the present and future climate and the factors affecting air quality are presented.

7.6.1 Current climate

Meteorological forces, together with hydrographical processes, have a strong influence on the environmental conditions of the Baltic Sea. These processes influence the water temperature and ice conditions, the regional river run-off and the atmospheric deposition of pollutants on the sea surface. Moreover, they also govern water exchange with the North Sea and between the sub-basins, as well as the transport and mixing of water within the various sub-regions of the Baltic Sea /97/.

The Baltic Sea is located in the temperate climate zone, which is characterised by large seasonal contrasts. The climate is influenced by major air-pressure systems, particularly the North Atlantic Oscillation during wintertime, which affects atmospheric circulation and precipitation in the Baltic Sea basin.

The proposed NSP2 route in the Danish TW and EEZ extends east and south of Bornholm. Measurements during the period 1985-2005 at two stations on Bornholm have shown a temperature variation from 1.5 °C as the average for January to 17.4 °C as the average for August. The average yearly temperature is 8.5 °C /122/.

Although average precipitation in general is higher over land than at sea, the precipitation at Bornholm can be considered representative of conditions for the pipeline section in the Danish TW and EEZ. Measurements during the period 1985-2005 at three stations on Bornholm showed an average yearly precipitation of 655 mm. The average monthly precipitation varied from a minimum of 36 mm in April to a maximum of 76 mm in September /122/.

The Baltic Sea is located within the west-wind zone, where low-pressure weather systems coming from the west or south-west dominate the weather scene. Cyclones from a more southerly direction can enter the region periodically. Winds are closely related to the cyclones and pressure gradients around these wind systems. Winds of storm force, i.e. at least 25 m/s, are almost exclusively connected to deep cyclones that form west of Scandinavia and occur mainly from September to March. The winds in the Bornholm area are dominated by easterly winds in spring, although westerly winds are also common. During the rest of the year, winds from the west prevail /122/.

In the Baltic Sea, ice can appear as fast ice or as drift ice. Fast ice is smooth and stationary and can be attached to islands, islets and shallow reefs. Fast ice usually appears at a water depth of up to 15 m /125/ /126/. In deeper waters in the open sea, ice is more dynamically formed, consisting of drift ice that moves along with the currents and winds. On stormy days, drift ice can move 20-30 km. Drift ice and deformed ice can easily get packed against one another or other obstacles, which can result in pack ice or in vast ice ridges /125//126/. In shallow areas, packing of drift ice can result in ice packs that grow vertically downwards to the seabed. This kind of seabed-attached pack ice has been observed down to water depths of 20 m /125/.

In the areas where the NSP2 route crosses the Danish TW and EEZ, the probability of ice formation is 10-25%, which is relatively low compared with other parts of the Baltic Sea. In Danish waters, ice extends to the proposed route for NSP2 only during severe winters, and the maximum annual ice thickness is less than 10 cm in the waters around Bornholm /127/.

Atlas map CL-01 shows the extent of ice cover during three recent winters: 2010-2011 (severe winter), 2012-2013 (average winter) and 2014-2015 (mild winter).

7.6.2 Future climate

The annual mean sea surface temperature has increased by up to 1°C per decade from 1990 to 2008. At the same time, the annual maximum ice extent of the Baltic Sea has decreased about 20 % over the past 100 years, and the length of the ice season has decreased by about 18 days/century in the Bothnian Bay and 41 days/century in the eastern Gulf of Finland /128/. The purpose of this section is to describe how the forecasted global climate changes can be expected to affect the Baltic Sea region during the NSP2 lifetime.

An oceanographic study carried out by the Swedish Meteorological and Hydrological Institute (SMHI) shows that average sea surface temperatures for the entire Baltic Sea could increase by some 2-4ºC by the end of the twenty-first century /129/. Ice extent in the sea would also decrease by 50-80%. Increased freshwater inflow and increased mean wind speeds may cause the Baltic Sea to reach a new steady state with significantly lower salinity. In the southern Baltic, oxygen concentrations may decrease and phosphate concentrations may increase, thereby resulting in increased phytoplankton biomass. A recent report issued by HELCOM largely confirms these findings /128/ and concludes that the summer sea surface temperature is likely to increase by 2-4°C by the end of this century, and that there will be a drastic decrease in sea-ice cover in the Baltic Sea.

7.6.3 Air quality

The air quality in the Baltic Sea is influenced by a combination of global, regional and local emissions. Industrialisation of the coast and inshore areas around the Baltic Sea has led to increased levels of air pollutants in these areas which decrease as you move further offshore. Shipping is considered the major source of atmospheric pollution offshore.

The Baltic Sea constitutes one of the most intensely trafficked seas in the world and accounts for approximately 15% of the world's cargo transportation, see section 7.15. There is considerable traffic density in the central Baltic Sea and west of Gotland which amounts to approximately 57,000 vessel passages annually. Twenty percent of this volume is comprised of tankers of a size in excess of 150 m.

Pollutants originating from the combustion of fuel on ships can be divided into the following compound groups:

- Carbon dioxide (CO_2);
- Nitrogen oxides (NO_X), a term covering both NO and NO_2;
- Sulphur oxides (SO_X), particularly sulphur dioxide (SO_2);
- Carbon monoxide (CO);
- Particulate matter (PM);
- Hydrocarbons (HC).

CO_2 is emitted due to the carbon content in the fuel, whereas NO_X is emitted due to the nitrogen gas (N_2) content of atmospheric air. The amount of NO_X formed depends on the combustion process. Sulphur is naturally present in fuels. Combustion therefore gives rise to emissions of SO_2 or SO_X and PM, including primary soot particles and secondary inorganic sulphate particles formed as a result of atmospheric oxidation of sulphur dioxide. The remaining compounds are a result of incomplete combustion and impurities in the fuel.

CO_2 is an important green-house gas (GHG), i.e. the emission of CO_2 contributes to the greenhouse effect. The majority of the global emission of CO_2 originates from burning of fossil fuels such as coal, oil, gas and natural gas used in power plants, dwellings, industry and transport. Furthermore, increasing CO_2 levels in the atmosphere may contribute to lower pH in water bodies when dissolved in water. The other GHG's such as methane (CH_4) and nitrous oxide (N_2O) are not products of fuel combustion.

NO_X is a term covering NO and NO_2. It is formed during the combustion of fuel in gas and diesel engines due to oxidation of nitrogen in the combustion air and in the fuel. Emissions of NO_X contribute to acidification, which can cause effects on ecosystems in both terrestrial and marine environments. Furthermore, NO_X emissions contribute to eutrophication where high nutrient concentrations stimulate growth and thereby affect the natural state of ecosystems, also both in terrestrial and marine environments. On a local scale, NO_X emissions are able to contribute to the formation of ground-level ozone and impact human health. It is estimated that about 15% of the anthropogenic NO_X emissions are due to shipping /131/.

Sulphur is naturally present in fuels. It is emitted from the burning of coal and oil at power plants and movable sources such as the shipping industry. Continuous tightening of the allowed sulphur content in fuels has gradually reduced the SO_2 emissions from ships. SO_2 contributes to acidification and can impact human health and cause degradation of buildings on a local scale. It is estimated that approximately 7% of the anthropogenic SO_2 emissions are due to shipping /131/. The Baltic Sea has status as a Sulphur Emission Control Area (SECA), meaning that ships must use low-sulphur fuel or have a desulphurisation system on board.

CO is a colourless, odourless gas emitted from combustion processes. Nationally, and particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources, e.g. transport. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues.

Combustion of fuels give rise to the emission of particulate matter, e.g. soot particles (primary particles). However, the majority of particles with regard to air pollution originate from pollution 'born' as gases and transported over long distances, e.g. inorganic sulphate particles formed as a result of atmospheric oxidation of sulphur dioxide. Particulate matter can be transported long distances and may have impacts on human health. Particulate matter are usually handled as PM_{10} (particles <10 µm) and $PM_{2.5}$ (particles <2.5 µm), respectively.

HCs belong to a larger group of chemicals known as volatile organic compounds (VOCs). HCs are compounds of hydrogen and carbon only, while VOCs may contain other elements. They are produced by incomplete combustion of hydrocarbon fuels and also by their evaporation. Because there are many hundreds of different compounds, HCs and VOCs display a wide range of properties. Some, such as benzene, are carcinogenic; some are toxic and others are harmless to health.

When pollutants are emitted to the atmosphere they can cause impacts of local, regional and global range. Emissions of the four main polluting compounds CO_2, NO_X, SO_x and PM are presented in the following.

In 2013, the annual Danish emissions of CO_2, NO_X and SO_X amounted to 41,622,000 tonnes, 122,971 tonnes and 13,012 tonnes respectively, while PM (as total suspended particles (TSP)) in 2014 amounted to 91,300 tonnes /132/.

Looking at emissions from all vessels sailing in the Baltic Sea, the total emissions (2014) amounted to 15,000,000 tonnes of CO_2, 320,000 tonnes of NO_X, 81,000 tonnes of SO_X and 16,000 tonnes of PM /133/.

7.7 Plankton

Zoo- and phytoplankton constitute important components of the food chain in the Baltic Sea, and thus despite not being a protected species, are considered an important receptor.

7.7.1 Phytoplankton

Phytoplankton is a group of microscopic photosynthetic organisms (e.g. diatoms, dinoflagellates and cyanobacteria). They are the main source of primary production in the Baltic Sea and form the basis of the marine food chain. Phytoplankton grows photosynthetically (by using light as an energy source). Growth is therefore limited to roughly the upper 20 meters of the water column where sufficient light is present (photic zone). One of the key roles of phytoplankton is to provide the basis for the secondary production of higher trophic levels (zooplankton, fish, etc.). Phytoplankton also play a vital role in the biogeochemical cycles of many important chemical elements, e.g. the carbon cycle of the ocean.

Phytoplankton populations are highly dynamic and vary spatially in response to, e.g., light conditions, nutrient concentrations, climatic conditions and currents. Phytoplankton also exhibit significant cyclical changes in response to seasonal variations in sunlight and temperature.

For example, in the winter, the surface water is rich in nutrients, but phytoplankton biomass remains low because of the lack of light. There are typically three annual blooms in the southern Baltic Sea /138//139//140//141//142/:

- In spring, when nutrients and light become available, the biomass of phytoplankton increases. The spring bloom typically consists mostly of diatoms and/or dinoflagellates. When the dissolved nitrogen is depleted, the algal biomass in the upper part of the water column decreases.
- In summer, recurrent blooms of cyanobacteria usually dominate the coastal areas and surface waters /140/. Cyanobacteria blooms depend on the available amounts of phosphate in the surface water and favourable weather conditions during the summer. Some cyanobacteria are capable of nitrogen fixation, i.e. uptake of nitrogen from the atmosphere, and can form massive visible surface accumulations of several weeks' duration throughout large parts of the Baltic Sea /141/. One of the bloom-forming cyanobacteria, *Nitzschia spumigena*, can produce nodularin, a hepatotoxic toxin.
- In autumn, as temperatures decrease and winds increase, water mixing typically increases the supply of nutrients from nutrient-rich bottom water, which may lead to a third minor bloom.

Chlorophyll-*a* is the most abundant photosynthetic pigment among all photosynthetic organisms. Therefore it can be used to estimate phytoplankton biomass. Chlorophyll-*a* concentrations show considerable interannual variability.

Figure 7-21 shows the concentration of chlorophyll-*a* pigments in the Bornholm Sea. The figure presents measurements from the surface (0-10 m) for the periods 1979-1989, 1990-1999 and 2000-2005 /138/. The data series from 1979-1989 shows a pattern with two peaks in spring and autumn, and a maximum chlorophyll-*a* concentration of 2.75 mg/m^3 (in November). The data series from 1990-1999 and 2000-2005 are similar, and show three peaks in spring, summer and autumn, with a maximum chlorophyll-*a* concentration of 5 mg/m^3 (in April). More recent data from 2007-2011 show that the mean surface summer chlorophyll-*a* concentration for June-September was 3-5 µg/l in the Bornholm Basin /115/, which is a bit higher but comparable to the values presented in Figure 7-21.

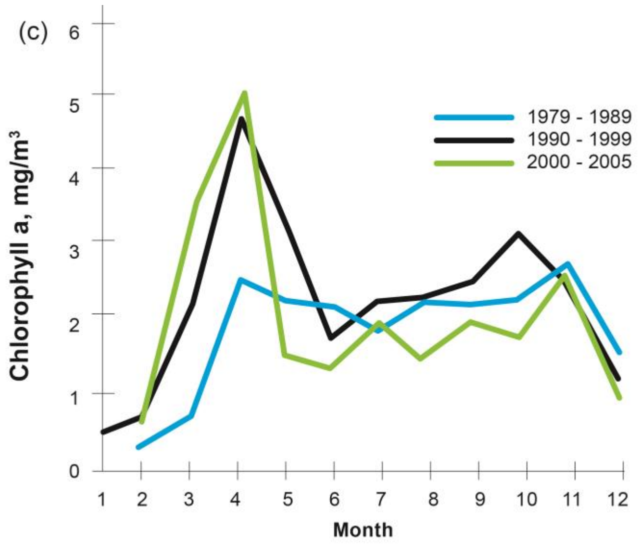


Figure 7-21 Seasonal patterns of chlorophyll-*a* (mg/m^3, monthly mean) for 1979-1989, 1990-1999 and 2000-2005 in the Bornholm Sea east of Bornholm, based on measurements of 0-10 m depth. Figure re-drawn from /138/.

Figure 7-22 shows the annual variation in chlorophyll-*a* content of the surface water of the Danish section of the Baltic Sea in 2012.

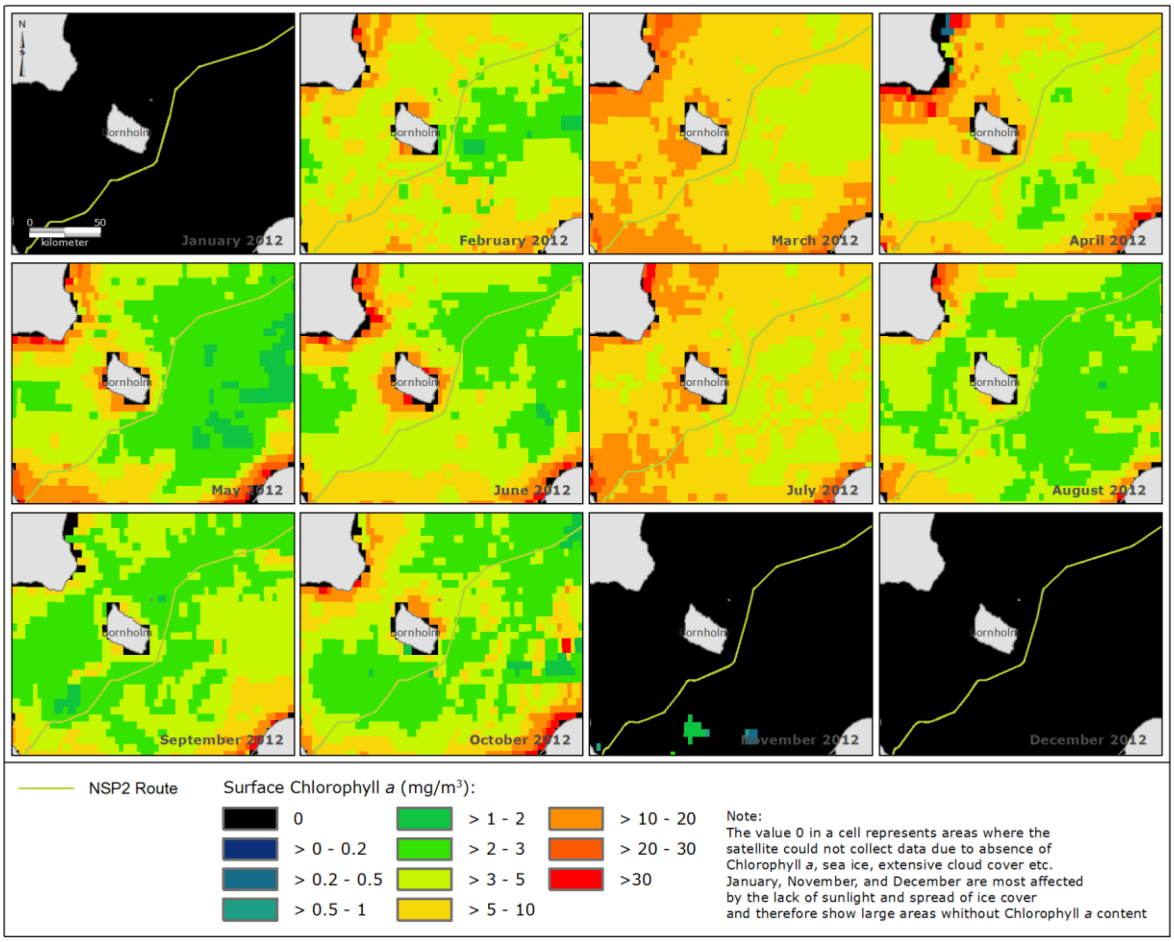


Figure 7-22 Annual variation in the chlorophyll-*a* content of the surface water in the Danish section of NSP2, based on satellite measurements.

As noted in section 7.5.3, eutrophication is a condition in an aquatic ecosystem where high nutrient concentrations stimulate growth of phytoplankton, leading to imbalanced functioning of the system /115/. HELCOM has presented the eutrophication status of the Baltic Sea 2007-2011, by defining the GES level for each basin in the Baltic Sea, with a chlorophyll-*a* average for summer (June-September). In the area near the proposed NSP2 route (Arkona Basin and Bornholm Basin), the GES level ranges between 1.8-2.0 µg chlorophyll-*a*/l (c. 1.8-2.0 mg/m^3), which is below the GES threshold /115//143/.

The composition of the phytoplankton biomass for the Bornholm Sea (2004 data), split into main taxonomical groups, is shown in Figure 7-23 /138/. Phytoplankton in the Bornholm Sea belongs to the following taxonomic groups: Cyanobacteria, Cryptopheceae, Dinophyceae (dinoflagellates), Bacillariophyceae (diatoms), Chryosphyceae, *Mesodiunium rubrum* and others. The figure shows three blooms: spring, summer and autumn. Though interannual variation is high, there is some consistency in the species composition /138/.

In early February, the biomass is low and consists primarily of Cryptophyceae. Later in the month *M.rubrum* (a protozoan capable of photosynthesis) starts to form a larger part of the population. The spring bloom (March-May) in the Bornholm Sea consists primarily of *M.rubrum*. There is no dominance by typical spring bloom groups of the southern Baltic Sea (diatoms and/or dinoflagellates) in 2004 /138/. The species composition during the summer bloom (June-July) in the Bornholm Sea varies annually. In 2004, dinoflagellates, Cryptophyceae (*Plagioselmis prolonga*), and other (*Phacus* sp.) dominated with a small presence of cyanobacteria (*Aphanotece* sp.), whilst in other yearsspecies of cyanobacteria dominate (e.g. *Nodularia spumigena*). The autumn bloom (November) in 2004 was dominated by diatoms (primarily *Coscinodiscus granii*) /138/.

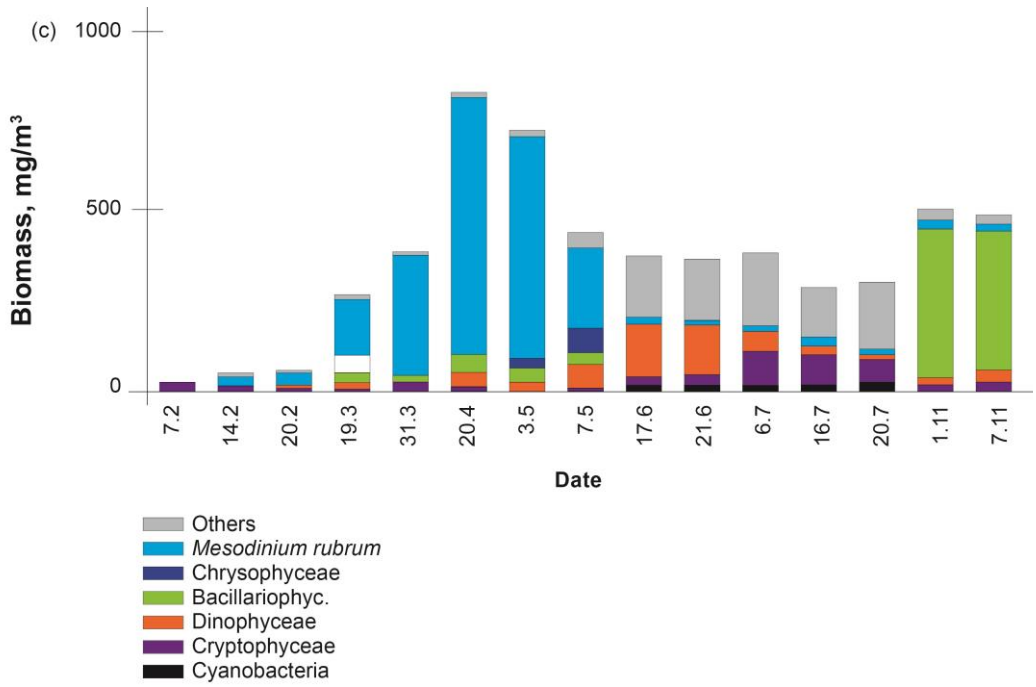


Figure 7-23 Seasonal variation of phytoplankton biomass in the Bornholm Sea east of Bornholm in 2004, split into the main taxonomical groups. Figure redrawn from /138/.

7.7.2 Zooplankton

Zooplankton plays an important role as a food source for fish. Zooplankton taxa often have different value as prey, because of the taxa-specific variations in size, abundance, escape response and biochemical composition /144/.

The zooplankton community in the Baltic Sea consists of freshwater, brackish and marine species, which are distributed vertically and horizontally depending on their ecophysiological tolerances and the availability of food resources /145/.

The zooplankton of the Baltic Sea is generally dominated by calanoid copepods and cladocerans (small crustaceans commonly known as water fleas). The thermocline and halocline in the Baltic Sea constrain the vertical distribution of zooplankton species, resulting in characteristic vertical assemblage patterns in the different layers of the water column. In the Baltic Sea, rotifers such as *Keratella quadrata* and copepods, e.g. the estuarine *Eurytemora hirundoides*, are present as well as species from shallow coast waters, e.g. *Acartia* spp. Occasionally, species of crustaceans from the North Sea, e.g. *Paracalanus parvus* as well as *Oithona similis*, are found, mainly below the halocline in the southern part of the Baltic Sea. Cladocerans, e.g. *Evadne nordmanii,* can also comprise a considerable part of the zooplankton community /146//148/.

Species-specific preferences often result in both seasonal and inter-annual changes in vertical abundance that, when combined with depth-specific water currents, also lead to horizontal differences in spatial distribution. In the Bornholm Basin, the most common zooplankton are cladocera, copepods and rotifers. A study from 2002-2003 shows, that each of five taxa (*Bosmina coregoni maritima*, *Acartia* spp., *Pseudocalanus* spp., *Temora longicornis*, *Synchaeta* spp.) contributed >10% to the zooplankton community composition /146/.

Fluctuations in zooplankton populations are well-known and related to the physical environment, e.g. changes in salinity and temperature as well as the structure of the food chain, i.e. the availability of food items, primarily microalgae and microzooplankton /145/. Trends in annual zooplankton biomass in the Baltic Proper between 1979 and 2005 were statistically analysed by the Finnish Institute of Marine Research (FIMR). In general, no significant trends in overall biomass development of zooplankton were found /149/.

7.8 Benthic flora and fauna

Zoobenthos (benthic fauna) and phytobenthos (benthic flora) are important components of the marine food chain and of the ecosystem in the Baltic Sea, often playing the role of 'habitat builders'. Therefore, despite no species listed as near threatened, endangered or vulnerable in the HELCOM Red List being present along the pipeline route, they are considered an important receptor.

A habitat-based approach has been used in this section to describe the existing conditions for benthic life along the proposed pipeline route through the Danish waters. An emphasis has been placed on identifying the basic conditions determined by the existing physical and chemical properties which define the habitat and influence the benthic life that exists along the proposed pipeline route.

7.8.1 Benthic environment in the Baltic Sea

The benthic communities in the open Baltic Sea sedimentary habitats are largely dependent on a number of factors including oxygen concentration, salinity-, light- and substrate conditions along with water movement. In addition, elements defining the status of the benthic habitat also contribute to the life conditions, including water quality, food supply, trophic competition with alien species, etc.

Changes in salinity influence the biodiversity of benthic fauna, with the number of species diminishing from the marine areas in the south-western end (Kattegat) towards the almost undiluted freshwater in the inner part of the Gulf of Finland and the Bothnian Bay, illustrated in Figure 7-24.

Oxygen conditions are crucial for the existing life in the Baltic Sea and the benthic habitats in the Baltic Proper are, in general, strongly affected by the low oxygen concentrations (see section 7.4.2), which are a result of eutrophication and a weak renewal of water. Oxygen consumption increases in the period from late summer to early autumn, when relatively high bottom-water temperatures and the presence of degradable organic matter accelerate mineralisation of organic matter. Eutrophication provides a surplus of organic matter to the benthic environment, which further increases oxygen demand.

The bottom water concentration of oxygen is therefore influenced by the balance between oxygen consumption at the seabed (which is affected by eutrophication) and the supply of oxygen from the surface layer due to vertical mixing and/or lateral transport of oxygen-rich water. Vertical exchange decreases with depth and is repressed by stratification caused by the salinity and temperature gradients. In addition, inflows of oxygen-rich marine water from Kattegat occur infrequently, with years between events, and are irregular in duration and magnitude. Such inflows usually occur in late autumn and in winter during periods of storms from the west and deep atmospheric low pressures over the Baltic region.

Because the water exchange usually decreases in intensity with depth, the low oxygen concentrations become more severe in the deeper parts of the Baltic Sea. In the deep basins, the concentration of dissolved oxygen in the bottom water is the most critical factor influencing species richness and the presence/absence of soft-bottom zoobenthos along the proposed pipeline route.

Tolerance to low oxygen concentrations is in general species-specific but also depends on the rate of oxygen decline, the duration of low oxygen concentrations and temperature /152/. Oxygen below 3 mg/l (hypoxia corresponding to approximately 2 ml O_2/l) is critical for most of the fauna, and the development of anoxic conditions and release of toxic hydrogen sulphide prevent the survival of zoobenthos.

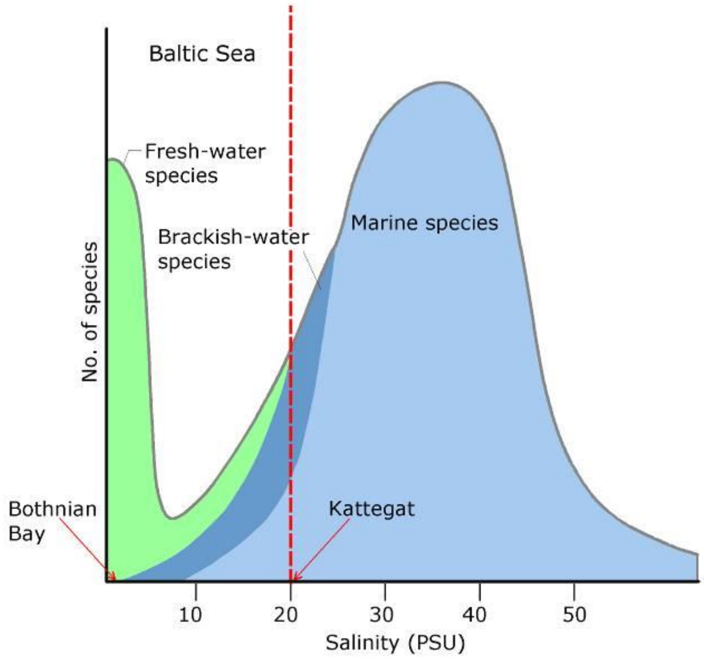


Figure 7-24 Number (arbitrary scale) of marine, brackish and freshwater species correlated with salinity. The range of salinity in the Baltic Sea is indicated as the mean surface water salinity between the Bothnian Bay and the Kattegat. PSU stands for practical salinity units and is closely related to the weight concentration in %.

Even occasional oxygen depletion will inhibit the usual successional pattern and prevent the development of a mature benthic community. In the Kattegat, the Danish straits, the western Baltic Sea and coastal areas, oxygen depletion is a seasonal phenomenon, while hypoxic/anoxic conditions in the deep waters (i.e. Baltic Proper) seem to be persistent and independent of seasonality /149/.

In addition to oxygen concentrations, the depth of the water column also affects the availability of light at the seabed. The photic zone, defined as the depth where 1% of the surface irradiance remains, reaches down to a maximum depth of 20 m in the Baltic Sea. At depths greater than 20 m, the absence of light prevents phytobenthos from growing on the seabed, and there will thus be no benthic flora. Given the depth along the proposed NSP2 route (>28 m), no benthic flora is present, and as such no further consideration has been given to this receptor in this EIA.

7.8.2 Benthic fauna in the Baltic Sea

Species richness in the Baltic Sea decreases from over 1,600 marine benthic species in the open Skagerrak to about 500 in the western part of the Baltic Sea (west of Bornholm), approximately 80 in the western regions (east of Bornholm) and fewer than 20 in the eastern regions of the Gulf of Finland. Conversely, the diversity of freshwater benthic species increases towards the inner reaches of the Gulf of Finland and the Gulf of Bothnia, as illustrated in Figure 7-24. The species richness of polychaetes, molluscs and echinoderms is dramatically reduced from west to east /149/.

Generally, the benthic communities in the Baltic Sea all belong to the so-called Macoma community and are characterised by the bivalve *Macoma balthica* and a few other species, e.g. the common mussel *Mytilus edulis*. The small brackich amphipod crustacean *Pontoporeia (Monoporeia) affinis*, the isopod crustacean *Saduria entomon* and the invasive polchaete genus of *Marenzellaria* are likewise characteristic species in the Baltic Sea. In the basins of the open part af the Baltic Proper the benthic communiies are often characterised by the amphipod crustacean *Pontoporeia femorata* and the Polynoidae *Bylgides sarsi* /151/. The abovde mentioned three crustaceans are all considered as ice age relict of the Baltic Sea.

The geographical trend in species richness in the Baltic Sea is largely true for the open and deeper waters in the Baltic Sea. However, the trend is less distinct closer to the coasts and in shallow waters, with these areas demonstrating a consistently high species richness due to habitat complexity and variable substrates. In these areas, freshwater species and insect larvae tend to dominate. The coastal and archipelago areas differ not only due to limnic species and insect larvae, but also because of a higher habitat complexity and variable substrates /149/. The more sandy parts of the coastal areas are often characterised by tiny snails of the brackish genus Hydrobiidae, the small polychaete *Pygispio elegans* and the brachish cockle *Cerastoderma glaucum* /151/.

HELCOM and the International Council for the Exploration of the Sea (ICES) have reported that approximately one-third of the total area of the seabed in the Baltic Sea is without benthic fauna /154/.

7.8.3 Benthic environment in the Danish Sector

A survey of benthic fauna along the proposed NSP2 route was conducted in October 2015 /66/ and supplemented data collected during NSP in 2008 and 2010-2014 /155/. As noted above, benthic flora is not present along the proposed NSP2 route through Danish waters and therefore only benthic fauna is discussed in this section.

In October 2015, seabed samples were collected at 14 stations along the proposed pipeline route for consequent analysis of benthic fauna present in the samples. In addition to the sediment sampling, depth, temperature, salinity and oxygen concentrations in the water column were measured at all stations (see section 7.1).

In the Danish sector there are already a number of naturally and anthropologically induced disturbances of the habitats. As described in section 6.4 poor oxygen conditions prevail along most of the proposed NSP2 route which limit the presence of higher trophic levels. In the shallower parts of the proposed NSP2 route however (located to the south and south-east of Bornholm), more favourable oxygen conditions exist and a more developed bottom life can be anticipated, with species at a higher trophic level.

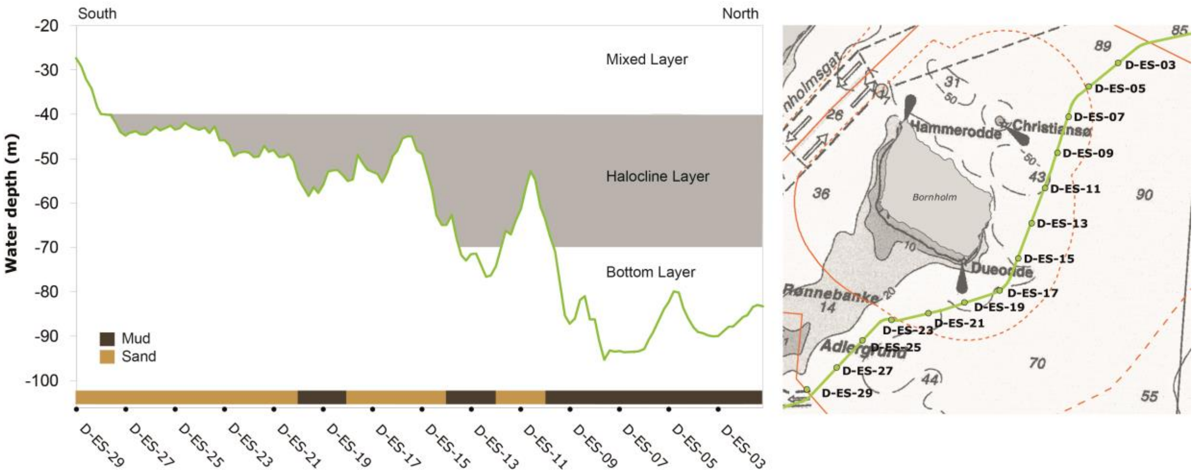


Figure 7-25 Depth profile and overall substrate type at the pipeline transect through the Danish sector (left). Mud consist of mainly clay and silt (<0.1 mm) while sand mainly consist of mineral particles between 0.1 and 2 mm. The positions of the survey stations are indicated in the map on the right.

Based on the physiochemical properties of the sediment and the water column described in sections 7.3 and 7.4, three sets of overall living conditions for benthic fauna can be identified along the proposed NSP2 route in the Danish sector:

- **Habitat type 1**: a deep, soft bottom habitat (>60 m) with fine sediment mainly consisting of silt and clay (<0.06 mm) and with a salinity of 15-20 psu. It is within the depth range of the halocline and therefore this habitat type experiences regular hypoxia/anoxia.
- **Habitat type 2**: a middle, deep bottom habitat (40-60 m) with fine sediment consisting mainly of sand (0.06-0.2 mm) and with a salinity of 8-15 psu. The habitat experiences semi-frequent occurrences of low oxygen or hypoxic conditions. The variable salinity and oxygen conditions are due to the proximity to the irregular pycnoclines (occurring between the mixed surface layer and the bottom layers).
- **Habitat type 3**: a shallow habitat in direct contact with the surface layer (<40 m), but below the euphotic zone (0-20 m). The sediment mainly consists of medium grained sand (0.2-0.6 mm) and salinity is constant at approximately 7-8 psu. Due to its location above the halocline, the habitat rarely experiences low oxygen conditions.

Along the proposed NSP2 route, the northern part within the Danish sector is characterised by habitat type 1. The southern part of the pipeline in the Danish sector, which follows the western slope of the Bornholm Basin, is characterised by habitat type 2 and the final 5 km of the southern part of the route is characterised by habitat type 3.

7.8.4 Benthic fauna along NSP2 in the Danish sector

All results obtained regarding the infauna and the sediment properties closely follow the patterns found during NSP in 2008, and 2010-2014 /66//155/. In Figure 7-26, the numbers of species that were found in 2015 at the sampling stations along the proposed NSP2 route are shown together with the oxygen concentration in the bottom water /66/.

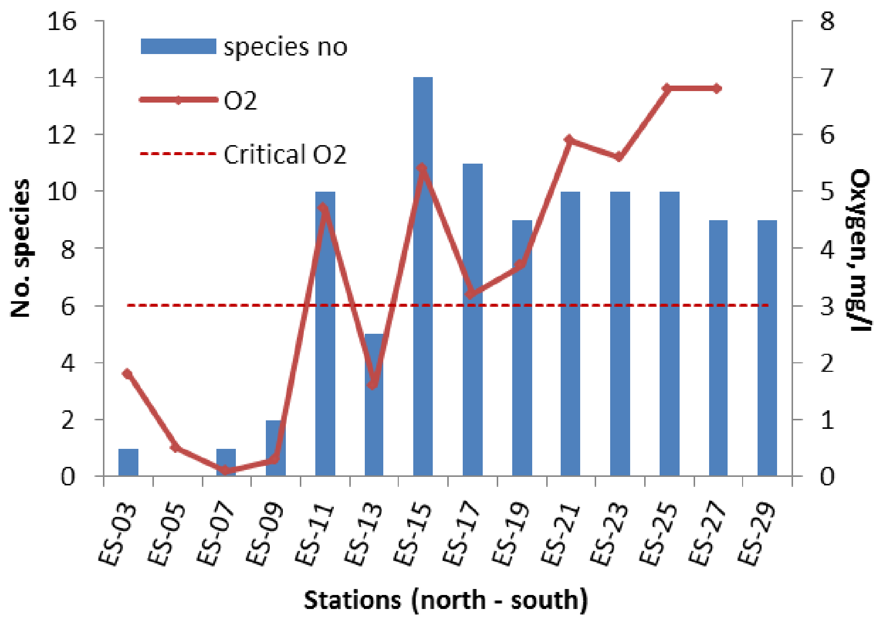


Figure 7-26 Number of species found at the survey stations (October 2015). The oxygen concentrations measured approximately 1 m above the seabed are also shown in relation to the critical limit of 3 mg/l.

With respect to abundance and number of species, the benthic fauna differ significantly between the two most common habitat types along the proposed NSP2 route in Danish waters (habitat types 1 and 2). In habitat type 1, zoobenthos are present in very low numbers, and consists mainly of opportunistic and H_2S tolerant species of the polychaetes *Trochocaeta nultisetosa* and *Scoloplos armiger.* At habitat type 2, biodiversity is higher, and the biomass is dominated by mussels such as *Macoma balthica*, *Astarte borealis*, *Astarte montagui*, and *Mytilus edulis.* Polychaetes (e.g. *Pygospio elegans*, *Scoloplos armiger, Terebellides stroemi* and *Bylgides sarsi*), Crustacea (e.g. *Pontoporeia femorata* and *Diastylis rathkei)* and Priapulids (*Halicryptus spinulosus* and *Priapulus caudatus)* are also relatively abundant in habitat type 2.

At the stations sampled along the proposed NSP2 route, the average biomass of zoobenthos in terms of ash-free dry weight (AFDW) was 0.1 g AFDW/m^2 and 2.0 g AFDW/m^2 for habitat types 1 and 2, respectively (AFDW is the weight loss of biomass during complete oxidation in a furnace at high temperature. i.e. a measure of the amount of organic carbon present in the biomass). This indicates that the overall productivity of the bottom-dwelling organisms in the region is quite low and far from what the supply of organic matter otherwise could sustain.

Annelids were the most abundant group of zoobenthos detected in habitat type 3, although the bivalves dominated the biomass. Because habitat type 3 is only represented by a single station (ES-29), it is difficult to draw any general conclusion about how it differs from the other habitat types with respect to infauna. However, the polychaete *Travisia forbesii* is only found here.

None of the benthic species identified along the proposed NSP2 route are listed as near threatened, endangered or vulnerable in the HELCOM Red List. Of the detected species, two have a status of least concern (*Monoporeia affinis* and *Pontoporeia femorata*) /188/. None of the species are included in the EU Habitat Directive.

7.9 Fish

Fish are an important component of the marine food chain and of the ecosystem in the Baltic Sea; they are also a valuable component of the Danish economy (commercial value of fish is described in more details in section 7.16). Given this, in combination with the fact that a number of fish species present along the proposed NSP2 route have protection status under national/international legislation, fish are considered an important receptor.

7.9.1 Fish species in the Baltic Sea

The fish communities in the Baltic Sea are largely dependent on the basic physical settings (i.e. salinity, temperature, oxygen) which constrain biodiversity, fish recruitment and water quality.

In particular, the distribution of the fish species inhabiting the Baltic is governed by salinity, with a gradient of salinity observed from the Bothnian Bay to the Kattegat. As a result, marine species dominate the Baltic Proper and account for approximately two-thirds of the species found in the Baltic Sea, while freshwater species (one-third of the species) occur in the coastal areas and in the innermost parts of the Baltic Sea.

Approximately 70 marine species of fish (including lampreys) are regularly observed in the Baltic Sea, which is considered a low number compared with more saline waters.

The marine species cod, herring and sprat comprise the large majority of the fish community in terms of both biomass and abundance (>75%). Demersal marine fish species include flounder, plaice and turbot, which live in the central and south-western parts of the Baltic Sea. Compared with true marine areas, the contribution of diadromous species (species that live part of their lives in the sea and part in freshwater, where they also spawn) is relatively large. They mainly consist of the salmonid species salmon, trout and smelt which all are pelagic, and the demersal European eel. The typical freshwater species include bream, pike, perch, pike-perch, roach and turbot. In some years, three-spined stickleback also occurs in large numbers. These species mostly occur along the coastline of the Baltic Sea.

Fish communities, especially in the coastal areas of the Baltic Sea, underwent dramatic changes during the late twentieth century as a result of both human activities and natural factors /158/. Fish are subject to a number of anthropogenic impacts, such as enhanced nutrient loads (eutrophication); contamination by heavy metals, organic contaminants and hormone-like substances; destruction of recruitment habitats; introduction of non-indigenous species (NIS) and an increased fishing pressure. Climate-driven changes in the salinity, temperature and oxygen content of the water can also affect the recruitment and growth of cod, herring and sprat. Hydrophysical-climatic variability (i.e. low frequency of inflows from the North Sea and increasing temperatures) in combination with heavy fishing over the last 10-15 years has led to a shift in the fish community from cod to clupeids (herring, sprat). This is due to weakening cod recruitment and subsequently because of favourable recruitment conditions for sprat.

A natural factor that impacts fish communities is predation by seals and cormorants. For the cod population, however, the influence of grey seals is minor compared with the mortality induced by fishery /159/.

7.9.2 Fish species along the proposed NSP2 route

In the Bornholm basin, the most common fish species are cod (*Gadus morhua*), sprat (*Sprattus sprattus)*, flounder (*Platichthys flesus*) and four-bearded rockling (*Rhinonemus/Enchelyopus cimbrius*) /160/. Plaice (*Pleuronectes platessa*) and sand goby (*Pomatoschistus minutus*) are also frequently found in this part of the Baltic Sea.

The fish monitoring programme for NSP, conducted in 2011-2014 /155/, showed the presence of the following commercially important species in the Danish sector: cod, whiting (*Merlangius mar-*

langis), flounder, plaice, turbot (*Psetta maxima*), sprat, herring (*Clupea harengus*) and salmon (*Salmo salar*). Other species found along the pipeline route but of lesser importance to fishery included shorthorn sculpin (*Myoxocephalus scorpius*), lumpfish (*Cyclopterus lumpus*), viviparous blenny (*Zoarces viviparous*), snake blenny (*Lumpenus lampretaeformis*), four-bearded rockling (*Enchelyopus cimbrius*), three-bearded rockling (*Gaidropsarus vulgaris),* hooknose (*Agonus cataphractus*), striped sea snail (*Liparis liparis*), smelt (*Osmerus eparlanus*), dab (*Limanda limanda*) and brill (*Scophthalmus rhombus*).

The northern half of the proposed NSP2 route is situated in relatively deep water where the seabed is characterized by habitat type 1 (section 7.8). In this part of the route, benthic fish are not common due to the low oxygen content and limited presence of benthic fauna. Conversely, as the proposed NSP2 route continues south, the seabed is characterized as habitat type 2 or 3 (section 7.8) which have high levels of oxygen in the water. This encourages a more diverse and abundant community of benthic invertebrates as well as bottom dwelling fish of small- and medium-size species (i.e. gobies, juvenile cod and flatfish). Top predators such as cod and salmon strongly depend on this food chain.

7.9.3 Important commercially exploited fish species in the Danish section

The most important commercially exploited species in the Baltic Sea are cod, sprat and herring which comprise 95% of the commercial catches in the Baltic Sea. Other commercially important species, especially in the southern part of the Danish sector, include flounder, plaice, turbot, eel and salmon.

The most commercially important pelagic and benthic fish species in the southern part of the Baltic also happen to be the most common in the Danish section. These species and their spawning period are listed in Table 7-19 and described below in more detail.

Table 7-19 Spawning periods for commercially important fish stocks in the Baltic Sea. The acronyms N, S, E and W refer to the spawning location – cf. text below.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Herring[1]			X	X	X	X						
Salmon[2]							X	X	X	X	X	
Flounder[3]			X^{S}	X^{S}	$X^{S/N}$	$X^{S/N}$	X^{N}					
Turbot[4]						X	X					
Sprat[5]	X^{win}			X	X	X	X				X^{win}	X^{win}
Plaice[6]	X	X	X	X								X
Cod[7]	X^{W}	X^{W}	X^{W}	$X^{E/W}$	X^{E}	X^{E}	X^{E}	X^{E}	X^{E}			

[1]: Spawning periods for spring spawning stocks of different herring populations in the Baltic Sea:

- Western Baltic: March-May;
- Central Baltic: April-May (ICES 25), March-May (ICES 26, Polish coastal waters), April-June (ICES 28), May-June (ICES 29);
- Gulf of Finland (ICES 32): May-June.

Demersal eggs with an adhesive layer that attaches them to the substratum/vegetation in shallow waters /162/.

[2]: The spawning period for salmon depends on latitude and the geographical locations of the breading rivers. Demersal eggs are buried in river-gravel bottoms /163/.

[3]: There are two different types of flounder in the Baltic Sea: a northern type (N) with demersal eggs, and a southern type (S) with pelagic eggs. The former may reproduce successfully in the northern Baltic Proper, the Bothnian Sea and the Gulf of Finland. The spawning period for the southern stock with pelagic eggs is March-June. The main spawning period for the northern stock is May-July /164//165/.

[4]: Turbot eggs are demersal at the low salinities occurring in the Baltic Sea /166/.

[5]: Winter spawning (Nov-Jan) of sprat (win) is followed by summers with exceptionally warm surface water in the Baltic Sea. However, the contribution of winter spawning compared with annual egg and larval production is negligible /167//168/.

[6]: Spawning in Dec-May /164/.

[7]: Significant inter-annual variations in spawning time of eastern Baltic cod (E). A remarkable shift in the timing of spawning from April-June to June-August was observed in the 1990s. The spawning period for western Baltic cod – the Belt Sea cod (W) – is Jan-April /156//169//170//171/.

7.9.4 Fish species of conservation value in the Danish section

Some of the fish and lamprey species present in the Danish waters around Bornholm are identified as threatened (critically endangered, endangered or vulnerable) on the HELCOM Red List /188/, and/or are included in Annex II of the EU Habitat Directive. These species are listed in Table 7-20.

Table 7-20 Species that occur within the Danish section of the project area and that are on the HELCOM Red List or listed in the EU Habitat Directive.

Species	Red List status	Included in EU Habitat Directive
European eel (*Anguilla anguilla*)	Critically endangered	No
Sea lamprey (*Petromyzon marinus)*	Vulnerable	Yes, Annex II
Atlantic salmon (*Salmo salar*)	Vulnerable	No
Sea trout (*Salmo trutta)*	Vulnerable	No
Whitingg (*Merlangius merlangus*)	Vulnerable	No
Cod (*Gadus morhua*)	Vulnerable	No
Whitefish (*Coregonuc maraena*)[1]	Endangered	No
Grayling (*Thymallus thymallus*) [1]	Critically endangered	No
Razor-fish (*Pelecus cultratus*) [1]	Less concern	Yes, Annex II
Bullheas (*Cottus gobio*) [1]	Less concern	Yes, Annex II
Asp (Aspius aspius) [1]	Not threatened	Yes, Annex II
Spined loach (Cobitis taenia) [1]	Less concern	Yes, Annex II

[1]Freshwater species that occur sporadically in Danish waters around Bornholm

Of the fishes listed in Table 7-20, only cod spawns in the waters around Bornholm. In accordance with the EU Habitat Directive, the Danish authorities have appointed SAC (see section 7.13) in which the species listed in the Habitat Directive should be protected. These, however, do not include the waters around Bornholm.

7.9.5 Description of important fish species in the Danish section

Below is a description of the fish species that are considered important in the area, either because they are commercially valuable, the population is on the Helcom Red List, or the species is listed in the EU Habitat Directive.

7.9.5.1 Baltic cod (*Gadus morhua*)

The abundance and distribution of Baltic cod has varied considerably over time owing to natural as well as anthropogenic causes. Two populations are present in the area: eastern and western Baltic cod. These stocks have different morphological characteristics and population genetics. The eastern cod stock occurs in the central, eastern and northern Baltic, but only in small numbers north of the Åland Islands. The western cod stock inhabits the areas west of Bornholm, including the Danish straits. The two stocks overlap in the area near Bornholm. The eastern population is the largest, accounting for approximately 90% of the cod stocks in the Baltic Sea /172/. However, the subpopulation of the Gdansk and Gotland Deep is considered seriously reduced, in particular in the Gotland Deep, where almost no spawning occur /169/.

The availability of suitable habitats for cod varies between areas and years depending on the prevailing environmental conditions. The fish may be periodically or permanently absent in some areas, e.g., in the bottom layers of deep basins due to low content or absence of oxygen. Spawning in the eastern Baltic is confined to areas at 40-60 m deep, e.g. in the waters of the Bornholm Deep and previously in the Gdansk Deep and Gotland Deep. Successful egg development requires a minimum oxygen level of approximately 3 mg/l seawater and salinity higher than 11 psu in the reproductive volume, at which the buoyancy of cod eggs is neutral /173//177/. Eggs of three- to five-year-old spawners (the basis of the spawning stock) maintain neutral buoyancy at a salinity of 14.5 psu ± 1.2 psu /174/. In periods without major inflows, oxygen depletion of the saline water affects the survival of the eggs. As the Gdansk Deep and Gotland Deep are considerably farther from the saline water inflow from the North Sea, the salinity, oxygen and halocline depth conditions in these areas are more variable than in the Bornholm Deep, which directly affects reproductive success /175//176/. The traditional spawning grounds for cod are shown in Figure 7-27.

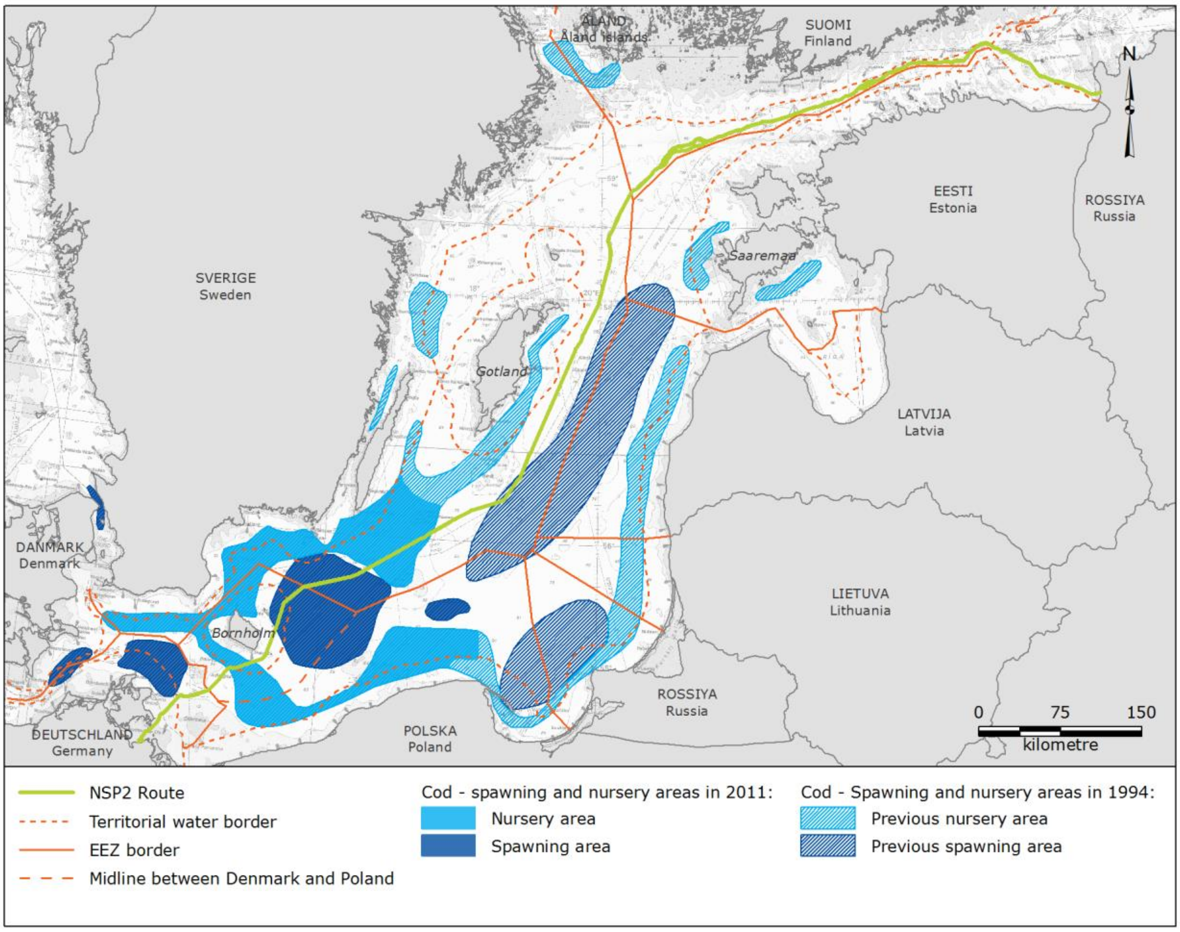


Figure 7-27 Traditional spawning and nursery areas for eastern Baltic cod. During the last decades, cod spawning has taken place only in the southern parts of Bornholm Deep and in Slupsk Furrow (the small area east of the Bornholm Deep) /176/. After the late 1980s, spawning in the Gdansk Deep and the Gotland Deep was almost eradicated /172/ (a larger version of this figure can be seen in NSP2 Atlas Map FI-01).

The time from fertilization until hatching varies between two and four weeks depending on temperature. A few days after hatching, larvae avoid critical oxygen levels by migrating vertically into upper water layers with sufficient light conditions and prey concentrations for feeding /180/. The lack of recovery in recruitment in the mid-1990s, despite improved hydrographical conditions for egg development, was related to poor larval survival apparently due to lack of food availability. A decline in the abundance of the copepod *Pseudocalanus* spp., related to lower salinity, limited the food supply of first-feeding cod larvae /156/. Declining salinity and oxygen concentrations also enhanced the vertical overlap between eggs and clupeid predators in the remaining productive spawning area of the Bornholm Basin. A temperature-related increase in sprat stock further intensified egg predation /156/.

Inter-annual variations in spawning time of cod, defined as the peak in egg abundance, in the Bornholm Basin have been thoroughly clarified in a study /170/. During the 1970s and late 1980s, peak spawning took place between the end of April and mid-June. A remarkable shift in the spawning time to the end of July was observed in the 1990s. The key factors governing the spawning time are water temperature during the period of gonadal maturation, density-dependent processes related to the size of the spawning stock and food availability. The age structure of the spawning stock is also suggested to have an additional effect.

The eastern Baltic cod spawning stock declined from its historically highest level in 1982-1983 to the lowest level on record in 2004-2005 /169/. The decline was caused by reduced reproductive success in combination with increasing fishing pressure.

The Western Baltic cod stock has been decreasing over the last three generations but the decrease has levelled off since the cod management plan was put into action in September 2007. The main threat is overfishing that has continued over a long time.

In order to enable undisturbed spawning, cod fishery in the whole eastern Baltic is regulated by a seasonal closure from 1 July to 31 August. Closure for all fisheries in a specific part of the main spawning area in the Bornholm Deep has been implemented during the main spawning seasons since the mid-1990s. A year-round area closure for all fisheries in specific areas of the Bornholm Deep, the Gotland Basin and the Gdansk Deep was introduced in 2005, aimed at reducing fishing mortality. Since 2006, area closure in the Bornholm Deep has been implemented from 1 May to 31 October /169/.

ICES reports that the eastern Baltic cod stock is still at historically low levels, despite the stock has increased continuously since 2005. At the start of 2012, the spawning stock biomass had recovered to its 1970 level /169/.

The western Baltic cod stock has historically been much larger than what it is today. ICES classify the stock as being at risk of reduced reproductive capacity, suffering from too high fishing pressure /172/. Cod is also classified as vulnerable on the HELCOM red list.

7.9.5.2 Herring (*Clupea harengus*)

Herring occur in large schools throughout the Baltic Sea, with clearly distinct stocks in different areas. Herring tend to make seasonal migrations between coastal archipelagos and open sea areas, staying close to the coast during spring and autumn, while spending summer in productive open sea areas. Older herring move into deeper waters of the open sea during winter, whereas younger individuals tend to remain close to the coast. Herring feed primarily on zooplankton, although older herring may also feed on fish eggs and fry. The abundance and biomass of Baltic herring generally decreased during the last 40 years owing to changes in the amount and composition of zooplankton and overfishing /158//178/. However, the general trend has been reversed albeit slowly, since the beginning of the year 2000 /172/.

Herring populations include both spring and autumn spawners. Previously, autumn-spawning herring dominated the general herring population, but this changed in the 1960s. Since then, spring spawners have dominated the population. Herring spawn in coastal areas in most parts of the Baltic Sea /178/, see Figure 7-28. They are sensitive to low oxygen concentrations and high concentrations of suspended particles.

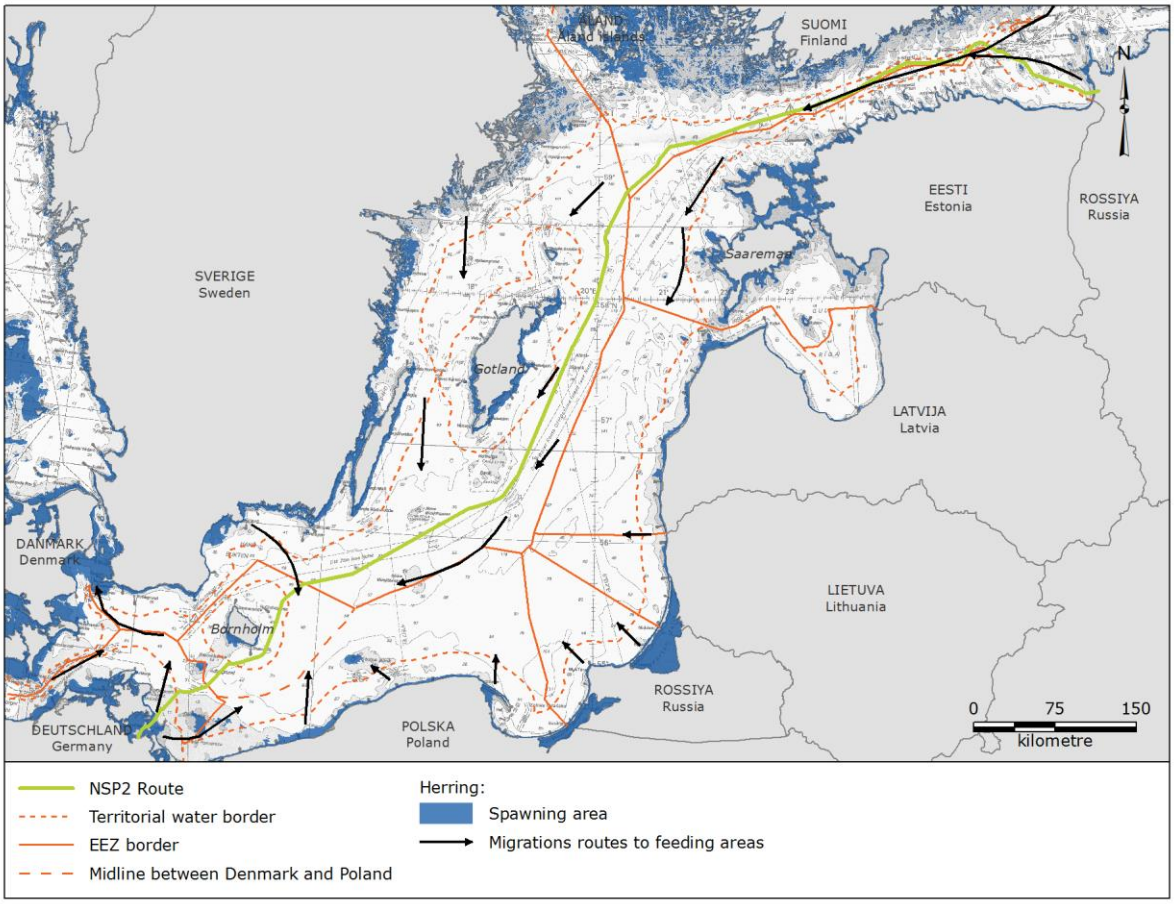


Figure 7-28 Herring spawning areas and migration routes in the Baltic Sea /178/ (a larger version of this figure can be seen in NSP2 Atlas Map FI-02).

7.9.5.3 Sprat (*Sprattus sprattus*)

Sprat lives in schools throughout the Baltic Sea, although they are not as common in the Bothnian Bay. Sprat is an open-sea species that is rarely found along the coast. Sprat migrate in open water areas, seeking out warmer water layers during different seasons and avoiding areas were the water temperature drops to less than 2-3°C. During harsh winters, the distribution of sprat shrinks, entailing an increase in density in some distinct regions. Sprat eats zooplankton as well as cod eggs and fry /178/.

Sprat larvae have a strong preference for the copepod *Acartia* spp. as their main food source. The abundance of *Acartia* has drastically increased since the 1990s in parallel with the increase in temperature. This may have led to generally higher sprat larval survival /169/.

Figure 7-29 shows the distribution of sprat. The spawning of sprat and the distribution of their planktonic eggs are restricted to the central part of the deep basins in the Baltic, with the highest concentration in the upper part of the halocline, typically between 45-55 m. The Bornholm Basin is an especially important spawning ground for sprat /181/. Spawning occurs from February to August, depending on the geographical area /172/. Years of strong larval displacement towards the southern and eastern Baltic coasts indicates weak recruitment conditions, while years of retention within the deep basins are associated with relative recruitment success /167/.

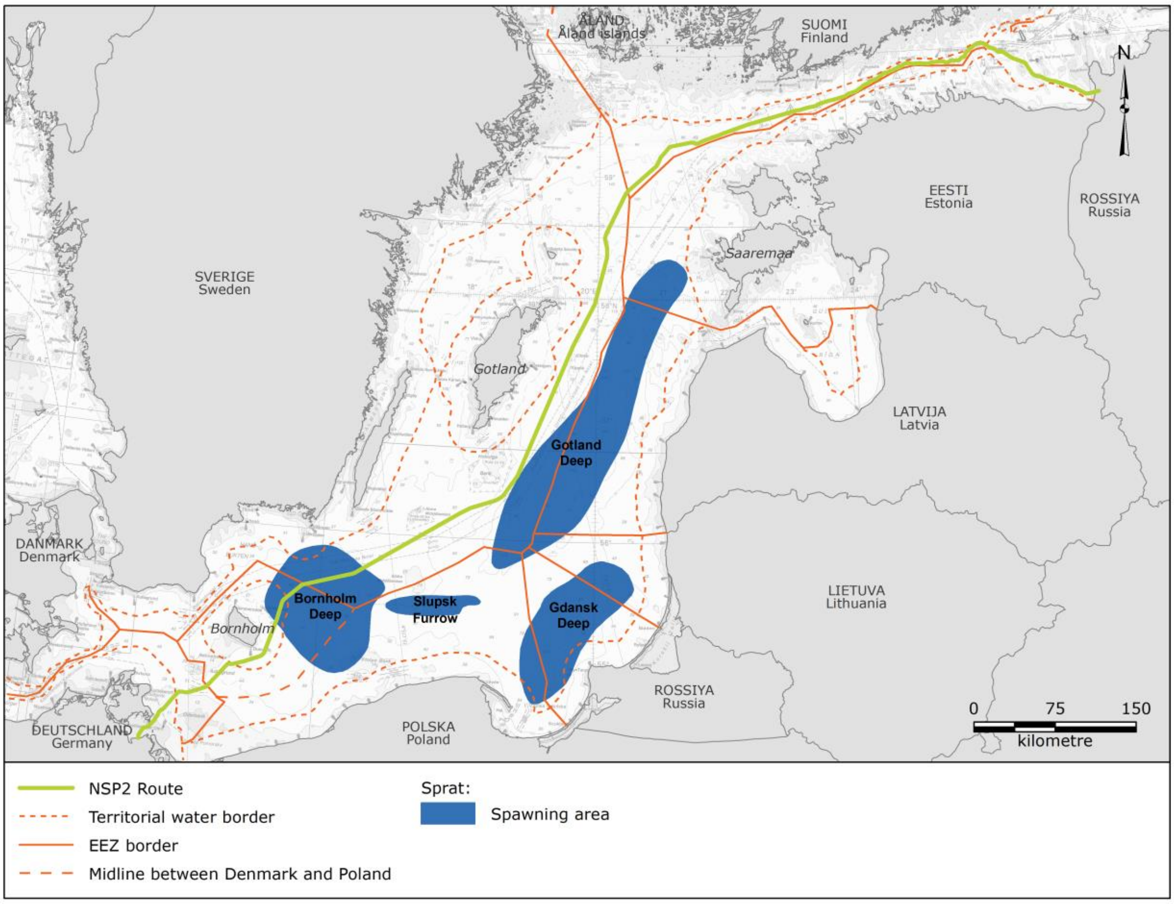


Figure 7-29 Distribution and spawning areas of sprat /182/ (a larger version of this figure can be seen in NSP2 Atlas Map FI-03).

7.9.5.4 Flounder (*Platichthys flesus*)

Flounder inhabit most of the Baltic Proper, except for the deeper parts of the Gotland Deep, and show a wide tolerance to changes in salinity. The flounder species, in general, is the most economically important species among flatfish in the Baltic Sea. Flounder are presently divided into six separate stocks in the Baltic Sea. The stocks are moderately exploited and are stable or slightly increasing in the Eastern Baltic Sea /172/.

There are two ecological types of flounder in the Baltic: one southern, with pelagic eggs, and one northern, with demersal eggs. In the southern Baltic, flounder migrate between coastal feeding areas and spawning areas in the deep basins (spawning period March – June). They have larger, pelagic eggs adapted to floating, despite low salinity. Salinity determines the buoyancy of the eggs, and the pelagic eggs require a minimum salinity of 10 psu in order to float. Furthermore, the success of spawning also depends on oxygen content. Oxygen content below 1 ml/l is critical for egg survival /165/. The other ecological type of flounder occurs in the northern Baltic, where flounder are more stationary and spawn in shallow banks or coastal areas. Their eggs are smaller, more thick-shelled and demersal. The minimum required salinity is lower, only 6-7 psu, and the main spawning period is from May-July. The larvae inhabit the bottom in shallow coastal areas before they metamorphose /165/.

The onset of spawning in the spring is influenced by rising temperatures. Consequently, the spawning period varies across different areas in the Baltic; for example, in the Kattegat, spawning starts in February-April, while in the Gotland Basin spawning occurs in April-May /165/.

7.9.5.5 Plaice (*Pleuronectes platessa*)

Plaice inhabit the western Baltic and are rarely found east of the Bornholm Basin. Plaice are less tolerant to low salinity and low oxygen content than flounder, which affects their distribution patterns.

Fluctuations in abundance are assumed to be mainly caused by migration of plaice from the Kattegat into the western Baltic Sea, but opportunities for successful reproduction of plaice exist regularly in the Bornholm Basin. There is only limited information about the potential effects of salinity on stock development of the Baltic plaice population, but it has been observed that the stock recovered during the 1950s at the same time as major saline water inflows occurred.

7.9.5.6 Turbot (*Scophthalmus maximus*)

Turbot occur in large parts of the Baltic Proper, but their abundance is rather low. Successful spawning is possible in waters with a salinity of 6-7 psu or higher. Spawning takes place in shallow water at depths between 5-40 m. After spawning in the spring, turbot reside in shallow areas during the summer and return to deeper waters in the autumn /184/. Like most flatfish, turbot have pelagic larvae. Turbot feed mainly on demersal fish, bivalves and crustaceans. Because of its high commercial value, turbot is of some importance to the fishery sector.

7.9.5.7 Atlantic salmon (*Salmo salar*)

Salmon make long feeding migrations in the Baltic Sea. Salmon show strong homing behaviour and return to their natal river to spawn, resulting in the development of genetically differentiated stocks. The most important feeding grounds for Baltic salmon stocks are in the southern part of the Baltic Sea. The most important food species for salmon are herring and sprat /163/. The management of salmon in the Baltic Sea is subject to the Salmon Action Plan (SAP) adopted by the International Baltic Sea Fishery Commission in 1997. Fishing for salmon is banned during summer (1 June – 15 September) throughout most of the Baltic Sea.

Altantic salmon is classified as vulnerable on the HELCOM red list.

7.9.5.8 European eel (Anguilla anguilla)

The European Eel is present in the Baltic Proper, and known to migrate from the northern part of the Baltic Proper along the Swedish coast, as well as migrate from the eastern part of the Baltic Sea into the open sea areas, including the waters around Bornholm /185/. Feeding usually takes place in shallow waters, but they may also dive to deeper waters at night /186/.

Eel reproduction is seriously impaired, and that the stock is likely to be severely depleted. ICES recommend that eel fishing be reduced to a level as close to zero as possible in order for the stock to recover. There is no spawning behaviour in the Baltic Sea.

The European Eel is classified as critically endangered according to the HELCOM Red List.

7.9.5.9 Sea lamprey (*Petromyzon marinus*)

Sea lampreys are a parasitic species that is mainly present on rocky bottom habitats or attached to a host. Adults are found in Kattegatt and in the southern Baltic Sea along the coasts, including the waters around Bornholm. Spawning occurs in fresh water, particularly along the coasts in Kattegatt.

Sea lamprey has two stages in its life cycle. As larvae they are buried at the bottom of a stream and feed on small zooplankton and particles filtered from the water. After six to eight years, they go through a metamorphosis where the characteristic mouth with sharp teeth and a circular suction disc evolves. The Sea lampreys then migrate downstream to the sea. Once in marine waters, it attaches itself to increasingly larger fish such as cod and salmon, and feed off their blood and tissues.

Sea Lamprey are classified as vulnerable on the HELCOM red list and are listed in Annex II of the EU Habitat Directive.

7.9.5.10 Sea trout

Sea trout is widely distributed in northern and Western Europe, including the entire Baltic Sea area. Spawning occur in fresh water, and there are in total approximately 1,000 trout rivers in the Baltic Sea area.

Although still numerous, the sea trout populations have been affected by anthropogenic pressures such as migration obstacles, pollution, and aquaculture. The populations in the Bothnian Sea and Gulf of Finland are considered to be in a 'poor' state /183/.

Sea trout are classified as vulnerable on the HELCOM red list.

7.9.5.11 Whiting (*Merlangius merlangus*)

Whiting is a common species in the Kattegat, the western Baltic, the Belt Sea, and the Sound. Spawning predominantly occurs within the Kattegat.

HELCOM has placed Whiting on the list of vulnerable species due to a sharp decline in abundance in the Skagerrak and Kattegat, as well as scarcity of adult individuals in the population as a whole.

7.9.5.12 Other important fish species

Several freshwater species are listed in Table 7-20, including whitefish, grayling, razor-fish, bullhead, asp, and spined loach. Within the Baltic Sea, these are all mainly distributed in the northern and eastern parts where salinity is low.

7.10 Marine mammals

Marine mammals are an important component of the marine food chain and of the ecosystem in the Baltic Sea. Furthermore, a number of marine mammal species have protection status under national/international legislation and are therefore considered an important receptor.

Marine mammal species resident in the Baltic Sea include harbour porpoise (*Phocoena phocoena*), grey seal (*Halichoerus grypus grypus*), ringed seal (*Pusa hispida baltica*) and harbour seal (*Phoca vitulina*). Several other cetacean species such as the minke whale (*Balaenoptera acutorostrata*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), common dolphin (*Delphinus delphis*) and white-beaked dolphin (*Lagenorhynchus albirostris*) are sighted from time to time, mainly in the southern part of the Baltic Sea, although these sightings are not considered frreuqent and they are not native to Baltic waters /189/.

This section describes the biology, distribution and abundance of the three species regularly found in the Danish waters of the Baltic Sea, which comprise the harbour porpoise, grey seal and harbour seal.

7.10.1 Harbour porpoise

This section presents the Baltic Sea population of harbour porpoise, with information on behaviour, reproduction, echolocation and protection status.

7.10.1.1 Population structure and size

Several studies have sought to understand the population structure of harbour porpoises in the north-east Atlantic and particularly in the transition zone between the North Sea and the Baltic Sea. Studies on morphometric skull differences /190/ and genetics /191/ have found that three populations (or subpopulations) may exist in this area, namely (1) in the Baltic Proper (henceforth called the Baltic Sea population), (2) in the western Baltic, the Belt Sea and the Southern Kattegat (henceforth called the Belt Sea population) and (3) in the Skagerrak and North Sea.

Two visual surveys (albeit with low resolution in coverage) of population size in the Baltic Proper have been conducted. Approximately 599 (95% confidence interval (CI) 200-3,300) individuals were observed in 1995 /192/, and 93 individuals (95% CI 10-460) were observed in 2002 /193/. In 2016, the Static Acoustic Monitoring of Baltic Sea Harbour Porpoise (SAMBAH) project ended after having deployed 304 acoustic data loggers (C-PODs) for two years covering all Baltic EU countries. The project estimated the remaining number of porpoises in the Baltic Proper to be approximately 500 (95% Cl 80-1,100) /194/. The severe decline of the harbour porpoise population in the Baltic Sea makes it the smallest population of harbour porpoise in the world /195/. The harbour porpoise is listed as "critically endangered" by the International Union for Conservation of Nature and Natural Resources (IUCN Red List).

For comparison, the total number of harbour porpoises in the north-east Atlantic continental shelf waters was estimated to be 375,358 (95% CI=256,304–549,713) /196/. This number includes all populations of porpoises in the North Sea as well as the majority of the spatial extent of the Belt Sea population.

7.10.1.2 Distribution

Harbour porpoises are widely, but unevenly, distributed throughout European waters. The distribution is presumably linked to the distribution of prey (e.g. /197/), which in turn is linked to parameters such as hydrography and bathymetry /198/.

The porpoise detections from the SAMBAH project /194/ were analysed as porpoise positive seconds (PPS) per day and divided into two seasons, summer and winter (Figure 7-30 and Figure 7-31, respectively).

In Figure 7-30 each acoustic station is indicated by a dot. If porpoises were detected, the dot is black and scaled in size to depict the density (PPS per day). If no porpoises were detected, the station is indicated by an white circle. In the summer period, the data could be divided into the two population groups (i.e. east and west of the determined population border). Green indicates the area inhabited by part of the Belt Sea population extending to the east, and blue is believed to contain the breeding distribution of the remaining Baltic Sea porpoise population.

During the breeding period in summer, porpoises in the Baltic Proper concentrate around the shallow banks south of the Gotland and Öland islands (Figure 7-30). There is a clear drop in the density of harbour porpoises as you move away from this area in all directions, this illustrates the isolation of this population. The highest density of the Baltic Sea harbour porpoise population is found around the Midsjö Banks, south of Gotland, in summer. According to the results from the recently finished EU LIFE+ SAMBAH project, this area is considered a population hotspot and the most important area during the breeding season for this population of porpoises /194/.

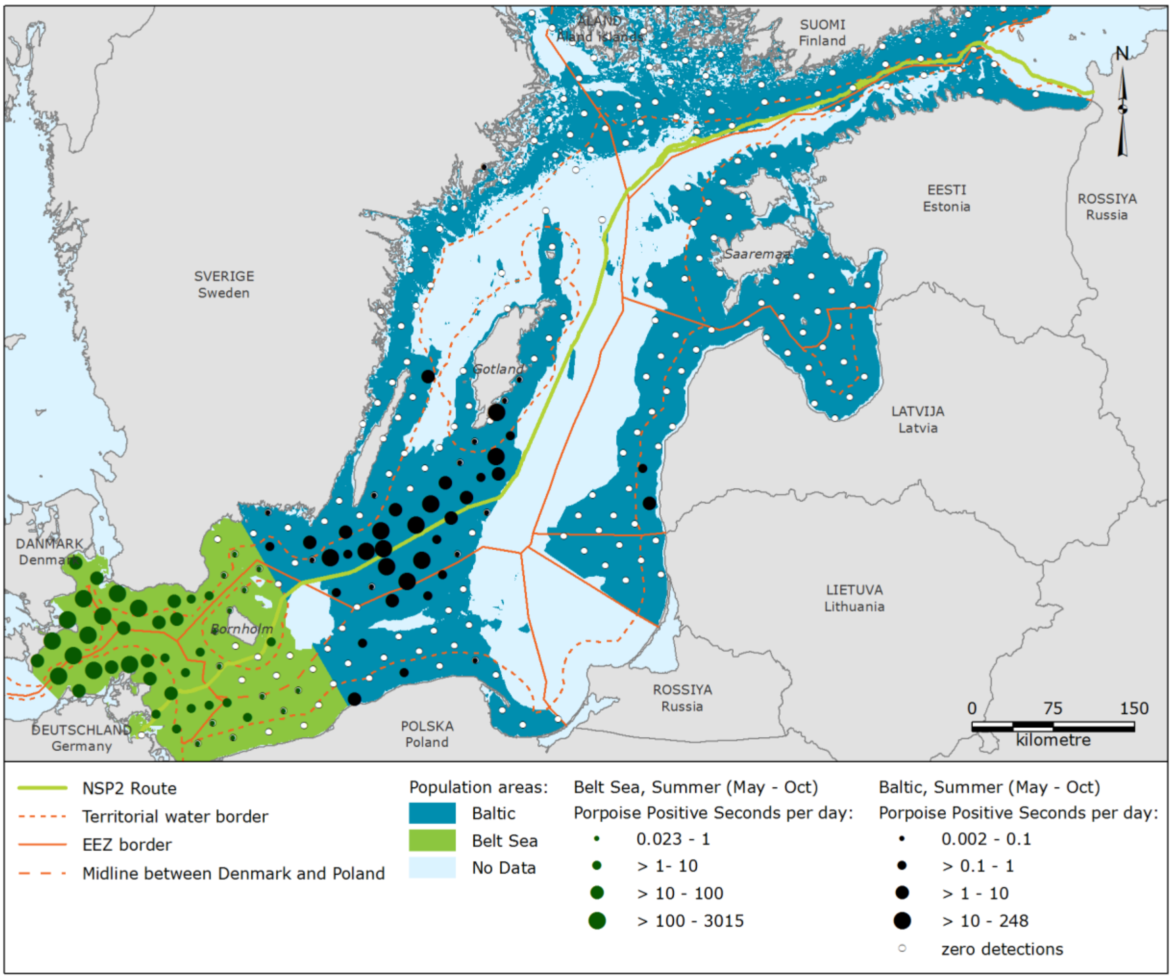


Figure 7-30 Summer distribution of porpoises in the Baltic Sea. Data source: SAMBAH /194/.

During winter, porpoises are more widespread in the northern part of the Baltic Sea (Figure 7-31). Each acoustic station is indicated by a dot. If porpoises were detected, the dot is black and scaled in size to depict the density (PPS per day). If no porpoises were detected, the station is indicated by an white circle. In winter, it is not possible to separate the two populations, and the blue area is believed to contain a mixture of the Baltic Sea porpoise population and the Belt Sea porpoise population.

Overall, the areas around the Danish section of the proposed NSP2 route are characterised by a relatively low abundance of harbour porpoises.

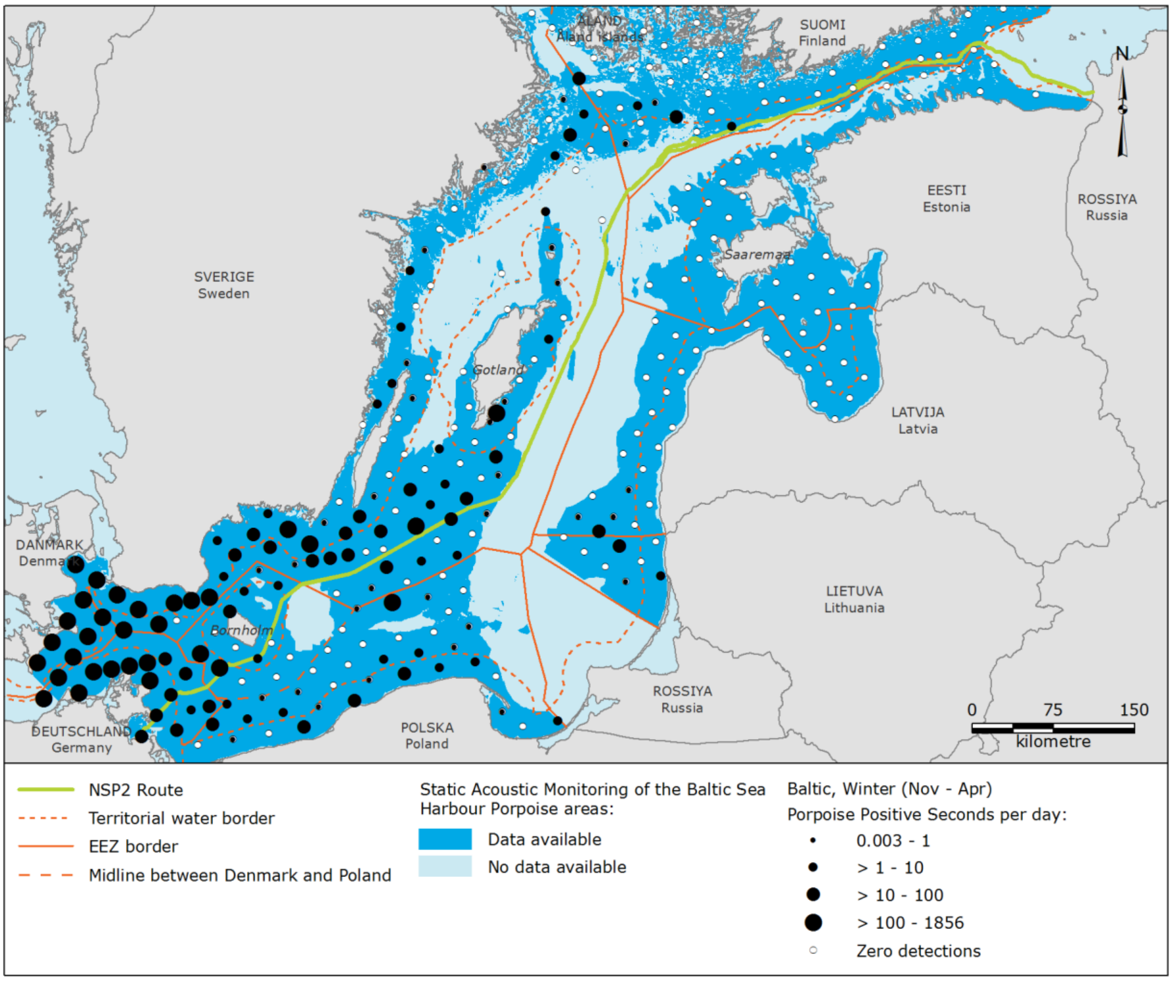


Figure 7-31 Winter distribution of porpoises in the Baltic Sea. Data source: SAMBAH /194/.

7.10.1.3 Behaviour and reproduction

In the Baltic, harbour porpoises have a maximum length of 1.8 m and a maximum weight of up to 90 kg. They are relatively short-lived, with a maximum recorded lifetime in the wild of 23 years. Harbour porpoises are opportunistic feeders, with a preference for herring and sprat.

The breeding period of Baltic harbour porpoises begins in mid-June and ends in late August. Ovulation and conception typically take place in late July and early August /199/, and the females give birth to a calf in early summer. Calves are sighted throughout their range and areas of high porpoise density may therefore also be considered to be important for reproduction /200//201/. Consequently, no specific breeding areas for harbour porpoises have been identified in the Danish sector of the Baltic Sea.

7.10.1.4 Echolocation and hearing

Harbour porpoises have good underwater hearing and use sound actively for navigation and prey capture (echolocation). Harbour porpoises produce short ultrasonic clicks (130 kHz peak frequency, 50-100 μs duration; /202//203/) and are able to orient and find prey in complete darkness. Data from porpoises tagged with acoustic data loggers indicate that they use their echolocation almost continuously /204//205/. Their hearing sensitivity is extremely high and covers a vast frequency range (Figure 7-32, /206//207//208//209/). The audiogram (Figure 7-32) shows the hearing threshold: porpoises can only hear sound above the threshold for each frequency. The best ability to detect sound is at frequencies with the lowest threshold (the highest sensitivity).

Mammals do not hear equally well over their entire range of hearing. For sound intensities close to the hearing threshold, the audiogram is a good approximation of the perceived sound levels (the loudness of the sound). In marine mammals, there is a great difference in sensitivity between the frequencies of best hearing and those close to the cut-off frequencies.

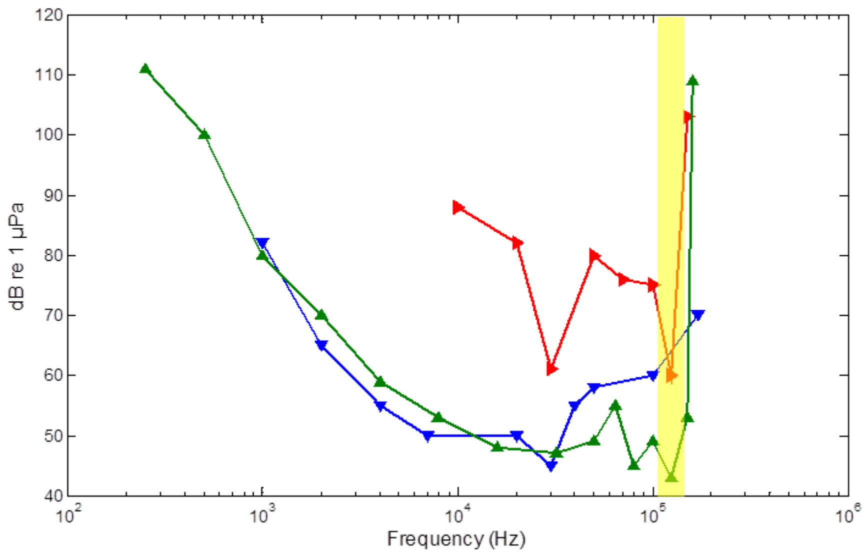


Figure 7-32 Audiograms for harbour porpoises modified from /209/ (green), /206/ (blue) and /207/ (red). The audiogram also shows the frequency range of harbour porpoise vocalisation (yellow).

7.10.1.5 Protection

A number of international treaties, agreements and laws have been enacted in order to protect the harbour porpoise. In northern European waters, the species has been listed in Annex II and IV of the Habitats Directive 92/43/EEC, Annex II of the Bern Convention, Annex II of the Bonn Convention and Annex II of the Washington Convention. Furthermore, the harbour porpoise is covered by the terms of ASCOBANS, a regional agreement under the Bonn Convention and HELCOM. In Denmark, the species is furthermore protected under Order 867 dated 27/06/2016 /210/.

Protected areas for marine mammals are described in section 7.13.

7.10.2 Harbour seal

This section presents the Baltic Sea population of harbour seal, with information on behaviour, reproduction, echolocation and protection status.

7.10.2.1 Population structure and size

Based on genetic data and satellite telemetry, harbour seals in the Baltic region have been split into three management units or sub-populations, among which there is at least partial reproductive isolation: (1) Kalmarsund (between Öland and the Swedish mainland), (2) the south-western Baltic (along the southern Danish and Swedish coasts) and (3) the Kattegat /211//212/. The Kalmarsund population comprises approximately 1,000 individuals /213/, the south-western population comprises approximately 1,500 individuals, and the Kattegat population comprises approximately 7,800 individuals /214/.

7.10.2.2 Distribution

Harbour seals are found in temperate and arctic waters of the Northern Hemisphere. Haul-out sites (also called colonies) are land localities occupied by seals during periods of mating, giving birth and moulting. Haul-out sites for harbour seals are well known and do not change between years. Annual counts are made during the moult in August. The knowledge on abundance and density of seals is extensive with respect to the locations of the haul-out sites, which are shown in Figure 7-33. A tagging study showed that harbour seals travel no more than 27 km from the haul-out sites /215/, and the zone of regular occurrence (blue areas) is taken as the maximum distance from the tagging site.

In the Baltic Sea, harbour seals are only found in Kalmarsund between Öland and the mainland of Sweden and in the south-western Baltic concentrated around the Rødsand sandbar (7 km west of Gedser in Denmark) and Falsterbo and Saltholm in the Sound.

The proposed NSP2 route through Danish waters in the Baltic Sea does not cross any areas with colonies or regular occurrence of harbour seals.

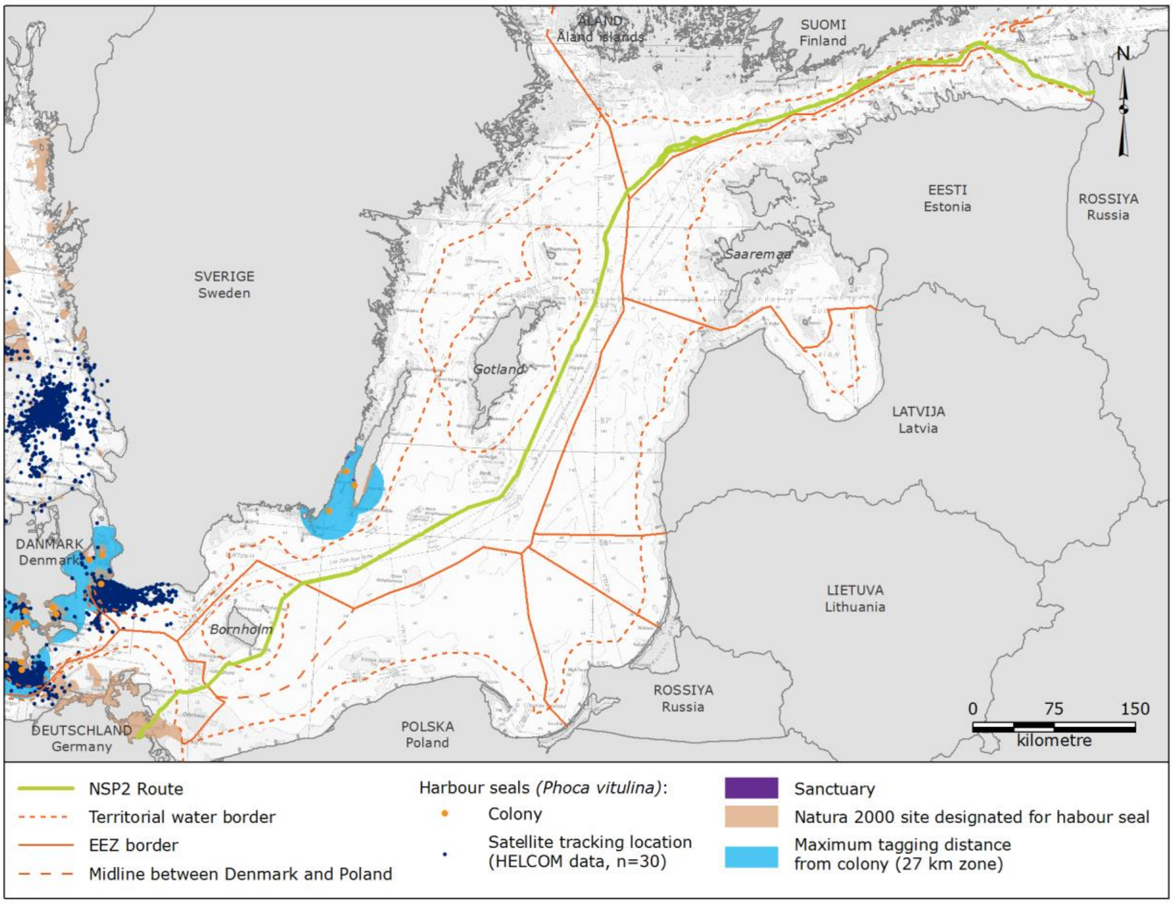


Figure 7-33 Haul-out sites (colonies) in the Baltic used by harbour seals for resting, breeding and moulting. Global positioning system (GPS) tracking of grey seals in the Danish sector is indicated by blue dots. No satellite tracking has been undertaken in the Swedish colonies. Data source: HELCOM Seal Database /216/.

7.10.2.3 Behaviour and reproduction

The harbour seal is a relatively small seal with an adult weight of approximately 65-140 kg. Harbour seals are opportunistic predators. They feed mainly on benthic fish but can catch and eat all fish species. Moulting occurs in August, when seals spend more time on land to develop their new fur.

Females are believed to give birth once a year on land between May and June, with a gestation period of 11 months. The pup suckles for about three to four weeks, after which it is left to feed on its own. Harbour seal pups shed their embryonic fur (lanugo) before birth and are thus born with adult fur. Pups are able to swim and dive just after birth. Mating occurs immediately after the end of suckling and takes place in the water. Little is known on the exact circumstances surrounding mating, however as noted above, mating and periods of birthing are focused on haul out sites/colonies (as shown in Figure 7-33).

7.10.2.4 Hearing

Seals have ears that are well-adapted to an aquatic life. These adaptations include cavernous tissue in the middle ear, which allows for balancing the increased pressure on the eardrum when the animal dives /217/ and also serves as a separate pathway for sound to the middle ear in water.

Figure 7-34 shows an audiogram of harbour seals, demonstrating that they have good underwater hearing in the range from a few hundred Hz to approximately 50 kHz.

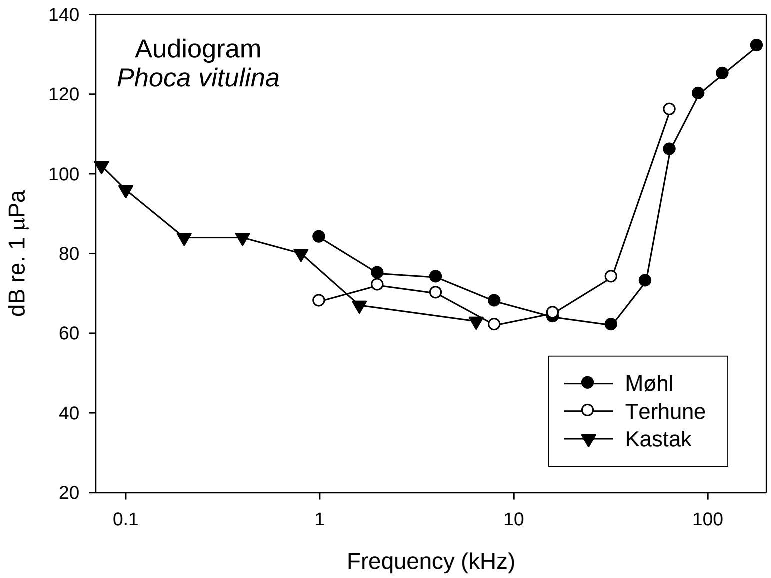


Figure 7-34 Audiograms of three harbour seals, showing the threshold of hearing under quiet conditions at frequencies in the range from 80 Hz to 150 kHz. Data from. The legend Møhl, Terhune and Kastak refers to results from reference /218/, /219/and /220/, respectively.

7.10.2.5 Protection

Harbour seals are protected under the EU Habitats Directive and the Convention for the Protection of Migratory Species (Bonn Convention). In addition, they are fully protected under national legislation. In addition, the Kalmarsund population is listed as endangered by the IUCN. The harbour seal is listed on the EU Habitats Directive Annex II, which means that it should be protected via the designation of special areas of conservation. For seals, these areas are primarily placed in connection to important haul-outs on land. In Denmark, the species is furthermore protected under Order 867 dated 27 June 2016 /210/.

Protected areas for marine mammals are described in section 7.13.

7.10.3 Grey seal

This section presents the Baltic Sea population of grey seal, with information on behaviour, reproduction, echolocation and protection status.

7.10.3.1 Population structure and size

There are three separate populations of grey seal in the world. One of them is the Baltic grey seal, which is found in the Baltic Proper, in the Bothnian Sea and in the Gulf of Finland; the other two populations live in the north-east and north-west Atlantic, respectively.

One hundred years ago, the grey seal population in the Baltic Sea comprised 80,000-100,000 individuals, while in the 1970s it had decrease to approximately 4,000 due to hunting and reproductive disorders which have been connected to pollution by organochlorides /221/. Abundance based on photo-identification in 2000 revealed an estimate of 15,600 individuals, while an aerial survey in 2004 observed 17,640 grey seals on land /222/. Studies estimate that the total population in the Baltic in 2014 was almost 40,000 /213/.

7.10.3.2 Distribution

The Baltic grey seals are distributed from the northernmost part of the Bothnian Bay to the south-western waters of the Baltic Proper (Figure 7-35). Generally, during the breeding period, the seals dwell on drift ice in the Gulf of Riga, the Gulf of Finland, the Northern Baltic Proper and the Bothnian Bay or on the rocks in the north-western Baltic. Similar to harbour Seals, haul-out sites/colonies are land localities occupied by grey seals. The locations of these sites are shown in Figure 7-35.

Satellite tracking of grey seals has shown that this species moves over several hundreds of kilometres in the Baltic Sea. There are indications that seasonal migrations are closely related to the species requirements for feeding and suitable breeding habitats /215/. Typically, however, the animals feed locally, foraging just offshore and adopting a regular pattern of travelling between local feeding sites and preferred haul-outs /223//224/.

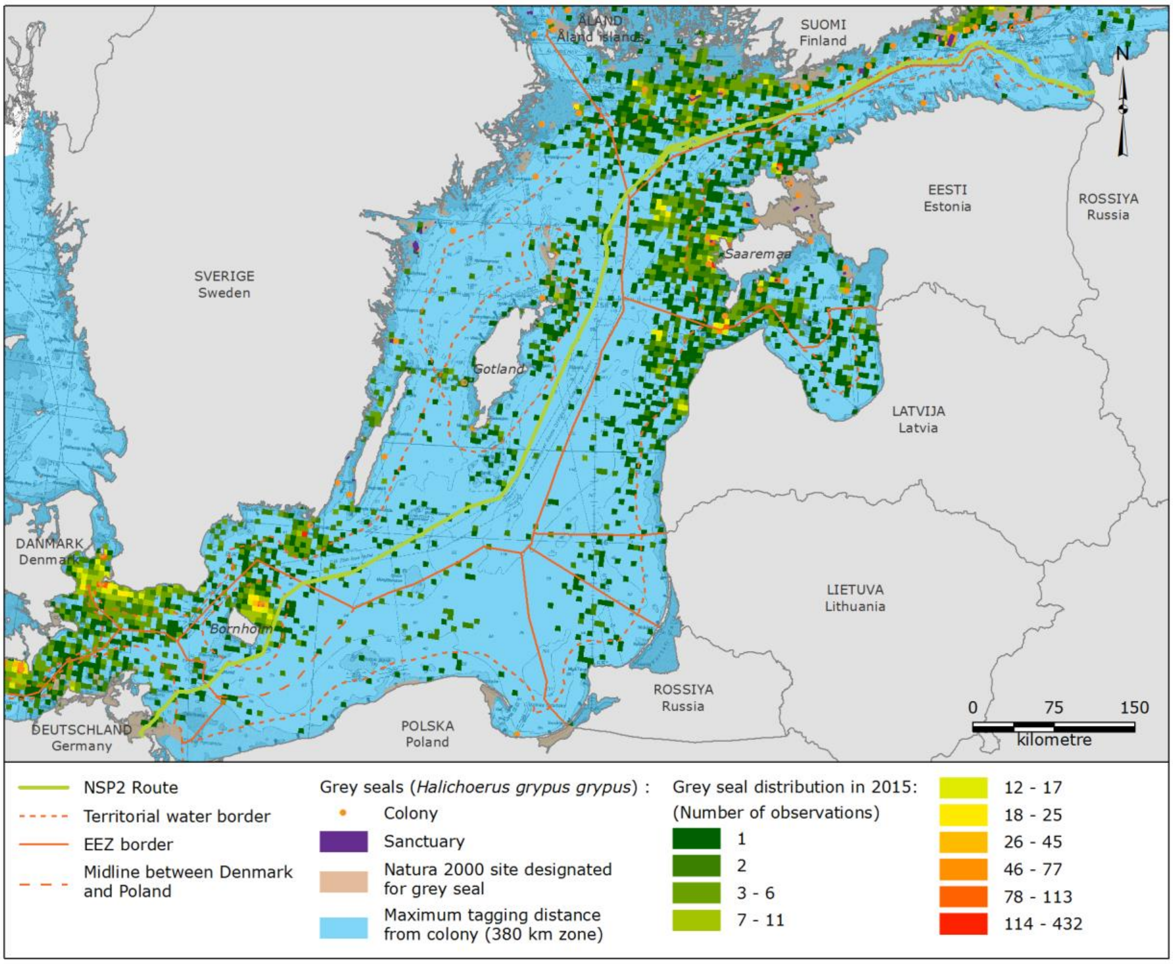


Figure 7-35 Haul-out sites (colonies) used by grey seals for resting, breeding and moulting. Global positioning system (GPS) tracking of grey seals is indicated by blue dots. Data source: HELCOM Seal Database /216/.

In the Danish part of the Baltic, the number of grey seals has increased drastically over the last decade (Figure 7-36). The grey seal colony in closest vicinity to the proposed NSP2 route is at Christiansø, north-east of Bornholm, approximately 13 km from the proposed NSP2 route. This colony is, at present, the largest Danish grey seal colony and in 2011-2014, 33%-99% of all observed grey seals in Danish waters were detected here /214/.

7.10.3.3 Behaviour and reproduction

Grey seals feed on many species of fish in cold, open waters and breed in a variety of habitats where disturbance is minimal, such as rocky shores, sandbars, sea ice and islands. Birth takes place on pack ice between February and March. Some grey seals, however, also pup at uninhabited islets, most notably in Estonia and in the Stockholm Archipelago as well as in Denmark (Rødsand sandbar). Males follow the female closely after she has given birth, in order to mate with her as soon as nursing has ended. Pups are born in autumn. Within a month or so they shed the pup fur, grow dense waterproof adult fur, and leave for the sea.

Grey seals are gregarious and gather for breeding, moulting and hauling out. They primarily haul out in coastal areas, in winter on drift ice close to open water and in summer preferably on uninhabited islands, outer islets and rocks. During the moulting period, they dwell on rocks and islets and sometimes on the last drift ice in the Bothnian Bay.

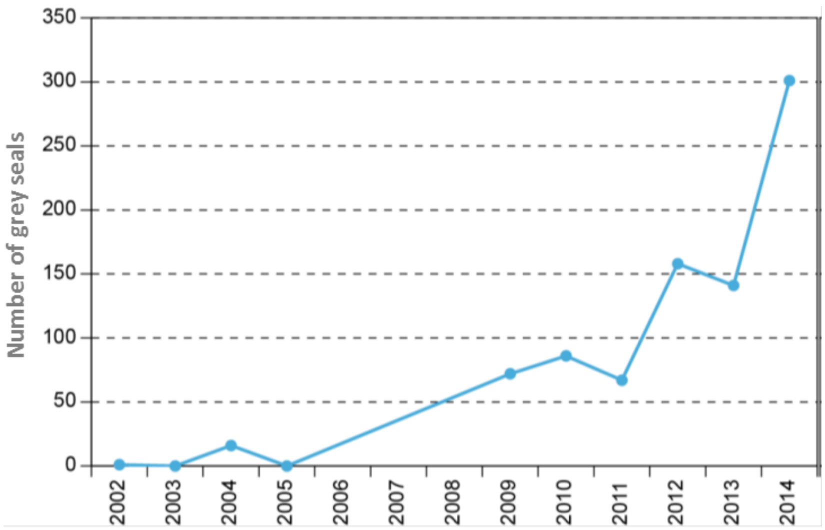


Figure 7-36 Number of grey seals counted during their moulting period (May-June) in the Danish part of the Baltic Sea 2002-2014 /214/.

7.10.3.4 Protection

The grey seal is a protected species listed in Annex II and Annex V of the EC Habitats Directive and Annex III of the Bonn Convention. The Baltic population of the grey seal is also listed as endangered by the IUCN. In Denmark, the species is furthermore protected under Order 867 dated 27 June 2016 /210/.

Protected areas for marine mammals are described in section 7.13.

7.10.4 Overview of critical periods for Baltic Sea mammals

The most vulnerable periods for seals in the Baltic Sea is during their moulting, breeding and lactation periods. Harbour porpoises are also vulnerable during the breeding period, but the calves may be vulnerable throughout the first year and especially in the first period after leaving their mother. Table 7-21 summarises the most critical periods for Baltic Sea marine mammals.

Table 7-21 Critical periods for marine mammals and countries around the Baltic Sea. Countries are defined as "countries in which the species distribution overlaps with the NSP2 route and potential impact area"

Species	Period		Country
	Breeding and lactation	Moulting	
Harbour porpoise	May-March (nursing persists throughout the following year)	-	Sweden, Denmark, Germany, Finland, Poland
Grey seal	February-March	May-June	Finland, Estonia, Sweden, Denmark, Poland, Russia, Germany
Harbour seal	May-July	August	Sweden

7.11 Birds

Birds are an important component of the marine food chain and of the ecosystem in the Baltic Sea. Furthermore, a number of bird species have protection status under national/international legislation and birds are therefore considered an important receptor.

The Baltic Sea is an important area for numerous seabird species, especially staging seabirds. Seabirds comprise both pelagic species (e.g. gulls (*Laridae*) and auks (*Alcidae*)) and benthic feeders (e.g. dabbling ducks, sea ducks, mergansers (*Anatidae*) and coots (*Rallidae*)) /110/. In 2006, the total number of waterbirds in the Baltic Sea was 10.2 million during winter, 9.8 million during spring, 3.9 million during summer and 5.8 million during autumn /225/. Thus, in terms of numbers, the Baltic Sea is relatively important as a wintering and staging area for seabirds and as a migration route, especially for waterfowl, geese and waders nesting in the Arctic tundra. In spring and autumn, the birds use the coastal areas in the Baltic Sea for resting and staging on their migration to and from their nesting grounds. During late summer and early autumn, many of the waterbirds congregate for moulting in particular areas with easy access to optimal feeding grounds. During this moulting period the birds are generally unable to fly.

Concerning wintering and staging seabirds, the majority of the species are associated with relatively shallow water (<30 m) including lower sub-littoral areas, offshore banks and lagoons. The deeper part of the littoral zone is less important to seabirds. The distribution of seabirds is also affected by proximity to human activities in the shallow areas. A lower number of birds forage in the more open and deeper parts of the Baltic Sea where the main part of the pipeline is situated. These feeding grounds are mainly used by pelagic-feeding species such as razorbill (*Alca torda*), guillemot (*Uria aalge*), herring gull (*Larus argentatus*), common gull (*Larus canus*) and great black-backed gull (*Larus marinus*).

7.11.1 Important Bird and Biodiversity Areas (IBAs)

IBAs are sites of international significance for the conservation of birds and other nature. An IBA does not necessarily support protected birds, but are considered of international importance for birds and generally supports significant numbers of birds in general, or of a particular species. To be designated as an IBA, an area must meet one or more of the following criteria:

- Hold significant numbers of one or more globally threatened or restricted-range bird species;
- Hold biome-restricted assemblages of birds (that is, species restricted to a specific area);
- Regularly hold >1 % of the flyway population of one or more congregatory seabird species.

Two IBAs, DK079 Ertholmene north-east of Bornholm and DK120 Rønne Banke south of Bornholm, are located within Danish waters of the Baltic Sea. Ertholmene is also a designated Natura 2000 site (see section 7.13) as well as a Ramsar site (see section 7.12).

An increasing number of IBAs are under threat from expanding human activities. IBA DK120 Rønne Banke is characterised as an "IBA in Danger". IBAs in danger are identified by BirdLife Partners and include sites at "particularly high risk of losing their natural value, owing to intense threats and inadequate protection or management" /231/.

IBAs in Danish waters in the vicinity of the project area, including key bird species, season of stay and IBA criteria are shown in Table 7-22. IBA areas within the Danish part of the project area are presented in Figure 7-37.

Table 7-22 The Danish IBAs DK79 Ertholmene and DK120 Rønne Banke in the vicinity of the project area with key bird species, season of stay and distance to the planed pipeline route.

IBA	Species	Season	IBA criteria	Status on Danish Red list /228/	Status on Birds Directive /227/	Distance to NSP2 route
DK079: Ertholmene east of Born-holm	Guillemot (*Uria aalge*)	B, W	A4i, B1i, C3	NT	M	13 km
	Razorbill (*Alca torda*)	B, W	A4i, B1i, C3	NT	M	
DK120: Rønne Banke	Common scoter (*Melanitta nigra*)	P	A4i, B1i, C3	-	M	3-17 km for most of the route. For the final 10 km of the NSP2 route the distance is 0 km = crossing
	Velvet scoter (*Melanitta fusca*)	p	A4i, B1i, C3	-	M	
	Long-tailed duck (*Clangu-la hyemalis*)	P	A4i, B1i, C3	-	M	
	Red-breasted mer-ganser (*Mergus serrator*)	P	A4i, B1i, C3	LC	M	
	Red-necked grebe (*Podi-ceps grisegena*)	P	A4i, B1i, C3	LC	M	
	Great crested grebe (*Podiceps cristatus*)	P	A4i, B1i, C3	LC	Annex I	
	Horned grebe (*Podiceps auritus*)	P	A4i, B1i, C3	RE	Annex I	
	Black guillemot (*Cepphus grille*)	P	A4ii, B1i, C3	LC	M	

Season:
B=breeding
W=wintering
P=passage (migrating birds)

IBA criteria:
A4i Congregations – site known or thought to hold, on a regular basis, >1% of a biogeographic population of con-gregatory waterbird species.
A4ii Congregations – site known or thought to hold, on a regular basis, >1% of a global population of congregatory seabird or terrestrial species.
B1i European congregations – site known or thought to hold ≥1% of a flyway or other distinct population of a wa-terbird species.
C3 Congregations of migratory species not threatened at the EU level – site is known to regularly hold at least 1% of a flyway population of a migratory species not considered threatened at the EU level (as referred to in Article 4.2 of the EC Birds Directive) (not listed on Annex I of the EU Birds Directive).

Status on Danish Red List:
NT: Near threatened
LC: Least concern
RE: Regionally extinct
"-" Not on the Danish Red List

Status in birds directive:
M: migratory species designated in Natura 2000 sites relevant for NSP2.

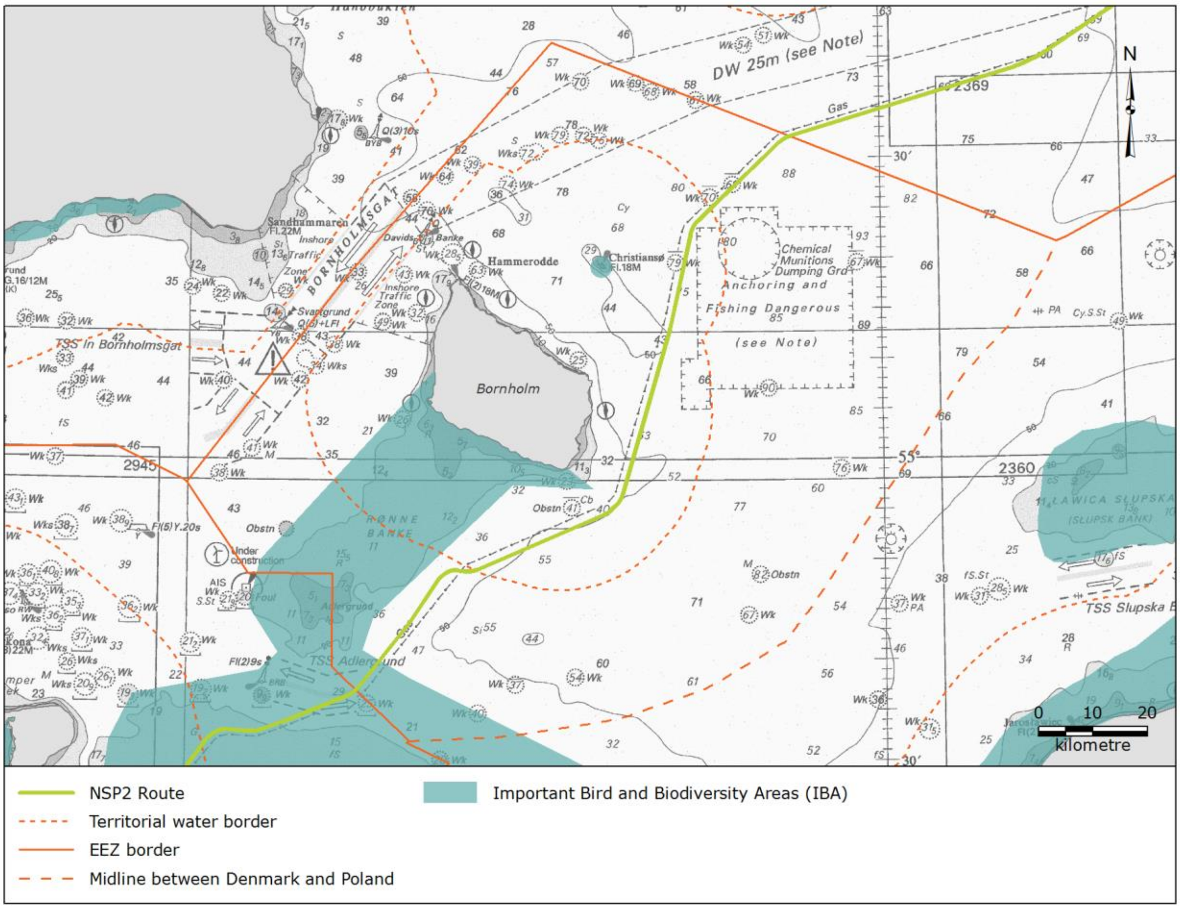


Figure 7-37 IBAs present in Danish waters of the Baltic Sea.

7.11.2 Seabirds in the Danish sector of the Baltic Sea

Information concerning distribution and abundance of waterbird species outside the protected areas is sparse. However, based on a census of the wintering waterbird population covering the Baltic Sea in 2007-2009, a total of 14 species were observed within the Danish EEZ (at Rønne Bank and along the coasts of Bornholm) /226/. The most abundant species by far was the long-tailed duck (*Clangula hyemalis*), with approximately 12,000 registered individuals, mainly at Rønne Bank. All species observed in the Danish EEZ represented less than 1% of the Baltic population. Information on observed species, abundance and conservation status is presented in Table 7-23.

Table 7-23 Abundance of waterbirds observed during winter surveys in 2007-2009, including status on the Danish Red List /226/.

Species	Average number of wintering birds** 2007-2009	Relative number of the Baltic population (%)	Status on Danish Red List /228/	Status on Bird Directive /227/
Long-tailed duck (*Clangula hyemalis*)	12,000	0.81	-	M
Red-throated diver (*Gavia stellata*) and black-throated diver (*Gavia arctica*)	50	0.58	-	Annex I
Great cormorant (*Phalacrocorax carbo*)	138	0.26	LC	M
Mute swan (*Cygnus olor*)	70	0.05	LC	M
Mallard (*Anas platyrhynchos*)	2,472	0.97	LC	M
Common pochard (*Aythya ferina*)	42	0.14	LC	M
Tufted duck (*Aythya fuligula*)	1,334	0.28	LC	M
Greater scaup (*Aythya marila*)	3	0.00	NA	M
Common goldeneye (*Bucephala clangula*)	73	0.04	NT	M
Smew (*Mergus albellus*)	2	0.02	-	Annex I
Red breasted merganser (*Mergus serrator*)	21	0.13	LC	M
Goosander (*Mergus merganser*)	24	0.04	VU	M
Common coot (*Fulica atra*)	241	0.01	LC	-

LC: Least concern.
VU: Vulnerable.
NT: Near threatened.
NA: Not applicable.
- Not on the Danish Red List.
** Wintering birds includes staging and migrating (passage) birds.

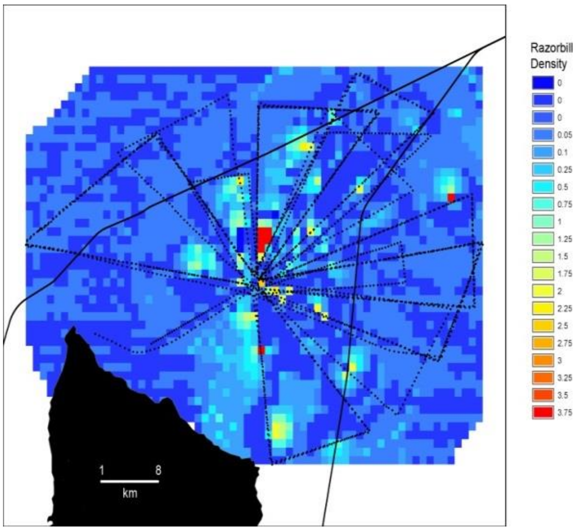
Status in birds directive:
M: migratory species designated in Natura 2000 sites relevant for NSP2.

It should be noted that not all of the waterbird species present in the Danish part of the project area are included in the study summarized in Table 7-23 /226/. Only birds observed at the defined transect for surveys are included. Other species are presented below, based on information from the Important Bird and Biodiversity Areas (IBAs), and some species are presented in the section covering the Natura 2000 sites, see section 7.13.

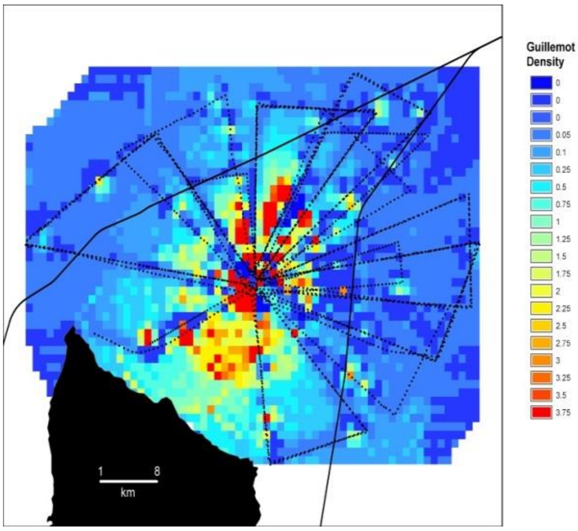
In addition, Ertholmene (approximately 13 km north of NSP2 route) holds one of the largest breeding populations of common eider (*Somateria mollissima*) and herring gull (*Larus argentatus*) in Denmark.

7.11.2.1 Foraging distribution of two seabird species at Ertholmene

Baseline studies of foraging distribution of the two Natura 2000 designated bird species, razorbill and guillemot, were carried out as part of the NSP baseline studies between May and July 2008 /229/. The study was designed using ship-based line transect methodology to determine the mean location of the main feeding area of the two target species during the breeding season. The study involved observation by two experienced observers at six different line transects (dotted lines in Figure 7-38) during seven individual field trips.



A density of foraging razorbills



A density of foraging Guillemots

Figure 7-38 Density of foraging razorbills (left) and guillemots (right) in the summer of 2008. Colour gradients refer to the density (number of individuals) of each bird species. Black dotted lines show the line transects surveyed. The black area represents Bornholm /229/.

Results from the study revealed a high-density foraging area 20 km north-east of the razorbill and guillemot colonies on Ertholmene. The average density of razorbills and guillemots was approximately 10 and 20 birds per square kilometre, respectively. The high-density areas were relatively small for razorbills (radius 6 km) and large for guillemots (radius 20 km) /229/.

7.11.2.2 Winter and summer abundances between Rønne Bank and Oder Bank

The abundance and distribution of seabirds were also investigated as part of the NSP baseline studies in Rønne Bank and Oder Bank (see Figure 7-39) in winter (February and March 2007) and in summer (July and September 2006). Birds were counted in transects from ships (winter surveys) or aircraft (summer surveys) /230/.

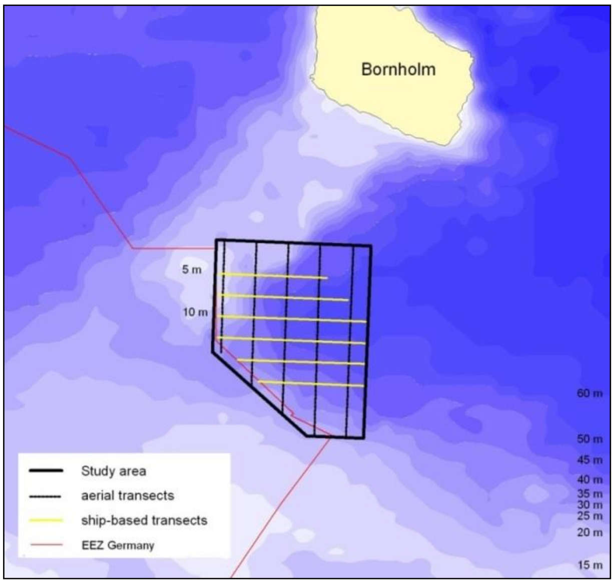


Figure 7-39 Study area of winter and summer abundances of waterbirds south of Bornholm /230/.

Winter numbers (ship-based surveys)

Density and total estimated number of the observed bird species during the winter are summarised in Table 7-24.

Table 7-24 Density and estimated total number of seabirds during winter 2007 /230/. Protection status is shown in Table 7-23 and Table 7-22.

Species	6-7 February 2007		3-4 March 2007	
	Density birds/km^2	Estimated total number	Density birds/km^2	Estimated total number
Long-tailed duck (*Clangula hyemalis*)	25.9	16,376	10.8	6,823
Velvet scoter (*Melanitta fusca*)	0.37	234	3.5	2,227
Common scoter (*Melanitta nigra*)	0.0	0	0.0	0
Divers (*Gavia arctica* and *G. stellata*)	0.06	39	0.22	140
Razorbill (*Alca torda*)	0.0	0	0.0	0
Guillemot (*Uria aalge*)	0.44	281	0.06	37

Long-tailed ducks (*Clangula hyemalis*) were by far the most abundant species in the area. During the winter surveys, high densities of long-tailed ducks (*Clangula hyemalis*) were observed in the shallow parts of Rønne Banke at <20 m water depth. Lower densities were observed on the adjacent slopes. Numbers in March were significantly lower than in February, indicating an early start of spring migration or movements to other habitats. The same development was observed for guillemot (*Uria aalge*).

Numbers of velvet scoter (*Melanitta fusca*) and Divers (*Gavia arctica* and *G. stellate*) were significantly higher in March than in February. Conversely, the common scoter (*Melanitta nigra*) and razorbill (*Alca torda*) were not observed.

Summer numbers (aerial surveys)

Common scoter and guillemot were the only species present during the July and August 2006 surveys. Two common scoters were observed on 19 July 2006 in a single grid cell, and no birds were present on 10 September 2006. The July observation may be regarded as a case of migration through the study area. The density and total estimated number of guillemot during the summer are summarised in Table 7-25.

Table 7-25 Density and estimated total number of seabirds during summer 2006 /230/.

Species	July/August 2006		10 September 2006	
	Density birds/km^2	Estimated total number	Density birds/km^2	Estimated total number
Guillemot (*Uria aalge*)	3.06	2428	0.91	723

German aerial surveys revealed that summer adult chicks of guillemot (possibly also razorbill) from the colony near Christiansø congregate in the southern part of Rønne Bank /230/. In July 2006, more than 33% of the guillemots from this colony may have been present in the study area. This corresponds well with the results of Danish surveys that did not observe immatures in the study area for foraging areas for razorbills and guillemots see section 7.11.2.1 and /229/. Besides the main moulting and post-fledging areas, both species are believed to be found offshore outside the study area /229/.

Other surveys

Ship and airplane surveys were performed in October and December 2010, January 2011 and in March 2012 /233//234/, aiming to define the prevalence of bird species within German EEZ. However, the survey area also overlapped with a minor part of the Danish EEZ and the southwestern part of Rønne Banke. Generally the surveys reveal high numbers and high densities of seabirds in the German EEZ with seasonally fluctuations in all species. Very low numbers of seabird species were recorded in the Danish waters, with Auks (Common Guillemots and Razorbills) and Long-tailed ducks being the most frequent with numbers up to 150 birds. Velvet scoter, Common scoter and Divers were mainly present in March (2012) but in low numbers (<50 individuals per species).

7.12 Protected areas

Protected areas in the Baltic Sea comprise marine and coastal biotopes, including habitats and species. The protection varies from strict legal protection, e.g. Natura 2000 sites, to designations or recommendations, e.g. Ramsar sites, HELCOM Marine Protected Areas (MPAs, previously Baltic Sea Protected Areas), United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Sites and UNESCO Biosphere Reserve Areas. Due to their designated status (see section 4) as well as their role in providing a wide range of environmental, social and economic benefits, protected areas are considered an important receptor.

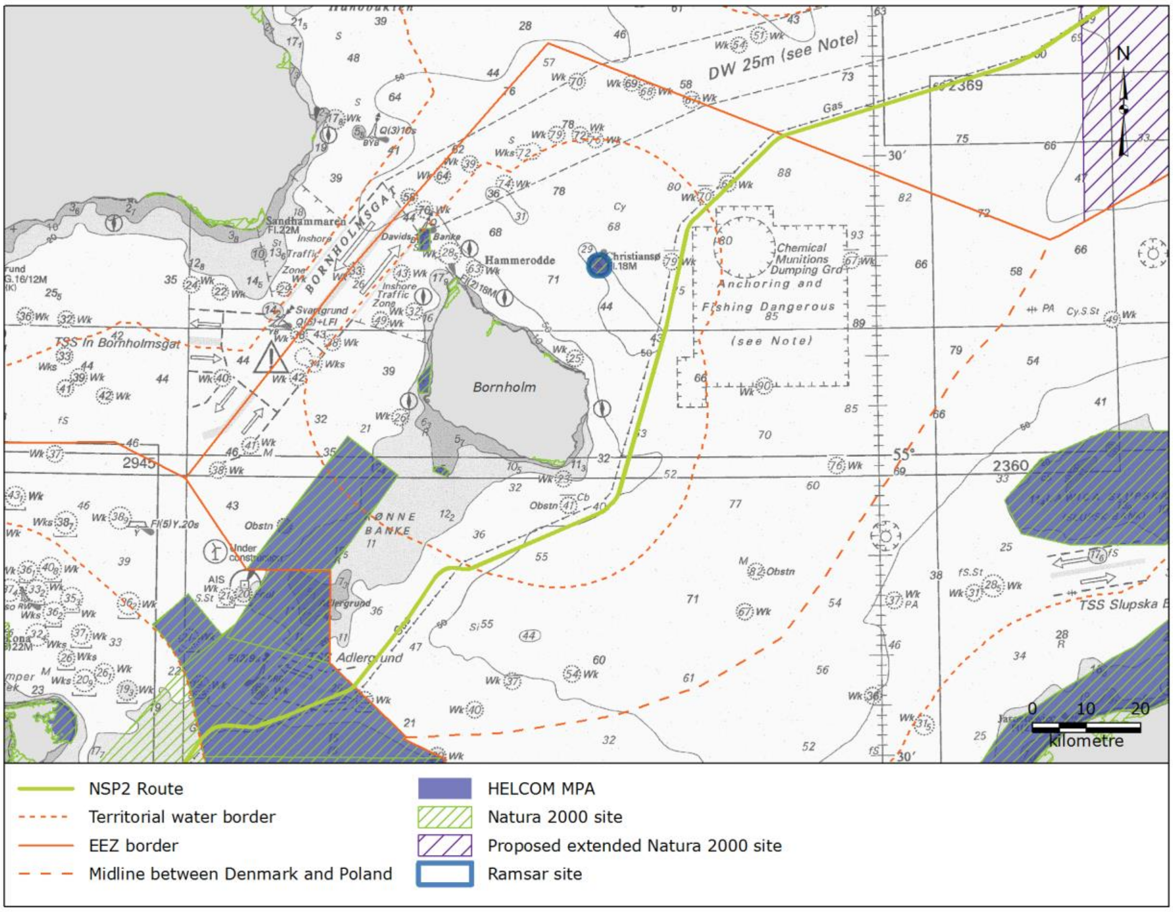


Figure 7-40 Protected areas along the pipeline route within the Danish TW and EEZ. Protected areas include Natura 2000 sites, Ramsar sites, HELCOM MPAs. UNESCO sites and Shellfish waters are not designated in the Danish TW and EEZ near the proposed pipeline.

IBAs and Natura 2000 sites are described separately in section 7.11 and 7.13 respectively.

7.12.1 Ramsar sites

The Convention on Wetlands of International Importance (the Ramsar Convention) is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation of wetlands. The convention requires contracting parties to formulate and implement their planning so as to promote the conservation of wetlands and as far as possible the wise use of wetlands in their territory /225/.

The Ramsar contracting parties have committed to designating suitable wetlands for the List of Wetlands of International Importance and ensuring their effective management.

In Denmark, Ramsar sites are integrated in Natura 2000 sites together with SPAs (Special Protection Areas of the EC Birds Directive), see section 7.13. Ramsar sites along the proposed NSP2 route in the Danish waters are shown in Figure 7-40 whilst further details are provided in Table 7-26.

Table 7-26 Ramsar sites closest to the proposed NSP2 route within the Danish TW and EEZ /236/.

Ramsar site	Description	Listed pressures to site	Distance from pipelines (minimum)
DK165 Ertholmene	Sea area with rocky islands (1,266 ha) and sparse vegetation. The area was designated as a Ramsar site in 1977. The area is used by birds, such as common eider (*Somateria mollissima*), a breeding visitor, and razorbill (*Alca torda*) and common guillemot (*Uria aalge*), which are breeding residents. An area of 30 ha on and around Græsholm (scientific sanctuary) is fully protected. There is no public access and hunting is prohibited. Sailing and windsurfing are restricted.	Oil spills from tankers Eutrophication Disturbances of breeding birds from recreational activities (sailing, anchoring and kayaking) near the coastline.	13 km

7.12.2 HELCOM Marine Protected Areas

HELCOM works to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental cooperation. HELCOM is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea.

In 1994, 62 Baltic Sea Protected Areas were designated under the HELCOM Recommendation. Today, there are 174 sites in the HELCOM MPA network (previously Baltic Sea Protected Areas). The purpose of the designation is *"to protect representative ecosystems of the Baltic as well as to guarantee sustainable use of natural resources as an important contribution to ensure ample provident protection of environment and of biodiversity."* This is done by designating sites with particular nature values as protected areas, and by managing human activities within those areas. Each site has a unique management plan /237/.

HELCOM and OSPAR have adopted a joint Work Programme on MPAs to ensure that the implementation of the HELCOM/OSPAR Ministerial Declaration is consistent across maritime areas /238/.

The HELCOM MPAs are shown in Figure 7-40 whilst Table 7-27 provides details of the three HELCOM MPAs within 20 km of the proposed NSP2 route in Danish waters. The Danish HELCOM MPAs are identical to EU Natura 2000 sites.

Table 7-27 HELCOM MPAs closest to the proposed NSP2 route within the Danish TW and EEZ /239/.

HELCOM MPA name	Description	Listed pressures to site	Distance to pipelines
#184 Ertholmene	MPA of 12.6 km^2, with both marine and coastal values. The MPA includes reefs and cliff coasts. Species on site include guillemot (*Uria aalge*), razorbill (*Alca torda*) and grey seal (*Halichoerus grypus*).	Input of nutrients and organic matter.	13 km
#245 Bakkebrædt and Bakkegrund	MPA of 3 km^2, with reefs and sandbanks. The area has high natural biodiversity and is of biological, geological and marine value.	Input of nutrients and organic matter.	17 km
#275 Adler Grund and Rønne Banke	MPA of 320 km^2, with reefs and sandbanks. The area has high natural biodiversity and is of biological, geological and marine value.	Disturbance or damage to seabed. Input of nutrients and organic matter Introduction or spread of NIS.	16 km

7.12.3 UNESCO Biosphere Reserves

Biosphere Reserves are areas comprising terrestrial and coastal ecosystems that are recognised within the framework of UNESCO's Man and the Biosphere (MAB) Programme. They are internationally recognised, nominated by national governments and remain under sovereign jurisdiction of the states where they are located. Each biosphere reserve is intended to fulfil three basic functions: a conservation function, a development function and a logistic function.

There are several sites in the Baltic Sea, but none of them are within Danish waters /240/.

7.12.4 UNESCO World Heritage Sites

Sites on the UNESCO World Heritage List are cultural, natural or mixed properties recognised by the World Heritage Committee as being of outstanding universal value.

There are no UNESCO World Heritage sites within Danish waters of the Baltic Sea /241/.

7.12.5 Shellfish waters

Shellfish waters have been designated in accordance with Executive Order 840 dated 27/06/2016 in order to protect or improve shellfish waters, to support shellfish life and growth and to contribute to the high quality of shellfish products intended for human consumption. Designated shellfish waters must comply with physical, chemical and microbiological requirements.

There are no designated shellfish waters within Danish waters of the Baltic Sea.

7.13 Natura 2000 sites

Natura 2000 is an ecological network of protected areas that was established to ensure the survival of Europe's most valuable species and habitats. The Natura 2000 network comprises:

- **Special Protection Areas (SPAs)**: Areas for the conservation of bird species listed in the Birds Directive as well as migratory birds;
- **Special Areas of Conservation (SACs)**: Areas for the conservation of habitat types and animal and plant species listed in the Habitats Directive;
- **Sites of Community Importance (SCIs):** Areas for the conservation of habitat types and animal and plant species listed in the Habitats Directive (sites that have been adopted by the European Commission but not yet formally designated by the government of each member state).

The objective of the Habitats Directive is to protect biodiversity by requiring Member States to take measures to maintain or restore the favourable conservation status of natural habitats and wild species. The objective of the Birds Directive is to implement special measures to maintain the favourable conservation status of wild birds, focusing primarily on conserving the habitats of certain rare species of birds and regularly occurring concentrations of migratory birds. The Natura 2000 network protects the habitats listed in Annex I and the rare and vulnerable species listed in Annex II of the Habitats Directive, as well as the rare and vulnerable bird species listed in Annex I of the Birds Directive and regularly occurring concentrations of migratory birds. They are therefore an important receptor.

The conservation objective of the Natura 2000 network is to achieve favourable conservation status for the designated species and habitats.

The conservation status of a natural habitat is defined in the Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) as "favourable" when:

- The habitat’s natural range and areas it covers within that range are stable or increasing;
- The specific structure and functions necessary for long-term maintenance of the habitat exist and are likely to continue for the foreseeable future;
- The conservation status of the habitat’s characteristic species is favourable.

The conservation status of a species is considered “favourable” when:

- Population dynamics data indicate that the species is maintaining itself as a viable component of its natural habitats on a long-term basis;
- The natural range of the species is not being reduced nor is it likely to be reduced for the foreseeable future;
- There is, and probably will continue to be, a sufficiently large habitat to maintain the population of the species on a long-term basis.

The Danish Nature Agency has developed management plans for each Natura 2000 sites. The management plans include an assessment of the current conservation status, main threats and measures to achieve the conservation objectives of Natura 2000 sites. The first generation of Natura 2000 management plans covered the period 2010-2015, while the second generation covers the period 2016-2021.

Natura 2000 sites in proximity to the proposed NSP2 route in Danish waters are shown in Figure 7-41, with additional details provided in Table 7-28. The proposed Swedish Natura 2000 sites are not directly adjacent to the proposed route in the Danish EEZ, and therefore have not been included within Table 7-28.

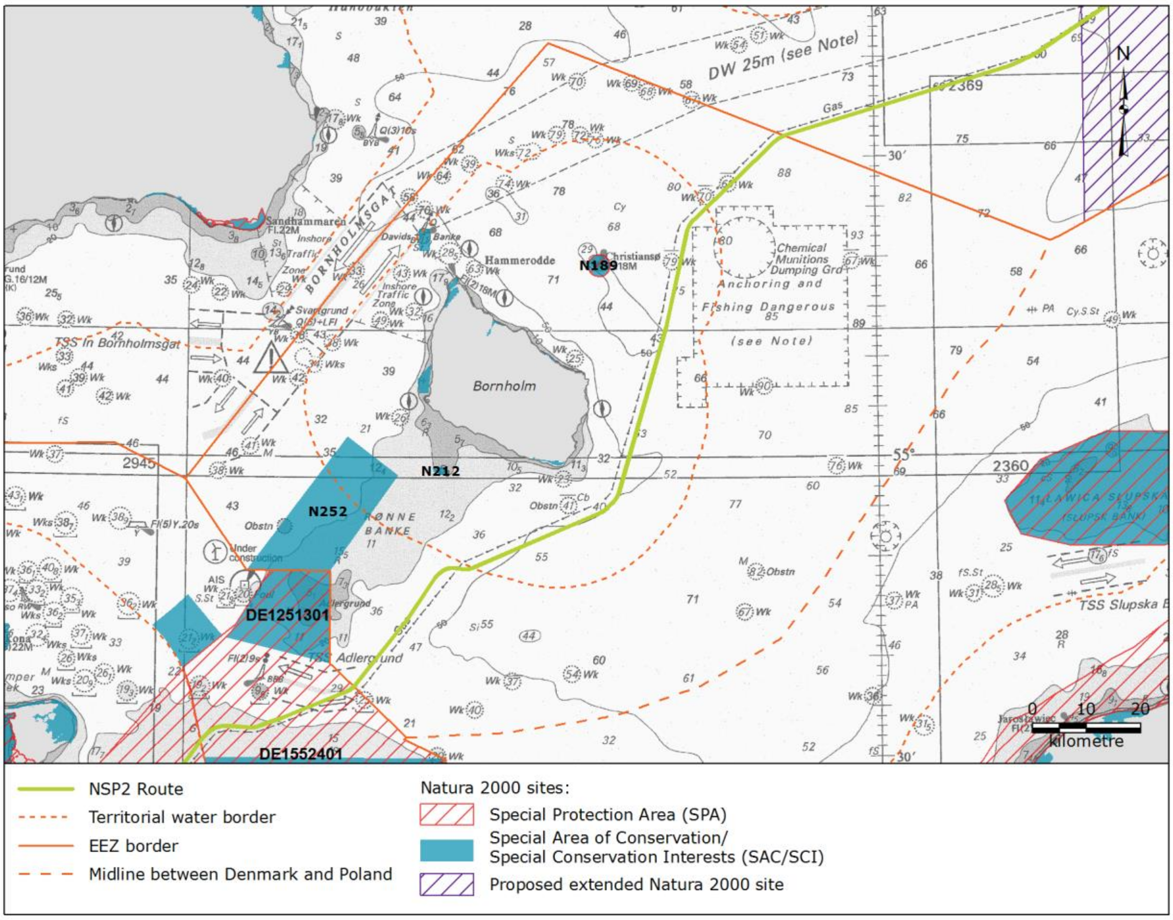


Figure 7-41 Natura 2000 sites (a larger version of this figure can be seen in NSP2 Atlas Map PA-01-D).

Table 7-28 Selected Natura 2000 sites (comprising marine designations) within approximately 20 km of the proposed NSP2 route.**

Natura 2000 site	Distance to proposed NSP2 route	SPA and/or SAC	Designated marine species	Designated marine habitat types
N189 Ertholmene (DK007X079)	Approximately 13 km	SAC 210	1364 Grey seal (*Halichoerus grypus*)	1170 reefs
		SPA 79	Guillemot (*Uria aalge*) Razorbill (*Alca torda*)	-
N212 Bakkebrædt and Bakkegrund (DK00VA310)	Approximately 17 km	SAC 212	-	1110 sandbanks 1170 reefs
N252 Adler Grund and Rønne Banke (DK00VA261)	Approximately 16 km	SAC 261	-	1110 sandbanks 1170 reefs
Adler Grund* (DE1251301)	Approximately 6 km	SAC	1351 Harbour porpoise (*Phocoena phocoena*) 1364 Grey seal (*Halichoerus grypus*)	1110 sandbanks 1170 reefs
Pommersche Bucht* (DE1552401)	0 km	SPA	Red-throated Diver (*Gavia stellata*) Black-throated Diver (*Gavia arctica*) Little gull (*Larus minutus*) Slavonian Grebe (*Podiceps auritus*) Razorbill (*Alca torda*) Black guillemot (*Cepphus grille*) Long-tailed duck (*Clangula hyemalis*) Herring gull (*Larus argentatus*) Common gull (*Larus canus*) Lesser black-backed gull (*Larus fuscus*) Great black-backed gull (*Larus marinus*) Black-headed gull (*Larus ridibundus*) Velvet scoter (*Melanitta fusca*) Common scoter (*Melanitta nigra*) Cormorant (*Phalacrocorax carbo*) Great crested grebe (*Podiceps cristatus*) Red-necked grebe (*Podiceps grisegena*) Eider (*Somateria mollissima*) Guillemot (*Uria aalge*)	

SPA: designated under the European Commission Birds Directive.
SAC: designated under the European Commission Habitat Directive (sites that have been adopted by the European Commission and formally designated by the government of each country in whose territory the site lies).
SCI: designated under the European Commission Habitat Directive (Sites that have been adopted by the European Commission but not yet formally designated by the government of each country)

* Designated Natura 2000 site in Germany. Due to the proximity of the site to the Danish EEZ, it has been included in this description.
** Only marine Natura 2000 areas are discussed in this chapter, the coastal and terrestrial Natura 2000 sites around Bornholm are not considered a relevant receptor since the NSP2 activities in the Danish sector are entirely offshore, and the distance to the coast of Bornholm is at least 10 km.

The designated marine habitat types have been mapped as part of Natura 2000 planning and are presented in Figure 7-42. The habitat types in the Danish Natura 2000 sites include reefs and sandbanks. Sandbanks are mapped in Natura 2000 sites N212 and N252, while reefs are mapped in N189, N212 and N252 (see Figure 7-42).

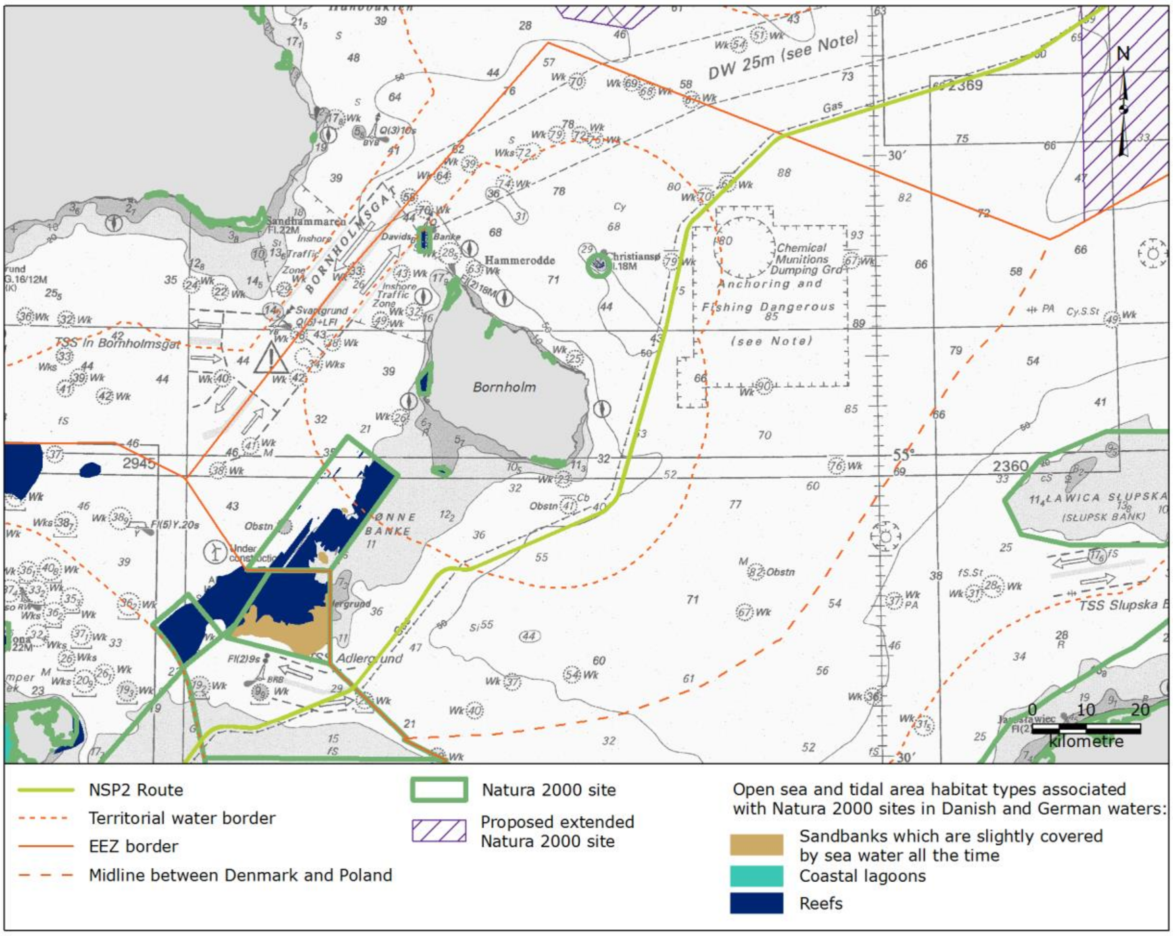


Figure 7-42 Habitat types designated under Natura 2000 within Danish waters (a larger version of this figure can be seen in NSP2 Atlas Map PA-02-D).

Each Natura 2000 site identified in Table 7-28 is described in detail below, in particular the conservation status and main threats are listed for each species and habitat type.

7.13.1 Danish Natura 2000 site N189 Ertholmene

The Ertholmene Natura 2000 site covers an area of 1,256 hectares (12.5 km^2), of which 97% is situated in the marine environment. The site is designated as both SAC and SPA, with marine, coastal and terrestrial designations. Only marine species and habitat types are described here.

The SAC is designated on the basis of one marine habitat type ('reefs'), which is situated in relatively shallow waters from 0-40 m. Some parts of the reefs are periodically above water. Floral growth on the reefs is dominated by brown algae. The SAC is also designated on the basis of the marine species grey seal (*Halichoerus grypus*).

The SPA is designated on the basis of two marine bird species: guillemot (*Uria aalge*) and razorbill (*Alca torda*) (see Table 7-28). The only Danish breeding population of guillemot is at the island Græsholmen, and a colony of breeding razorbill is also found at this island (one of the two Danish breeding colonies). Furthermore, the SPA is designated for migrating guillemots (*Uria aalge*) and razorbills (*Alca torda*). Details of number of breeding and migrating birds are provided in Table 7-29.

Table 7-29 Designated marine bird species for the SPA Ertholmene, including season of stay /243/

Designated bird species	Designation	Number of breeding birds 2004-2009	Number of migrating birds[1]
Guillemot (*Uria aalge*)	M, B	2500 - 2700	600 (2004)
Razorbill (*Alca torda*)	M, B	860 - 1100	7 (2006), 500 (2008), 50 (2009)
Season: M=migrating, B=breeding (see section 7.11) [1] Migrating birds have only been counted in certain years between 2004-2009.			

The grey seal species was designated in 2013, and therefore was not included in the 2010-2015 Natura 2000 management plan. In the Natura 2000 management plan for 2016-2021, the current conservation status was not assessed, nor were the main threats identified /242/.

The reef habitat is included in both the Natura 2000 management plans for 2010-2015 and 2016-2021. In the plan covering 2010-2015, the conservation status was "assessed as unfavourable" owing to eutrophication and bottom trawling fishery, which were identified as the main threats to the area /244/. In the management plan for 2016-2021, the current conservation status is not assessed but the main threat has been identified as bottom trawling fishery /242/.

The guillemot and razorbill species were designated are included in both the Natura 2000 management plans for 2010-2015 and 2016-2021. In the plan covering 2010-2015, the breeding populations of razorbill and guillemots were characterised as in "continuous progress", and the conservation status therefore "assessed as favourable". Main threats to the birds were identified as anthropogenic disturbance related to sailing (e.g. kayaking) and anchoring /244/. In the management plan for 2016-2021, the conservation status is not assessed but the main threats have been identified as sailing and anchoring /242/.

Table 7-30 Summary of conservation objectives, status and main threats for the designated marine species and habitats.

Natura 2000 site	Designated marine species and habitat types	Conservation objectives	Natura 2000 plan 2010-2015		Natura 2000 plan 2016-2021	
			Conservation status	Main threats	Conservation status	Main threats
N189 Ertholmene (DK007X079)	Grey seal (*Halichoerus grypus*)	Favourable conservation status	Not part of the designation for 2010-2015		Not assessed	Not identified
	Reefs	Favourable conservation status	Assessed as unfavourable	Eutrophication, contaminants and bottom trawling fishery	Not assessed	Bottom trawling fishery
	Guillemot (*Uria aalge*)	Favourable conservation status	Assessed as favourable	Sailing and anchoring	Not assessed	Sailing and anchoring
	Razorbill (*Alca torda*)	Favourable conservation status	Assessed as favourable	Sailing and anchoring	Not assessed	Sailing and anchoring

7.13.2 Danish Natura 2000 site N212 Bakkebrædt and Bakkegrund

The Bakkebrædt and Bakkegrund Natura 2000 site covers an area of 300 hectares (3 km^2). The SAC is designated on the basis of two marine habitat types ('reefs' and 'sandbanks'), see Table 7-28. Reefs cover approximately 75% of the area, and the majority of the reef structures are covered with blue mussels.

The sandbank habitat was designated in 2010, and was not included in the 2010-2015 Natura 2000 management plan. In the Natura 2000 management plan for 2016-2021, the current conservation status was not assessed but the main threats have been identified as eutrophication, contaminants and bottom trawling fishery /246/.

The reef habitat is included in both the Natura 2000 management plans for 2010-2015 and 2016-2021. In the Natura 2000 plan for 2010-2015, the current conservation status of the reef habitat was "assessed as unfavourable" and the main threats were identified as eutrophication, contaminants and bottom trawling fishery /245/. In the Natura 2000 plan for 2016-2021, the conservation status has not been assessed but the main threats have identified as eutrophication, contaminants and bottom trawling fishery /246/.

Table 7-31 Summary of conservation objectives, status and main threats for the designated marine species and habitats /245//246/.

Natura 2000 site	Designated marine species and habitat types	Conservation objectives	Natura 2000 plan 2010-2015		Natura 2000 plan 2016-2021	
			Conservation status	Main threats	Conservation status	Main threats
N212 Bakkebrædt and Bakkegrund (DK00VA310)	Sandbanks	Favourable conservation status	Sandbanks not part of the designation for 2010-2015		Not assessed	Eutrophication, contaminants and bottom trawling fishery
	Reefs	Favourable conservation status	Assessed as unfavorable	Eutrophication, contaminants and bottom trawling fishery	Not assessed	Eutrophication, contaminants and bottom trawling fishery

7.13.3 Danish Natura 2000 site N252 Adler Grund and Rønne Banke

The Adler Grund and Rønne Banke Natura 2000 site covers an area of 31,900 hectares (319 km^2). The SAC is designated on the basis of two habitat types ('reefs' and 'sandbanks'). Reefs cover approximatey 40% of the total area.

The Natura 2000 site was recently appointed (in 2010) and therefore does not have a plan for 2010-2015. In the Natura 2000 management plan for 2016-2021, the conservation status has not been assessed but the main threats have been identified as eutrophication, contaminants and bottom trawling fishery /247/.

Table 7-32 Summary of conservation objectives, status and main threats for the designated marine species and habitats /247/.

Natura 2000 site	Designated marine species and habitat types	Conservation objectives	Natura 2000 plan 2010-2015		Natura 2000 plan 2016-2021	
			Conservation status	Main threats	Conservation status	Main threats
N252 Adler Grund and Rønne Banke (DK00VA261)	Sandbanks	Favourable conservation status	The site was recently appointed (in 2010) and does not have a plan for 2010-2015		Not assessed	Eutrophication, contaminants and bottom trawling fishery
	Reefs	Favourable conservation status			Not assessed	Eutrophication, contaminants and bottom trawling fishery

7.13.4 German Natura 2000 sites DE1552401 Pommersche Bucht and DE1251301 Adlergrund

The Pommersche Bucht and Adlergrund Natura 2000 sites cover an area of 200,417 ha and 23,397 ha respectively. It is noted that these Natura 2000 sites are situated in the German EEZ and as such will be detailed in the national EIA for Germany. However, given their proximity to the Danish EEZ, a high level baseline description is provided below.

The SPA Pommersche Bucht is designated for 19 bird species /248/. The status of the site is assessed as "average or partially degraded structure" /248/. The main threats to the area include sailing, sand/gravel removal, disturbance, underwater noise and eutrophication /248/. The conservation status of the site is characterized as "good" concerning 8 of the bird species and "average or reduced" for 11 species /248/.

The SAC Adlergrund encompasses the shallowest parts of the Rønne Banke between the islands of Rügen and Bornholm. The SAC is designated on the basis of two marine habitat types ('reefs' and 'sandbanks') as well as two marine species (harbour porpoise and grey seal), see Table 7-28. Shallow reef ridges are colonised by macroalgae (*F. serratus, H. tomentosus, L. saccharina, F. lumbricina*), whilst deeped boulder fields are colonised by blue mussels. At the outer edges of the reef, the site is dominated by sandbanks formed from glacial sands. The Adlergrund is an important macrophyte site and an important feeding area for overwintering sea ducks and black guillemots and serves in severe winters as a sanctuary for the sea ducks of the Pomeranian Bight.

7.14 Biodiversity

The term biodiversity is a shortening of the words 'biological diversity' and is defined by the Convention on Biological Diversity (CBD) as *"The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* /250/. In a management context biodiversity is normally referred to as the 'health' of the ecosystem, focusing on the status of the habitats and the species richness within the community in the given area and not the absolute diversity /253/.

Biodiversity is considered important due to its role in providing ecosystem services such as a source for food, nutrient cycling and others, as well as inherent value of the species and habitats (some of which are designated under the EU Habitats Directive).

This section aims to provide an overview of the biodiversity within the Danish section of the Baltic Sea, before discussing components of biodiversity at the following levels (in accordance with the Marine Strategy Framework Directive (see section 10):

- Species;
- Habitats and communities;
- Ecosystems.

Such categorisation provides a basis for ensuring the protection and the management of human activities in the marine environment. It is noted that this section relies upon the information provided in section 7.7 - 7.11.

7.14.1 Overview

HELCOM experts assessed the biodiversity of 22 areas in the Baltic Sea in 2009 based on the environmental conditions at three levels (landscape, species and communities). Indicators which were used in the assessments include macrophytes, benthic animals and fish; and in a limited number on cases, birds, phytoplankton and zooplankton.

Areas were categorised as either achieving 'Good Environmental Status' reflecting an evaluation of 'Good' or 'High'; or 'Impaired status' reflecting an evaluation of 'Moderate', 'Poor' or 'Bad'. The overall assessment of an area reflects the worst-performing category /253/.

Within the Danish waters, which includes the Arkona and Bornholm basins, the biodiversity status was classified by HELCOM as being impaired as a result of 'poor' to 'moderate' eutrophication conditions, 'moderately to significantly affected' biodiversity and 'poor' to 'moderate' chemical status of the water, sediments and marine fauna (see Figure 7-43).

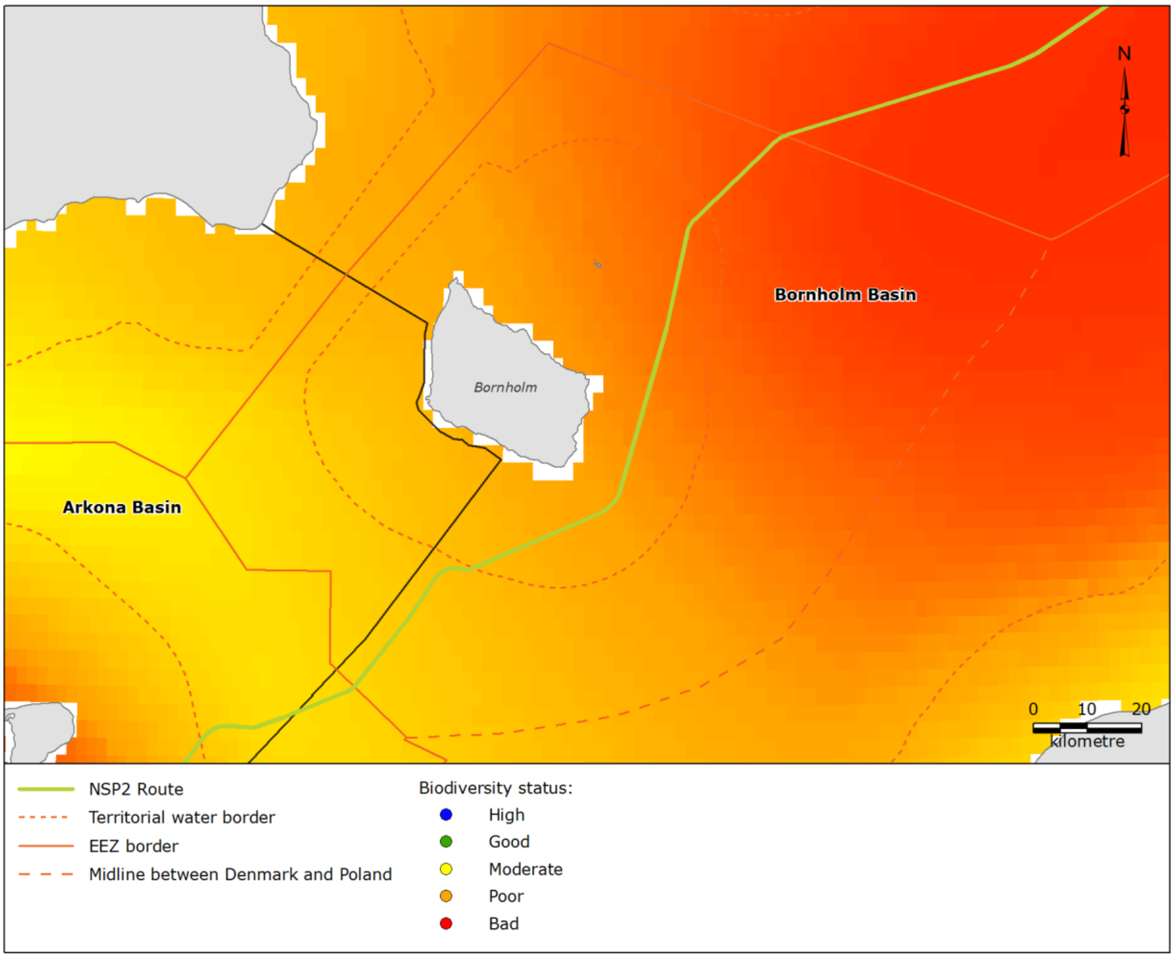


Figure 7-43 Biodiversity status of the Arkona and Bornholm Basin within the Danish EEZ

7.14.2 Species

Due to the geological young age (approximately 3,000 years) of the Baltic Sea, the marine environment is characterised by a small number of functional groups, and low diversity within functional groups. Only few endemic species have evolved and adapted to the brackish conditions, resulting in the main species composition consisting of true marine or freshwater species living at or near their physiological limits /253/.

At the highest level, the ecological receptors in the Danish section of the Baltic Sea can be divided into the following receptor groups:

- Plankton;
- Benthic flora and fauna;
- Fish;
- Marine mammals;
- Birds.

The species relevant to the Danish section of the Baltic Sea have been considered in detail in section 7.8-7.11 and are therefore not covered in this section. However, the broad relationship between species and their surrounding habitat, as well as their interaction within assemblages are described in the following sections.

Genetic variation is not specifically addressed, as most studies focus on few animal groups of commercial importance the studies therefore being of less relevance for NSP2.

7.14.3 Habitats

The landscape and abiotic conditions provide the basis for the biotic conditions within the Danish sector of the Baltic Sea. Together these determine the habitats which are present and subsequently the species which inhabit them. A summary of the abiotic conditions is provided in sections 7.2 - 7.5, whereas detailed descriptions of pelagic habitats can be found in section 7.7 and of benthic habitats can be found in section 7.8.

Based on the physical and chemical properties of the sediment and the water column described in sections 7.3 and 7.5 three sets of overall living conditions for benthic fauna can be identified along the pipelines in the Danish sector of the Baltic Sea and two sets of overall living conditions for pelagic fauna:

- **Benthic habitat type 1**: (Bornholm Basin) Water depth >60 m, soft bottom habitat with fine sediment mainly consisting of silt and clay and with a salinity of 15-20 psu. Because of its location below the halocline, this habitat suffers of regular hypoxia/anoxia.

- **Benthic habitat type 2**: (Western slope of the Bornholm Basin) Water depth 40-60 m with a fine sand bottom type strongly affected by its close proximity to the irregular pycnoclines prevailing between the mixed surface layer and the bottom layer, resulting in quite variable conditions of salinity (8-15 psu) and oxygen.

- **Benthic habitat type 3**: (Southernmost part of the pipeline route) Water depth 15-40 m with a medium grained sandy bottom type in direct contact with the mixed surface layer, but below the photic zone (0-20 m). Salinity is rather constant at around 7-8 psu.

- **Pelagic habitat type 1**: (Photic zone) The upper level of the water column where the sunlight allows for primary production to take place. The primary production forms the basis for the food web providing food for the second trophic level (zoo benthos).

- **Pelagic habitat type 2:** (Aphotic zone). Deeper layers (typically more than 20 m) where no primary production takes place because of poor light conditions. The basis of the food web is the plankton falling down the water column (marine snow) to finally sedimentate on the sea bed and become food for benthic detritus feeders.

Certain benthic communities within the Danish waters are of particular importance because they form a structure that is the habitat for many other species and communities during parts or the entire span of their life. Key species such as eelgrass (*Zostera marina*), bladder wrack (*Fucus vesiculosus*), and blue mussel (*Mytilus edulis*) are such habitat builders.

The habitat builders are very scarce in the NSP2 route due to water depth and following oxygen and light conditions. They are most commonly found in coastal zones, however, on Rønne Banke the *M. baltica* and the blue mussel and various polychaetes are abundant including the bristleworm and the invasive species *Marenzellaria viridis*.

7.14.3.1 Abiotic Features

A number of background parameters define the abiotic conditions of the Baltic Sea, in particular salinity and temperature (which result in the creation of permanent or temporary vertical thermoclines and haloclines) which prevent vertical mixing of the water column and consequent ventilation of the deeper areas such that hypoxic or anoxic areas occur. The abiotic parameters relevant to Danish waters are described in detail in sections 7.2 - 7.5, whilst their influences on biotic features are described in section 7.14.3.2 below.

According to HELCOM, the biodiversity status of the Bornholm Basin (Figure 7-43) is considered 'bad'. This is generally characteristic of the deep basins (>60-70 m) within the Baltic Sea where the mixing of outflowing freshwater and marine water (from rare inflow events) forms a strong saline gradient which can cause anoxic or hypoxic conditions (see above).

The Danish part of the Arkona Basin (see Figure 7-43) is considered "moderate", likely due to the seasonal inflow of oxygenated marine water which keeps the bottom layers of the shallower basins (average depth 25 m) relatively mixed and oxygenated throughout the year /251//253/. Therefore saline and temperature gradients are not as well established and may only occur temporarily through the year.

7.14.3.2 Biotic Features

The highest variation in habitats within the Baltic Sea is observed along the coasts, where complex rock structures, sheltered bays and archipelagos provide the most variation in habitat type and therefore a naturally higher diversity (species richness). In the open waters, such as those along the proposed NSP2 route in Denmark, a natural lower diversity is found. This is mainly due to the limiting conditions defined by the abiotic parameters primarily hypoxia/anoxia (see above) /149/.

As noted above, anoxic conditions are frequent in the Bornholm Basin and in some instances, permanent. Along sections of the NSP2 route, anoxic areas creates barriers to colonisation by habitat builders which limits species richness and results in areas biological deserts (see section 7.8) /188/. The species which are present are often short-lived, opportunistic or hypoxia-tolerant species.

Within the Arkona Basin, the oxygenated conditions allow colonisation of the seabed and provide favourable conditions for a relatively diverse community, with higher levels of species richness (see section 7.8).

Light conditions also influence the colonisation of habitat builders along the NSP2 route. The seabed along the route is below the photic zone in Danish waters and therefore there are no floral habitat builders present. Therefore detritus feeding polychaetes and bivalves form the basis of the biotic features of the habitats.

7.14.4 Ecosystem

Ecosystems can be defined as a mosaic of communities (comprising habitats and species) which interact to form one system. They can function independently or be part of a wider ecosystem which provides a further ecological function (e.g. migration routes).

Within the ecosystem, species and habitats interact to influence fundamental processes. Trophic interactions within the food web can influence productivity and stability and thereby also the overall functioning of the ecosystem. The individual species and habitats which form the communities within the Danish EEZ are described in sections 7.7 - 7.11, whilst their interactions are summarised in the sections below.

In Danish waters around NSP2 the ecosystem is generally referred to as the Macoma community, due to the presence of the bivalve Macoma baltica. The Macoma community is normally dominant at water depths down to 15-30 meters, but in the Baltic Sea the species is frequent also at deeper waters and it was found at many stations, including habitat type 2 stations (40-60 m) during NSP2 field surveys /66/. The open basins of the Baltic Sea are however more often characterised by the relict amphipod *Pontoporeia femorata* and the scaled worm *Bylgides sarsi*. Hence is most of the Danish part of the route referred as belonging to a community consisting of these two species /151/. Likewise, the brackish genus Hydrobiidae, the polychaete *Pygispio elegans* and the brachish cockle *Cerastoderma glaucum* frequently occurs in the more shallow sandy parts of the Baltic Sea.

Despite its low diversity, the Baltic Sea ecosystem is considered to have an intrinsic biological value, and provides a variety of goods and ecosystem services[42]. Nutrient recycling, water and climate regulation, production of fish and other food items as well as recreational opportunities are among the ecosystem services provided by the Baltic Sea /252//253/. As such, protection and improvement of biodiversity in the Baltic Sea is a main focus for the Baltic Countries.

An ecosystem with a high natural biodiversity has a higher stability and better regulates and adapts to changing conditions, such as climate change, and provides better resilience towards pollution events /251//252/. The low biodiversity in the Danish section of the Baltic Sea therefore means the function of each species present within the community is particularly important in this context.

7.14.4.1 Trophic Interactions

Trophic interactions are the interactions between organisms that are producers and consumers. Figure 7-44 provides a summary of the trophic interactions within the Baltic Sea, which is also relevant to the Danish EEZ.

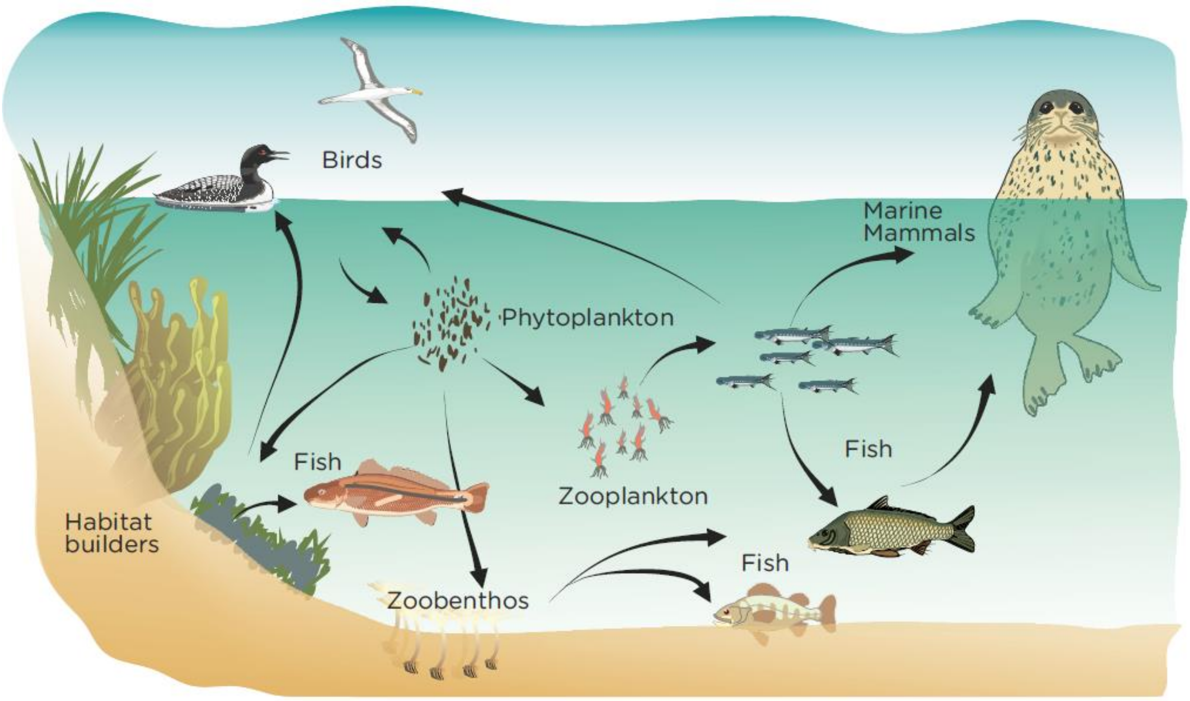


Figure 7-44 Schematic representation of the Baltic Sea Trophic Interactions. Adapted from /252/.

The first trophic level consists of different phytoplankton forming the functional group of primary producers along with macro algae /252/. Primary production takes place in the top of the water column, in the photic zone, where there is sufficient light to perform photosynthesis.

The second and third trophic levels comprise communities and species that graze on the primary producers and/or prey on a functional group of a lower trophic level (i.e. zooplankton, zoobenthos and small fish).

Top predators, such as seals, birds and large fish form the fourth trophic level.

[42] Ecosystem Services are the benefits people obtain from ecosystems.

The food web in the Baltic Sea is currently influenced by a general reduction in top predator populations (e.g. sea birds, cod and marine mammals) and hence reduced pressure down the trophic levels. Furthermore it is influenced by a general increase in nutrient loading (see section 7.14.5) which also favours the lower trophic levels as it encourages primary production in. Therefore, the Baltic Sea food web can be categorised as bottom controlled.

As noted above, due to the anoxic conditions found in the Bornholm Deep, no zoobenthos or sessile fish (second and third trophic levels of the food web) are present in close proximity to the NSP2 pipeline. As organic matter from the planktonic primary production accumulates in the basins, the decomposition in the Bornholm Deep relies on anaerobic microorganisms, which in relation to fish represent a dead end in the food web.

At the bottom of the Arkona Deep and along the rest of the NSP2 route in Danish waters (characterised by reduced water depths such as on the slope of the basins and on Rønne Banke) sufficient oxygen will be available for zoobenthos and habitat builders. This will favour bottom dwelling fish of small- and medium-size species (i.e. gobies, juvenile cod and flatfish) which will then sustain larger predators. Hence, within the Arkona Deep, the trophic interactions comprise all levels of the food web and both benthic and pelagic species.

7.14.5 Sensitivity and Existing Pressures

The sensitivity of individual species and habitats are presented in sections 7.7 -7.11. However, the predominant pressures on the biodiversity in the Baltic Sea ecosystem (and the Danish EEZ in particular) are considered to be:

- Eutrophication;
- Introduction of non-indigenous species;
- Other anthropogenic disturbance of important areas.

Eutrophication is the enrichment of nutrients and inorganic/organic contaminants (often as a result of run-off from agricultural land and/or pollution), which can lead to an imbalanced food web due to increase in primary production (first trophic level of the food web).

The introduction of invasive non-indigenous species (NIS) (often as a result of shipping or for aquaculture purposes) has the potential to cause a local decline or extinction of local species, alteration of native communities and habitats and/or a change in food web functioning. Invasive species may also hamper the economic use of the sea, i.e. financial losses in fishery and expenses for cleaning intake or outflow pipes of industries and structures from fouling. Within the Danish part of the Baltic Sea, a total of 39 NIS species have been observed /249/, though no NIS were reported during the NSP2 baseline surveys /66/.

As well as eutrophication and non-indigenous species, other anthropogenic activities taking place in the catchment area, coastal zone, and open sea (such as fisheries, maritime traffic, physical damage and disturbance, recreational activities, hunting, noise pollution and climate change) exert pressures on ecosystem interactions and biodiversity, particular where impacts affect important feeding, resting, spawning or breeding areas for members of different species (receptors).

7.15 Shipping and shipping lanes

The Baltic Sea constitutes one of the most intensely trafficked seas in the world and accounts for approximately 15% of the world's cargo transportation. Shipping and shipping lanes are therefore considered an important socio-economic receptor. Figure 7-45 shows the ship traffic intensity in the Baltic Sea, based on Automatic Identification System (AIS) registrations in 2014.

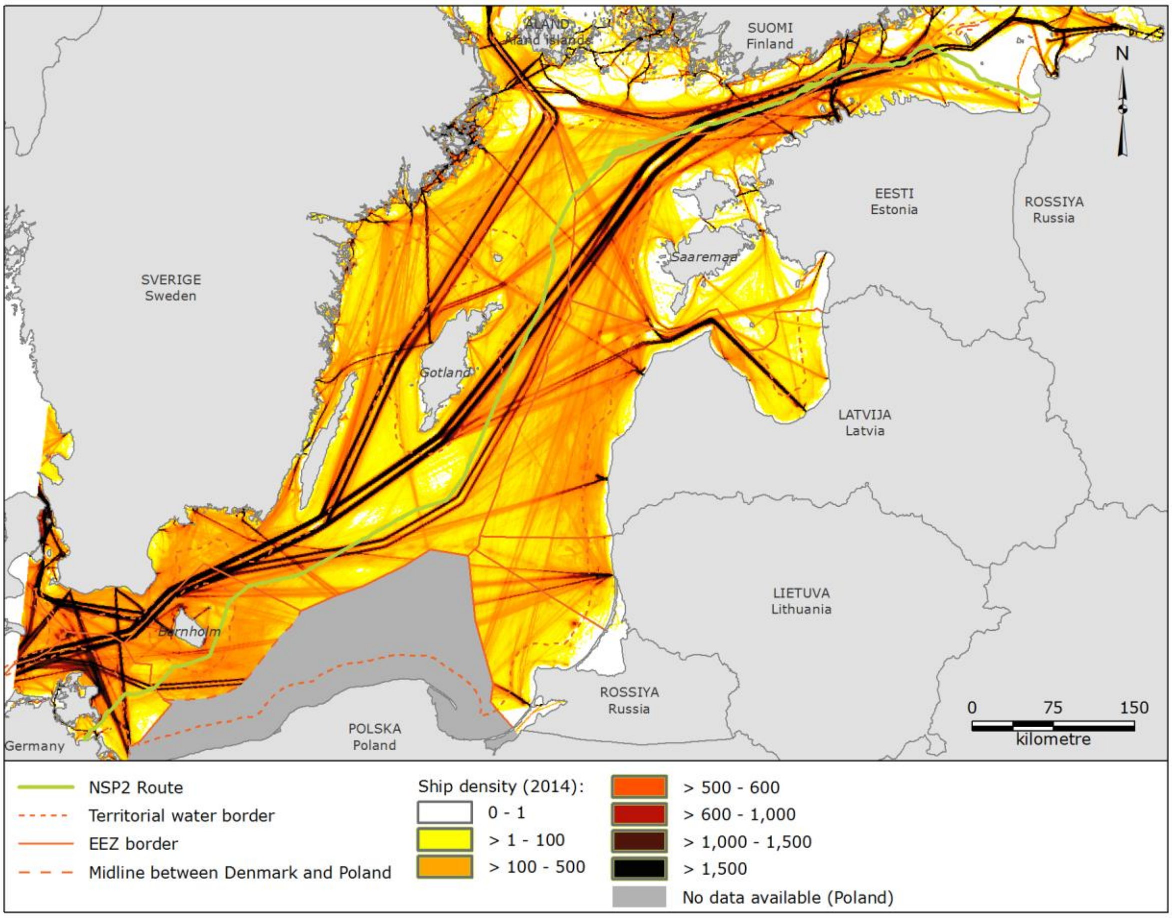


Figure 7-45 Ship intensity plot of the Baltic Sea, based on AIS registrations in 2014.

Figure 7-45 shows the most intensely trafficked routes and demonstrates that the majority of ships follow predesignated routes that are static and in accordance with existing traffic separation schemes (TSS). In addition, ferry routes are clearly identifiable, e.g. between Tallinn and Helsinki.

In Danish waters, the proposed NSP2 route will run east of Bornholm, avoiding the heavily trafficked TSS in Bornholms Gat. The only area with high ship traffic intensity is where NSP2 crosses the TSS Adlergrund which has approximately 7,000 ships movements per year. To the east of Bornholm, there are a number of pilot stations[43] and, in high wind conditions, some vessels anchor close to the coast in order to seek shelter.

The proposed NSP2 route in Danish waters is located in water depths for which a grounding scenario (scenario relevant where the pipelines are located in shallow water and where risk of ships grounding on the pipeline system exists) is not relevant.

The ship traffic density and primary ship traffic routes in Danish waters are shown in Figure 7-46.

[43] Pilot stations are on-shore stations where the pilots assisting the ships in the Baltic Sea are staying. From the pilot stations the pilots are transported (with pilot vessels) to the ships waiting offshore for a pilot.

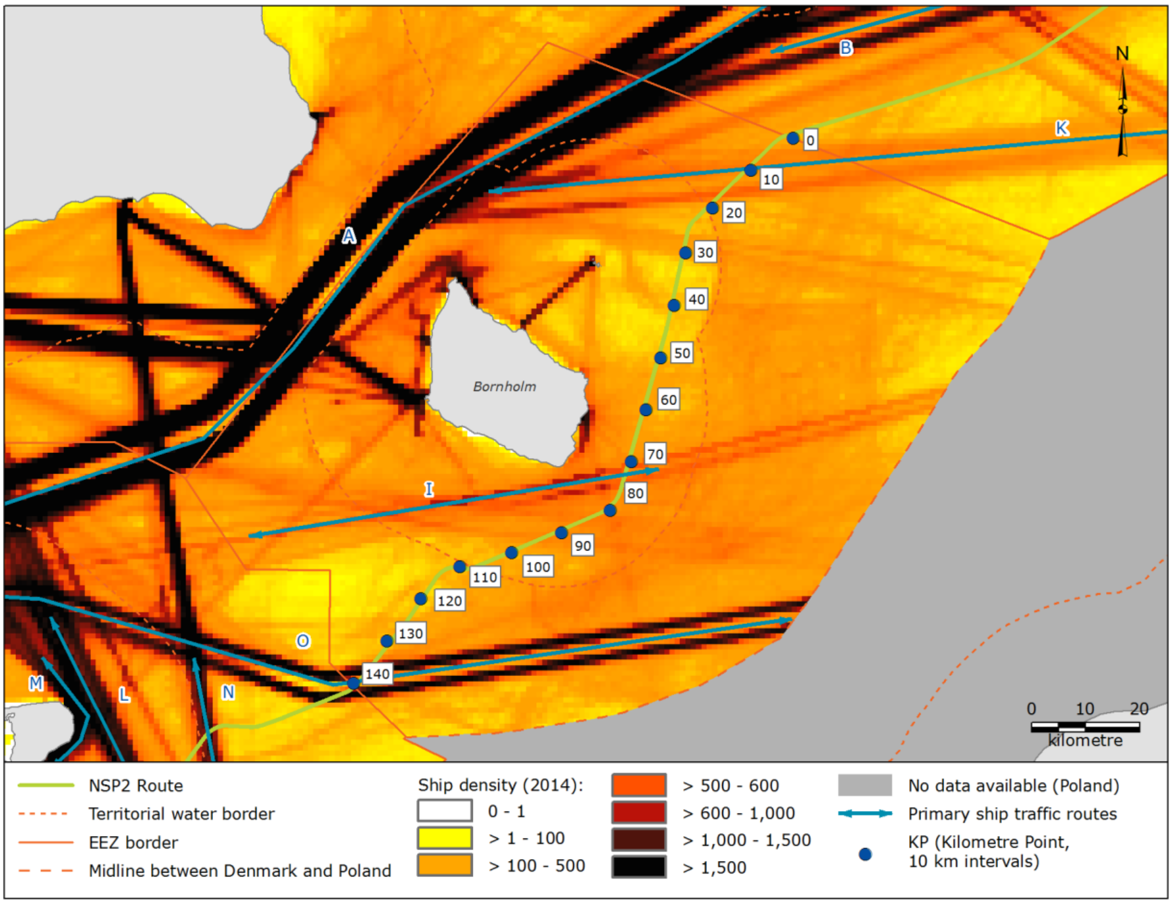


Figure 7-46 Ship traffic density in Danish waters. Please refer to annual crossings in Figure 7-50

Four ship traffic routes have been identified in the vicinity of the proposed NSP2 route in the Danish sector. These include:

- Route O. This route is used by ship traffic to/from ports in Poland (Gdynia and Gdansk), Russia (Kaliningrad) and Lithuania (Klaipeda) passing through the TSS Adlergrund. The TSS is located south of Adlergrund and north of Oder Bank.
- Route I. This route is used by ships passing Rønne Banke south of Bornholm. The traffic entering the Baltic Sea on this route travels further south and merges with route O or sails north, with Klaipeda Port in Lithuania as the main destination.
- Route K. The vessels using this route are sailing north of Bornholm to/from primarily Klaipeda Port. The route merges into route A north of Bornholm.
- Route A. This route is the main entrance to /exit from the Baltic Sea and is used by all ships travelling along the main routes in the Baltic Sea.

The annual ship movements in 2014 and the forecasted ship movements for 2025 for the four routes in Danish waters are shown in Figure 7-47 /254/. The distribution of ship type on these routes in 2014 is shown in Figure 7-48, while the length distribution is shown in Figure 7-49.

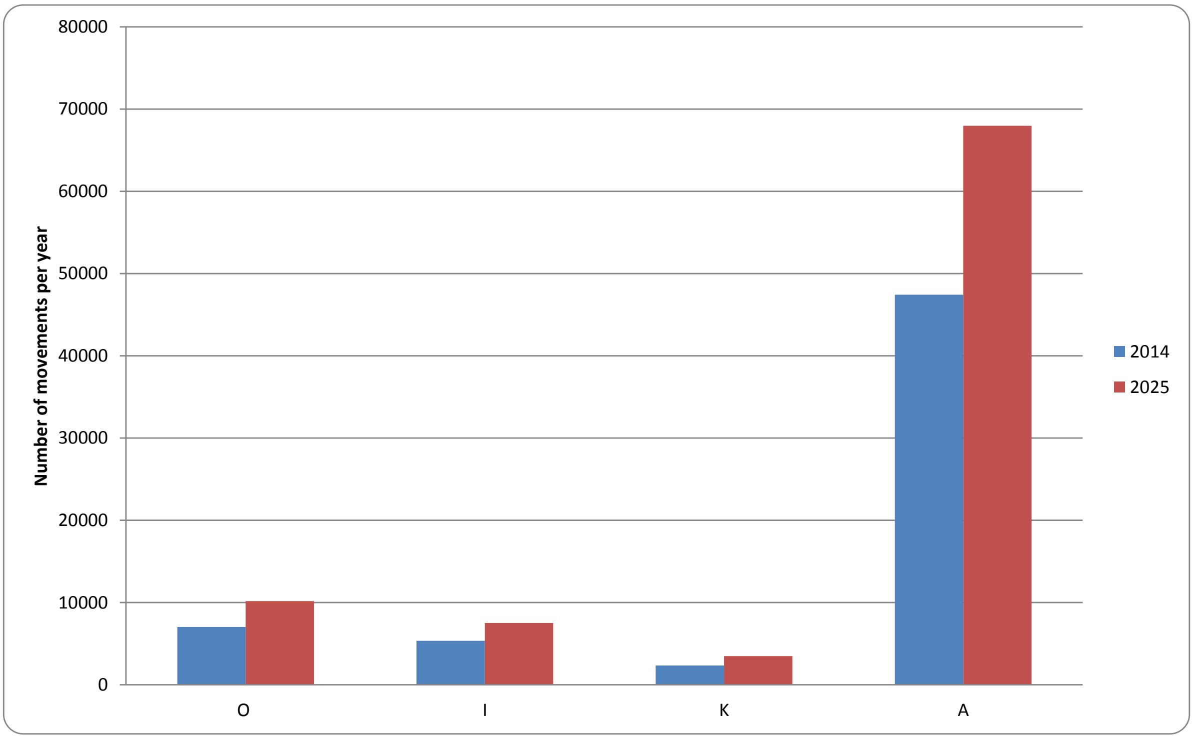


Figure 7-47 Annual ship movements on primary routes in Danish waters

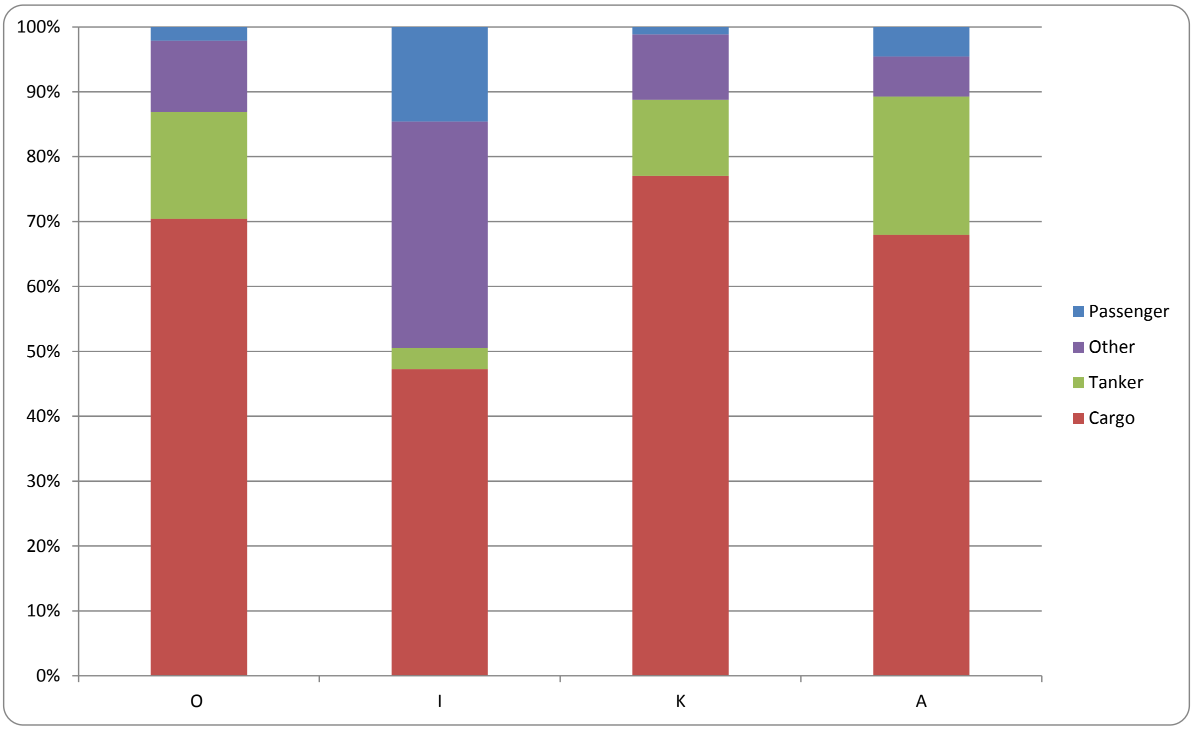


Figure 7-48 Ship type distribution in 2014 for primary routes in Danish waters

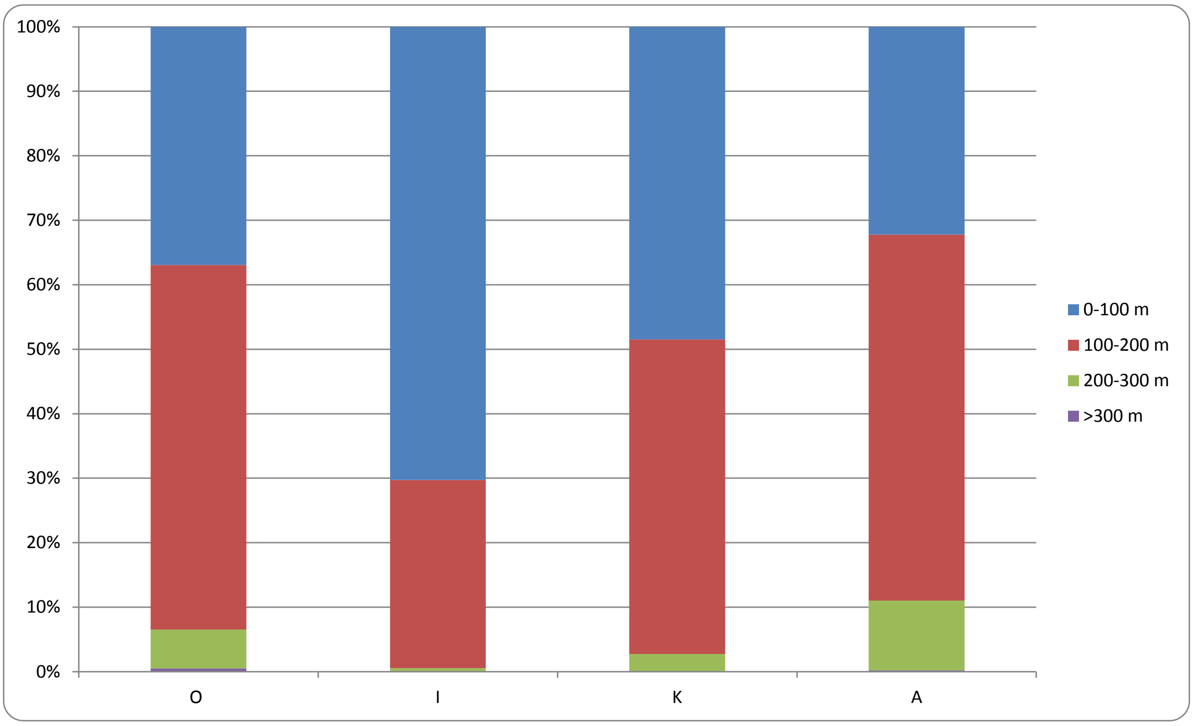


Figure 7-49 Ship length distribution on primary routes in 2014 in Danish waters

Route O is the primary route for cargo and tanker traffic to the ports located in the south/south-eastern part of the Baltic Sea. In 2014, there were approximately 7,000 movements. The annual ship movements are forecast to increase to 10,200 (45%) by 2025. The majority of the traffic is comprised of cargo vessels (70%), followed by tankers (16%). With regard to length, approximately 35% of the vessels are smaller than 100 m and approximately 50% are between 100 m and 200 m. The remaining vessels are 200 m or longer.

Route I had approximately 5,300 movements in 2014. The annual ship movements are forecast to increase to 7,500 (41%) by 2025. Approximately half of the vessels using this route are cargo vessels (50%). The remainder are primarily other types of ships or passenger vessels. The route is dominated by smaller vessels that are able to pass Rønne Banke (water depth approximately 11 m), which naturally restricts the vessels that can use this route.

The traffic on route K is rather limited, with 2,400 movements in 2014. The annual ship movements are forecast to increase to 3,500 (48%) by 2025. The ship type distribution is very similar to route O; therefore DK-C is dominated by cargo vessels (77%). With regard to length, approximately 50% of the vessels are smaller than 100 m and approximately 45% are between 100 m and 200 m. The remaining vessels are 200 m or longer.

Route A is the primary route in the Baltic Sea. This route does not cross the NSP2 pipelines in the Danish EEZ. In 2014, there were 47,500 movements. The annual ship movements are forecast to increase to 68,000 (43%) by 2025. The distribution of the ship type and ship length is very similar to route O.

The annual number of ships crossings the proposed NSP2 route within Danish waters has been estimated for each kilometre point (KP) and is shown in Figure 7-50.

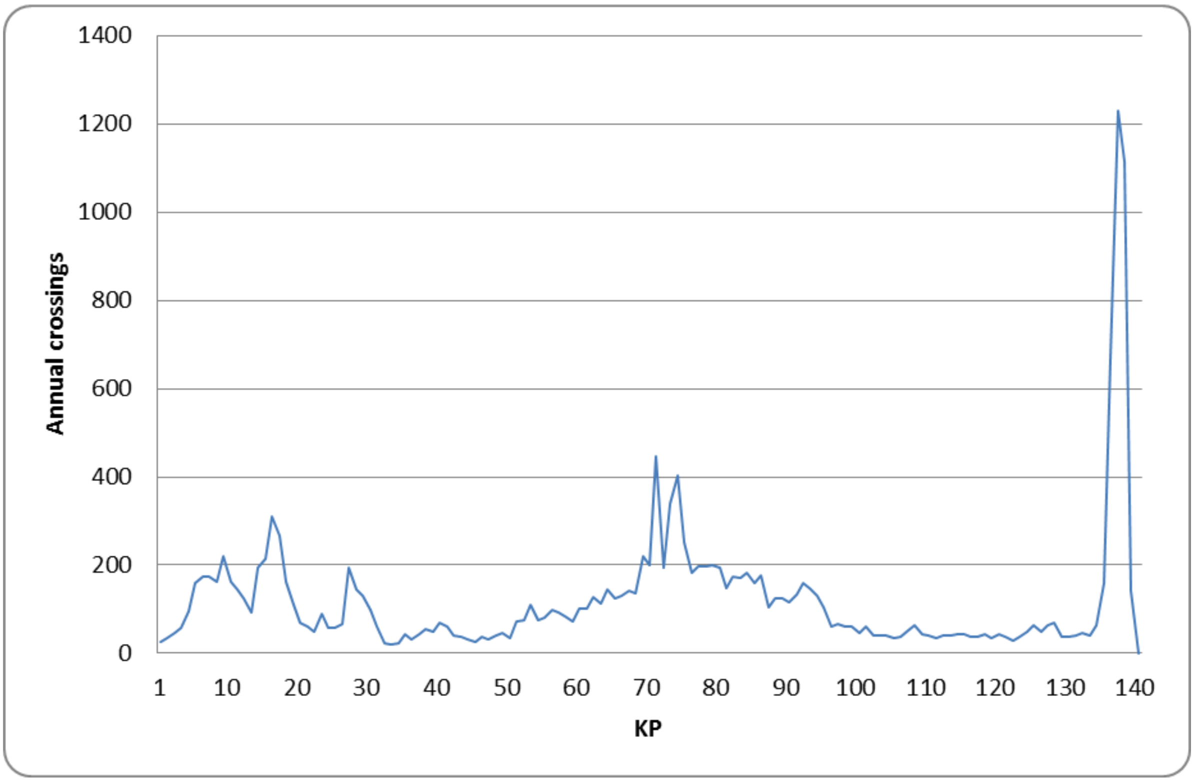


Figure 7-50 Annual crossings per KP-interval (e.g. 1 represents the interval between KP0 and KP1, see Figure 7-46) on the NSP2 route in Danish waters.

The area with the highest number of crossings (approximately 1,200) in Danish waters is associated with the westbound traffic at the TSS Adlergrund (KP 138) before entering the German EEZ.

7.15.1 Shipping forecast for the Baltic Sea

A historical review and forecast of the development of shipping traffic by category and length in the Baltic Sea has been undertaken. The historical AIS data from the period 2007-2014 have been evaluated, and a clear trend emerges that the length of ships in the Baltic Sea is increasing for all categories. This shift to larger ships is primarily related to the economic advantages that such ships offer in comparison with smaller ships.

In the cargo category, ships over 150 m in length are predicted to become more common as shipping companies attempt to realise economies of scale and more efficient transportation. A growth rate of 4.4% is forecasted. The preference for larger cargo ships has also been facilitated through brisk economic development in Russia and the Baltic countries during the considered period, which has increased the demand for such ships. In the tanker category, ships have increased in size significantly due to the development of Russian export ports at Ust-Luga and Primorsk and the higher prices of oil facilitating a robust demand for oil and refined products.

In the passenger and other categories, growth and competition in the passenger sector have been accompanied by an increase in the size of passenger ships in the region. The passenger and other categories are forecasted to experience growth up to 2025, with annual growth rates of 3.4% and 1.4% respectively. Only liquid tankers show a marginal decrease in frequency in the larger ship segment. This decrease is due to a weakening demand for oil imports in Europe and a shift in Russian exports to Asian markets via the Eastern Siberia-Pacific Ocean (ESPO) oil pipeline.

7.16 Commercial fishery

Fishery is an important profession for many people on Bornholm, and fishery vessels from other parts of Denmark and the EU periodically fish in Danish waters. It is also an important part of the Danish economy. Due to the extent of fishery in Danish waters, commercial fishery is considered an important socio-economic receptor.

Commercial fishery in the Danish part of the Baltic Sea can be divided into fishery with trawls (bottom and pelagic), gill nets, seine nets and other gear (passive gear such as hooks and lines, fish traps, pound nets and fyke nets, etc.).

Trawl fishery in Danish waters can generally be divided into two types of activities: fishery where the catches are used for industrial production of fishmeal, fish oil and animal feed and fishery where the catches are used for human consumption. Industrial fishery primarily uses pelagic trawls, which targets the species sprat (*Sprattus sprattus*) and herring (*Clupea harengus*), often in a mixed fishery. Fishery for human consumption primarily uses bottom trawls with larger mesh sizes than pelagic trawls, targeting cod (*Gadus morhua*), with flatfish species (flounder (*Platichthys flesus*) and plaice (*Pleuronectes platessa*) often being caught as bycatch. In some areas and depending on the season, flatfish species are also targeted directly.

Fishery with both types of trawls is often based on long hauls undertaken over several hours (two to seven hours). Therefore these fishing vessels can cover large distances in a single haul. Danish gill net fishery primarily targets cod and the most valuable flatfish species (plaice, turbot (*Psetta maxima*) and sole (*Solea solea*), etc.). Vessels for gill net fishery are usually smaller than trawlers and operate in more coastal areas. During the winter, many gill net fishermen shift gear to hooks and line and target salmon (*Salmo salar*). Gill net fishermen typically set a series of single nets (10-20 nets) that are linked together to form a long chain. Each single net is approximately 50-60 m long. These chains of nets are set along the bottom to target demersal or bottom dwelling commercial species and are generally set and retrieved within a time frame of 12-36 hours.

Danish seine net fishery is of relatively limited importance in the Baltic Sea, as it is responsible for only very few of the registered catches in comparison with bottom trawlers, pelagic trawlers and gill nets. The net section of the seine gear is laid out with a considerable amount of rope in a circular pattern. Fish are driven towards the seine net as the long ropes are pulled together along the bottom during retrieval. Thus, this type of fishery is dependent on relatively large areas without stones or objects along the bottom. The primary target species of Danish seine net fishery are cod and flatfish (plaice and flounder).

Hook and line fishery, which is undertaken primarily around Bornholm, and fishery using pound nets and fyke nets as well as other passive fish traps, can be considered smaller, more marginal types of fishery in comparison with trawl and gill net fisheries. Hook and line fishery around Bornholm primarily targets cod and salmon, while pound nets primarily target eel (*Anguilla anguilla*) in the autumn and, occasionally, also garfish *(Belone belone*) and herring in the spring.

All types of fishery are included in the baseline. However, most attention is given to bottom trawling activities, as this type of fishery has the greatest potential to be impacted by NSP2.

7.16.1 Baseline data source

It should be noted that fishery in Danish waters comprises both Danish fishing boats and fishing boats of other nationalities. Given the availability of data, this section focuses on Danish fisheries, though it is assessed that the descriptions represent the general fishing patterns in the area and therefore provide a robust baseline.

Fishery data in the Baltic Sea are separated according to international fishery statistical areas (so called 'ICES rectangles'), where national and international fishery regulations, requirements and quotas apply and the majority of the catch data are separated. All fishing vessels ≥8 m are required to register their catches within these ICES statistical rectangles (approximately 30 x 30 nm, see Figure 7-51). These data give a good overview of the spatial distribution of the catches of various species and the amount (weight) of catches. Fishing vessels <8 m are only required to record their catches in coastal water declarations, where the location of the catch is recorded in much larger areas (ICES subdivisions). The characteristics of Danish fishery have been determined on the basis of official fishery statistics from logbooks obtained from the Danish AgriFish Agency.

Vessel monitoring system (VMS) data for the years 2010-2014 have been used to indicate the spatial distribution and density of the bottom trawling activities within Danish waters. VMS is a satellite-based GPS technology used in commercial fishing to monitor the location and speed of fishing vessels[44]. By estimating the period of fishery activity according to vessel speed, VMS data can be used to indicate specific distributions of fishery. However, because only large vessels (≥12 m vessels/≥15 m before 2012) are required to be equipped with VMS systems, it is possible that this data underestimates the distribution of smaller vessels. The proposed NSP2 route, however, is a considerable distance offshore where the predominant fishing gear is trawlers, which are generally >12 m. Furthermore, because vessels using the same gear types generally utilize the same fishing areas, albeit the larger vessels often travel farther, the fishery patterns exhibited by VMS data are considered be representative of most of the fishery along the proposed NSP2 route.

The Danish value of all catches leading to economic calculations is based on the average price per kilogram for each commercial species for each year from 2010 to 2014. The data were obtained from the Danish AgriFish Agency. The catches and value for the other countries bordering the Baltic Sea (with the exception of Russia where data could not be obtained) were derived from data obtained from fishery authorities in each country.

[44] Before 2012, VMS data included only vessels ≥15; after 2012 it included vessels ≥12 m.

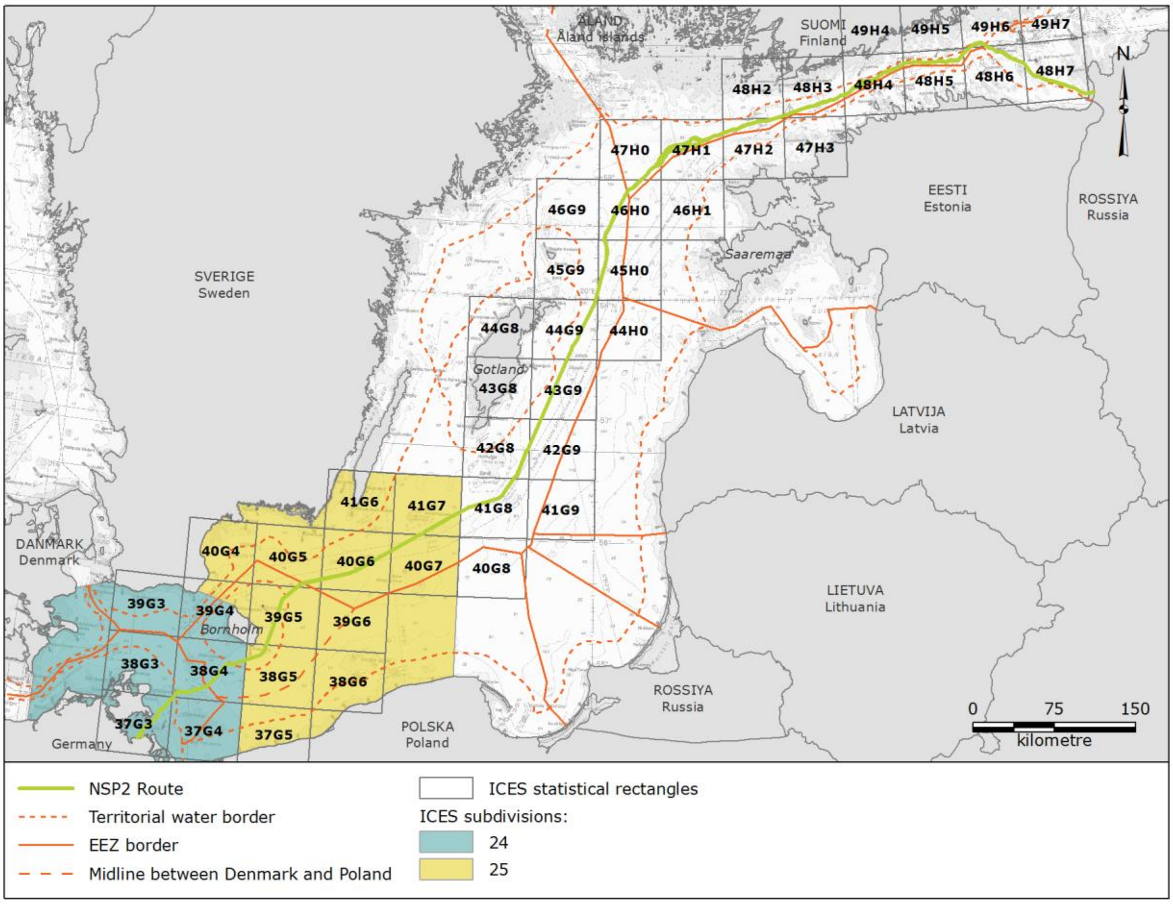


Figure 7-51 ICES rectangles along and adjacent to the NSP2 pipeline route.

7.16.2 Control and regulations

The commercial fishery in the inner Baltic Sea is subject to a number of regulations that define when and to what extent the Danish and international fisheries are able to operate. Management rules and regulations for fishery are determined at different judicial levels, primarily at the EU, national and for some countries such as Germany the federal state levels.

Fishery for most fish stocks in the Baltic Sea is managed under the Common Fisheries Policy (CFP) of the European Commission. The main instruments of fishery management by the CFP are:

- Catch limits (quotas) that restrict the quantity of fish that can be taken;
- Fishing effort limitations that restrict the size of the fleet at sea and the amount of time spent fishing (days at sea, kW-days) and in cases of passive (static) gear also its size and quantity;
- Technical measures that regulate the type (e.g. mesh sizes, gear types) and location of fishery.

The Bornholm Deep is closed to fisheries from 1 May to 31 October. This regulation is primarily undertaken to conserve cod stocks by protecting aggregations of mature cod when spawning (Figure 7-52). Also there is an area east of Bornholm in which bottom trawling is discouraged due to the fact that chemical munitions were dumped here following WWII (see section 7.18) (Figure 7-52).

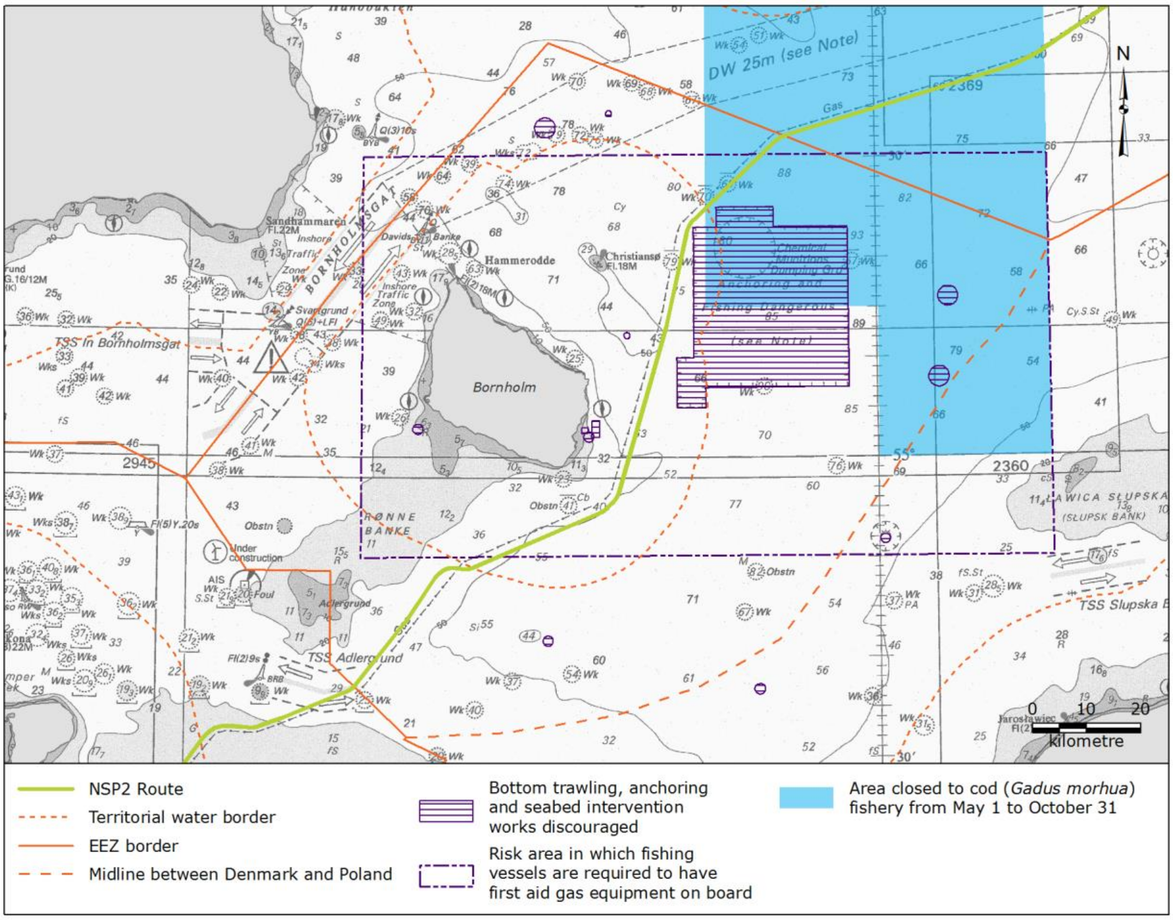


Figure 7-52 Area closed to fisheries from 1 May to 31 October and the area in which bottom trawling is discouraged

Other general fishery restrictions regarding trawlers apply within Danish water. In general, small trawlers (with motor power less than 175 horsepower) fishing with trawls with mesh sizes less than 90 mm are allowed to fish within 3 nm from the coast (bordering at low tide levels) /257/.

There is a trilateral agreement based on the principle of reciprocal access to fishery between Denmark, Sweden and Germany that allows fishing vessels from these countries to undertake fishery within the TW of the other countries. Fishing vessels from Poland, Estonia, Latvia and Lithuania are only allowed to undertake fishery within the EEZ of Denmark /259/.

7.16.3 Danish commercial fishing vessel activity

An overview of the number of Danish fishing vessels according to the main gear types (bottom trawl, pelagic trawl, gill nets, seine nets and "other gear") that have fished (registered catches) in the ICES rectangles along the NSP2 route is presented in Table 7-33 (ICES squares are shown in Figure 7-51).

Nationally, the total number of Danish fishing vessels has declined over the last 5-10 years. Overall, trawling is used more than any other gear in the Danish fishing fleet.

Data on the number of vessels fishing along the proposed NSP2 route indicate that bottom trawlers operate in the southern part of the Baltic Sea. On average 45-60 bottom trawlers have registered catches in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5) near the southern part of the planned NSP2 route (Table 7-33 and Figure 7-51).

In contrast to bottom trawlers, vessels using pelagic trawls operate throughout much of the main Baltic Basin. Based on data from 2010 to 2014, an average of 5-13 pelagic trawlers per year have registered catches in ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5).

In general, fishing vessels using gill nets are smaller than trawlers and therefore do not travel as far from the harbours where they are based. Based on data from 2010 to 2014, an average of 6-18 gill net vessels per year operated in the southern parts of the Baltic Sea, in the ICES rectangles (39G4, 39G5) east and west of Bornholm and in the ICES rectangles (38G4 and 38G5) south of Bornholm. The most intensively fished area was the ICES rectangle (39G4) west of Bornholm, which is more than 15 km from the proposed NSP2 route.

There are only a few Danish seine vessels (3 to 6) that operate in the inner Baltic Sea. Based on data from 2010 to 2014, an average of 1 vessel per year has registered catches in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5).

Furthermore, based on data from 2010 to 2014 an average of 8-16 fishing vessels per year using hooks and lines, pound nets or various types of fish traps and other passive gear have registered catches in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5). Vessels using this gear fish along or near the coast and are often smaller in length than trawlers.

Table 7-33 Number of Danish commercial fishing vessels (≥8 m) according to gear that fished in the ICES rectangles along and adjacent to the proposed NSP2 route in 2010-2014. ICES rectangles within Danish waters are shown in bold. Note that the same vessel can be registered in several ICES rectangles. ICES rectangles are shown in Figure 7-51 (Data source: Danish AgriFish Agency).

ICES rectangle	Bottom trawl					Pelagic trawl					Gill nets					Seine nets					Other gear				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
48H3							1																		
47H3										1															
47H2		1				4	5	1	2	5															
47H1		1				2	8	1	4	5															
47H0						2	9	2	5	4															
46H1		1				2	6	2	2	1															
46H0						5	13	5	6	3															
46G9						8	5	7	6	6															
45H0						7	6	5	3	4															
45G9						10	7	5	5	4															
44H0						4	1	1	1	2															
44G9						5	8	4	3	6															
44G8									1																
43G9		1				10	9	5	2	3															
43G8							2	1	1																
42G9	1					10	3	5		1															
42G8	1	1				7	7	4	3	4								1							
41G9						17	8	4	2	3															
41G8	1					13	6	2	4	6								1							
41G7	1	1				2	1																		
40G8	6	4	8	7	4	15	4	2	4	5			1					1							
40G7	4	5	5	4	4	1							1												
40G6	2	11	6	3	6		1						1				1	1							
40G5	**3**	**6**	**7**	**4**	**11**	**1**	**2**			**2**															
40G4	**5**	**4**	**2**	**4**	**2**	**4**	**5**	**3**	**2**	**2**								**1**							
39G6	**11**	**18**	**20**	**14**	**20**	**1**	**1**			**1**							**1**	**1**			**1**	**1**			**1**
39G5	**77**	**58**	**65**	**53**	**48**	**13**	**9**	**11**	**11**	**19**	**22**	**13**	**14**	**7**	**7**	**1**	**1**	**2**			**20**	**14**	**14**	**10**	**12**
39G4	**59**	**48**	**60**	**53**	**50**	**5**	**12**	**7**	**7**	**7**	**23**	**15**	**18**	**18**	**16**						**15**	**16**	**16**	**17**	**15**
39G3	**31**	**36**	**44**	**20**	**22**	**2**	**6**	**5**	**10**	**6**	**3**	**1**									**2**		**1**		**1**
38G6		**11**	**7**	**9**	**4**							**1**		**1**							**2**	**1**		**1**	
38G5	**61**	**58**	**66**	**53**	**44**	**11**	**7**	**6**	**7**	**14**	**9**	**8**	**6**	**6**	**7**	**1**	**1**				**13**	**10**	**7**	**8**	**8**
38G4	**57**	**40**	**47**	**43**	**41**	**2**	**1**	**4**	**7**	**9**	**7**	**5**	**4**	**7**	**6**	**1**		**2**	**1**		**9**	**8**	**8**	**7**	**9**
38G3	29	36	49	23	19			10	11	9	2					6	3	5	4	3					
37G5				1																					
37G4					1		2																		
Total	349	341	386	291	276	163	155	102	109	132	66	43	45	39	36	9	7	15	5	3	62	50	46	43	46

7.16.4 Harbours

To operate commercially, all Danish fishing vessels are required to register their vessel information with the Danish Maritime Authority and the Danish Agrifish Agency. In addition to other data, this information includes the owner(s) of the vessel, primary gear types, vessel length and home harbour.

In the five-year period between 2010-2014, fishing vessels from over 46 different Danish harbours have fished in one or more of the ICES rectangles along the proposed NSP2 route. The home harbours of the vessels that have landed the largest catches by species, weight and value are shown in Table 7-34.

Fishing vessels from the distant harbours of Skagen, Grenå, Hanstholm, Thyborøn, Hirtshals and Gilleleje caught between 3-23% (1,279-8,779 tonnes) of the total catches by weight along the proposed NSP2 route between 2010-2014. With the exception of vessels from Hirtshals harbour, the great majority of the catches from vessels of distant harbours comprise herring and sprat (industrial fish) from pelagic trawlers. Because the value of these species is less than that of the species caught and used for human consumption (cod and flatfish species, etc.), the total value of the catches of vessels from distant harbours only comprises 3-11% of the total value of catches along the proposed NSP2 route in the period between 2010-2014.

Of the harbours on Bornholm, fishing vessels from Nexø harbour caught the majority of commercial fish (18% of the total catch in weight) in the ICES rectangles along the entire proposed NSP2 route. The second and third most important Bornholm harbours were Tejn and Hasle, averaging 4% (1,327 tonnes) and 3% (1,199 tonnes) of the catches in 2010-2014, respectively. However, since the vessels from the harbours on Bornholm primarily targeted cod, flatfish species and salmon, the weight of the catches often represents a larger value compared with the weight caught by vessels catching herring and sprat. Looking at the value of the catches, vessels from Nexø caught 31% of the total value caught by Danish fishermen in the ICES rectangles along the entire proposed NSP2 route (corresponding to €6.6 million).

Table 7-34 Primary base harbours and mean yearly catch (tonnes and value in x1000 euro) of species in 2010-2014 by Danish vessels in the ICES rectangles along the proposed NSP2 route in the Baltic Sea. Other harbours include 37 nearby and distant harbours. (Source: Danish AgriFish Agency)

Mean yearly catch (tonnes) according to base harbours (2010-2014)

Species	Skagen	Nexø*	Grenå	Hans-tholm	Thy-borøn	Hirt-shals	Tejn*	Gil-leleje	Hasle*	Other har-bours
Cod	0	5,026	81	712	145	406	802	122	237	3,380
Sprat	8,297	1,362	4,546	2,191	2,374	384	4	29	464	2,160
Herring	480	35	0	0	0	0	348	1,118	426	497
Flounder	0	111	0	39	15	511	63	5	13	258
Plaice	0	45	0	16	4	43	95	2	32	219
Whiting	1	27	1	24	7	8	6	2	0	55
Salmon	0	17	0	0	1	0	8	0	26	50
Saithe	0	2	0	0	0	0	1	0	0	1
Turbot	0	1	0	0	0	0	1	0	0	3
Other species	0	57	0	1	1	0	0	2	1	178
Total	8,779	6,683	4,628	2,983	2,548	1,353	1,327	1,279	1,199	6,800
% of total	23	18	12	8	7	4	4	3	3	18

*Harbour on Bornholm.

Mean yearly value (x1000 euro) of catches according to base harbours (2010-2014)

Species	Skagen	Nexø*	Grenå	Hans-tholm	Thy-borøn	Hirt-shals	Tejn*	Gil-leleje	Hasle*	Other har-bours
Cod	0	6,067	98	864	178	493	963	150	288	4,092
Sprat	2,078	311	1,180	495	488	99	1	6	103	506
Herring	213	15	0	0	0	0	161	480	188	224
Flounder	0	57	0	20	7	256	32	3	7	133
Plaice	0	44	0	15	4	41	94	2	32	217
Whiting	1	26	1	21	6	7	6	1	0	46
Salmon	0	72	0	0	6	0	33	0	112	215
Saithe	0	2	0	0	0	0	0	0	0	1
Turbot	0	4	0	1	0	1	4	0	1	17
Other species	0	15	0	2	1	1	2	2	2	56
Total	2,292	6,613	1,279	1,418	691	899	1,296	643	733	5,506
% of total	11	31	6	7	3	4	6	3	3	26

*Harbour on Bornholm.

7.16.5 Number of fishing vessels from Bornholm

From 2010 to 2014, the number of registered fishing vessels associated with Bornholm, including Christiansø, decreased from 94 to 79 vessels (Table 7-35). Of the 14 harbours throughout Bornholm (including Christiansø), only 12 harbours had registered fishing vessels in 2014. The harbour of Nexø on the eastern side of Bornholm had the largest number of fishing vessels (33 vessels in 2014), which were dominated by trawlers and vessels using gill nets as well as vessels changing between gill nets and secondary gear (trawls as well as hooks and lines) depending on the season. Other important harbours in relation to the amount and value of catches, such as Tejn, Hasle and Rønne, had between 7-10 fishing vessels primarily using trawls and gill nets together with secondary gear (Table 7-35).

Table 7-35 Number of fishing vessels according to gear, from Bornholm harbours in the period 2010-2014. (Source: Danish AgriFish Agency vessel registration)

Harbours	Gear	2010	2011	2012	2013	2014
Nexø	**Total**	**29**	**29**	**33**	**34**	**33**
	Trawler	18	17	18	19	18
	Gill nets / trawler	3	4	4	3	4
	Gill nets	3	3	4	5	4
	Gill nets / hook and lines	4	4	5	5	5
	Small boat - undetermined	1	1	2	2	2
Tejn	**Total**	**14**	**14**	**14**	**11**	**8**
	Trawler	3	3	2	2	2
	Gill nets	1	1	2	1	1
	Gill nets / hook and lines	8	8	8	6	4
	Seine nets	1	1	1	1	1
	Small boat - undetermined	1	1	1	1	0
Hasle	**Total**	**12**	**10**	**10**	**10**	**10**
	Trawler	1	1	1	1	1
	Gill nets / trawler	1	1	0	0	0
	Gill nets	1	1	2	2	2
	Gill nets / hook and lines	5	5	5	5	5
	Small boat - undetermined	4	2	2	2	2
Rønne	**Total**	**8**	**8**	**7**	**7**	**7**
	Trawler	3	3	3	3	3
	Gill nets / trawler	1	1	1	1	1
	Gill nets / hook and lines	3	3	3	3	3
	Small boat - undetermined	1	1	0	0	0
Årsdale	**Total**	**7**	**7**	**7**	**6**	**6**
	Gill nets / trawler	2	2	3	2	2
	Gill nets	3	3	2	2	2
	Gill nets / hook and lines	1	1	1	1	1
	Hook and lines	1	1	1	1	1
Sømarken	**Total**	**5**	**4**	**4**	**4**	**4**
	Gill nets / trawler	1	1	1	1	1
	Gill nets	1	1	1	1	1
	Gill nets / hook and lines	2	2	2	2	2
	Small boat - undetermined	1	0	0	0	0
Listed	**Total**	**4**	**4**	**4**	**4**	**3**
	Trawler	1	1	1	1	1
	Gill nets / trawler	1	1	1	1	1
	Gill nets	1	1	1	1	0
	Small boat - undetermined	1	1	1	1	1
Christiansø	**Total**	**3**	**3**	**2**	**3**	**3**
	Trawler	1	1	1	1	1
	Gill nets / trawler	0	0	0	1	1
	Gill nets / hook and lines	2	2	1	1	1
Snogebæk	**Total**	**5**	**5**	**4**	**3**	**2**
	Gill nets	1	1	0	0	0
	Gill nets / hook and lines	2	2	2	2	2
	Small boat - undetermined	2	2	2	1	0
Gudhjem	**Total**	**2**	**2**	**2**	**2**	**1**
	Gill nets	1	1	1	1	0
	Hook and lines	1	1	1	1	1
Allinge	**Total**	**1**	**0**	**0**	**0**	**0**
	Trawler	1	0	0	0	0
Bølshavn	**Total**	**1**	**1**	**1**	**1**	**1**
	Small boat - undetermined	1	1	1	1	1
Svaneke	**Total**	**2**	**2**	**1**	**1**	**1**
	Gill nets / trawler	1	1	1	1	1
	Gill nets	1	1	0	0	0
Pedersker	**Total**	**1**	**1**	**0**	**0**	**0**
	Small boat - undetermined	1	1	0	0	0
Total		**94**	**90**	**89**	**86**	**79**

7.16.6 Fishing gear

The most important gear types for Danish fishery in the lower Baltic Sea and the area around Bornholm are trawls (pelagic and bottom), which accounted for an average of 92% of the value of catches between 2010 and 2014 (Figure 7-53).

Pelagic trawls accounted for an average of 29% of the catch value (€4.1-7.3 million) (Figure 7-53) and almost exclusively targeted large quantities of lower value industry fish (i.e. sprat and herring) (Table 7-36). In contrast, bottom trawls accounted for 63% of the catch value (€10-17.9 million). Bottom trawls typically targeted cod and had bycatch of a wide variety of more valuable species such as flounder and plaice (Table 7-36).

Gill nets accounted for approximately 3% of the total catch value (€395,000-1 million) in Danish fishery in 2010-2014 within the ICES rectangles along the entire proposed NSP2 route (Figure 7-53). Gill nets primarily target cod, plaice and flounder (Table 7-36).

Catches by seine nets fluctuated considerably between 2010 and 2014, but accounted for only approximately 1% of the value of the catches (€8,000-498,000). Seine nets primarily targeted cod, sprat and flatfish (Table 7-36).

Other gear such as hooks and lines, which target cod and salmon (Table 7-36) around the coast of Bornholm, and various fish traps such as pound nets, etc., together accounted for approximately 3% of the catch value (€604,000-769,000) (Figure 7-53).

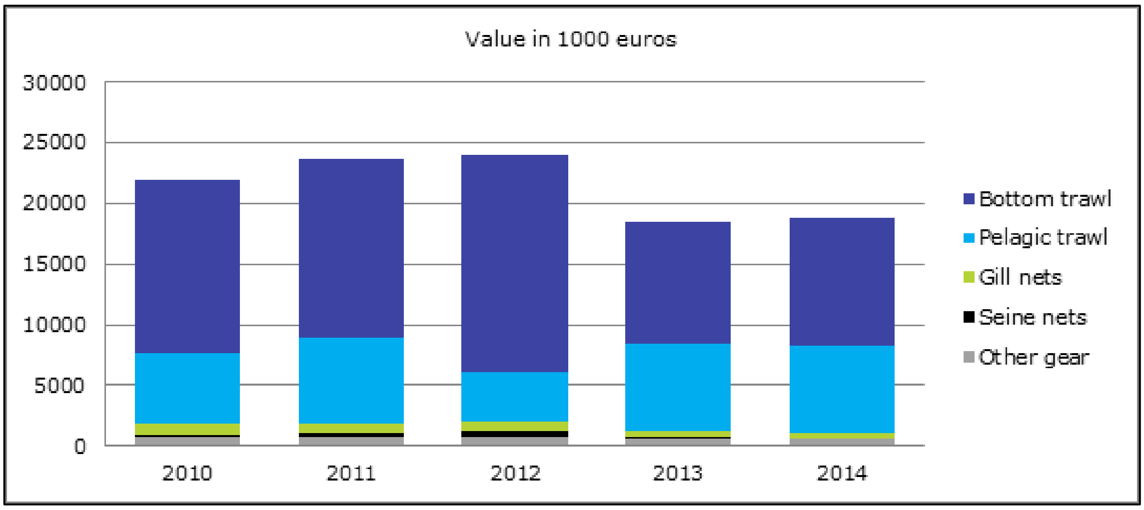


Figure 7-53 Value of Danish catches (x €1,000) in ICES rectangles along the NSP2 route in 2010-2014 according to gear (see Figure 7-51). (Source: Danish AgriFish Agency).

Table 7-36 Mean yearly value of Danish catches (x €1,000) of commercial species from ICES rectangles along and adjacent to the NSP2 route in 2010-2014.

Mean yearly value of Danish catches (x €1,000) (2010-2014)					
Species	**Bottom trawl**	**Pelagic trawl**	**Gill nets**	**Seine nets**	**Other gear**
Cod	12,189	55	573	105	269
Sprat	108	5,088	0	72	0
Herring	190	1,092	0	1	0
Flounder	478	2	34	0	0
Plaice	344	2	101	1	0
Dab	3	0	0	0	0
Turbot	22	0	6	0	0
Sole	3	0	1	0	0
Whiting	105	12	0	0	0
Salmon	0	0	0	0	437
Pollock	3	0	0	0	0
Other species	22	47	2	0	1
Total	13,467	6,298	717	179	707

7.16.7 Catches and target species in Danish fishery

In 2010-2014, the annual value of catches by Danish vessels in ICES rectangles along the entire proposed NSP2 route was €21.4 million (Table 7-36). Cod comprised 62% of the mean landing value (€13.2 million), while landings of sprat and herring comprised approximately 30.7% of the mean landing value (€6.5 million). The mean value of flounder, plaice and other species (e.g. salmon, turbot, brill, eel, garfish, etc.) amounted to 7.6% (€1.63 million) of the total value of the landings (Table 7-36). The spatial distribution of the catches (weight and value) in the various ICES rectangles is shown in Figure 7-54 and Figure 7-55.

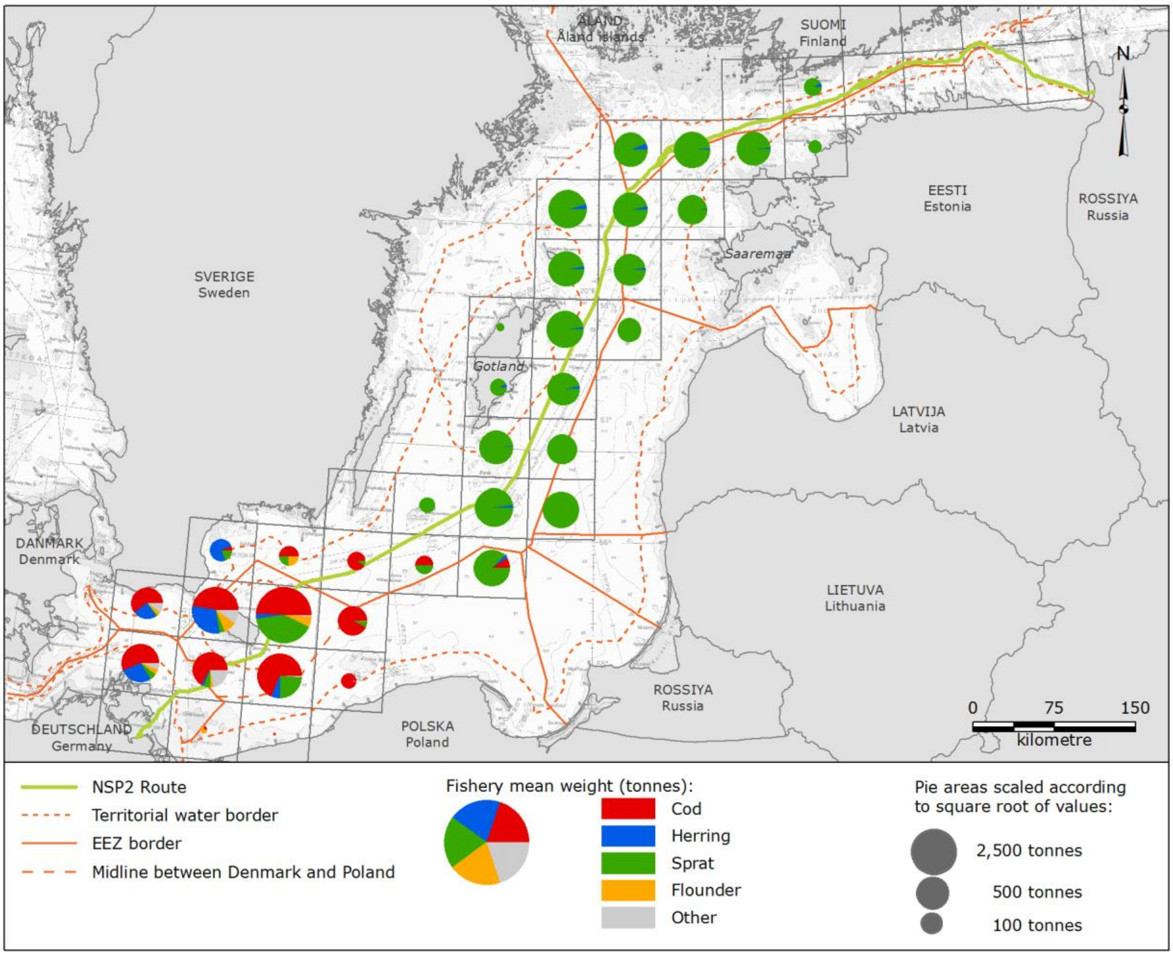


Figure 7-54 Mean yearly catches by weight (tonnes) of the most important commercial species caught by Danish vessels in the ICES rectangles along and adjacent to the NSP2 route in 2010-2014.

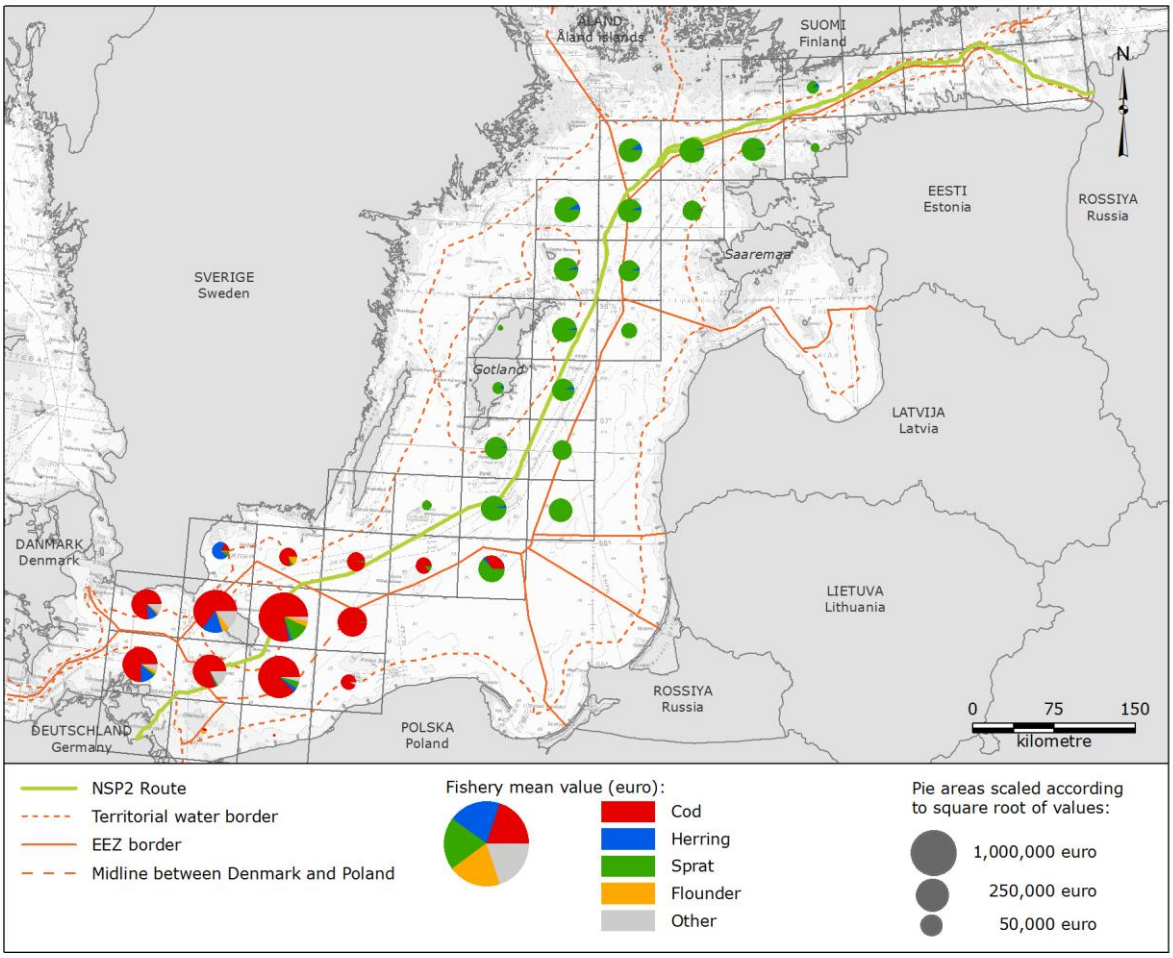


Figure 7-55 Mean yearly catches by value (euro) of the most important commercial species caught by Danish vessels in the ICES rectangles along and adjacent to the NSP2 route in 2010-2014.

7.16.8 Distribution of Danish bottom trawling

The spatial distribution of bottom trawling activities in Danish waters by Danish fishermen is mapped in Figure 7-56. The density plots only include fishery vessels with speed between 0-5 knots, which is the speed interval at which bottom trawling is likely undertaken.

Bottom trawl fishery is particularly intense in an area on the western side of Bornholm and in a larger area that extends from just south of Bornholm all the way around to the east/northeast of Bornholm (Figure 7-56).

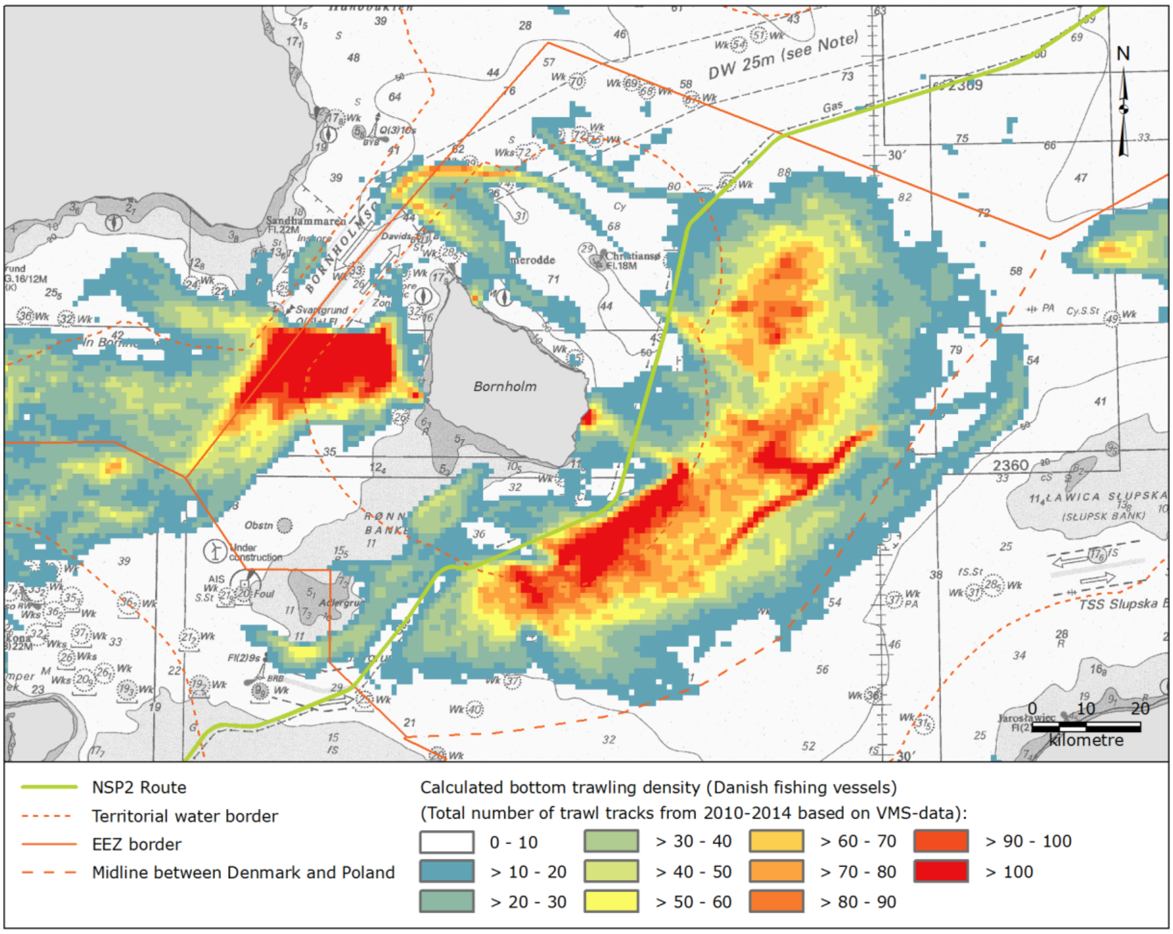


Figure 7-56 Distribution of fishery by bottom trawling in the waters around Bornholm. (Data source: Danish AgriFish Agency)

7.16.9 Fishing activities by other countries

The mean annual catch and mean annual value of the catch of all countries (with the exception of Russia) in the ICES rectangles along the entire proposed NSP2 route in 2010-2014 amounted to 279,245 tonnes and €107 million respectively (Table 7-37). The Danish mean annual catch and value of the fishery was approximately 13.5% (37,578 tonnes) of the total catch by weight and 20% (€21.3 million) of the total catch by value compared with the other countries bordering the Baltic Sea (with the exception of Russia) and fishing in the same ICES rectangles (Table 7-37).

Table 7-37 Mean annual catch (tonnes) and value of the catch (x €1,000) by countries fishing along the entire planned NSP2 route in 2010-2014. Data is from logbooks that include vessels ≥8 m and from the ICES rectangles that follow or are adjacent the NSP2 pipeline transect. (Source: data obtained from the respective fishery authorities and fishery institutes for each country)

Country	Mean catch (tonnes)	Range (min - max)	Mean value (x €1,000)	Range (min - max)
Denmark	37,578	31,704 - 46,382	21,371	18,529 - 24,026
Sweden	68,541	57,402 - 80,257	28,308	22,181 - 35,826
Finland	19,482	12,659 - 30,655	5,493	4,473 - 6,657
Estonia	40,708	33,567 - 52,887	7,724	7,085 - 8,299
Latvia	12,587	9,359 - 17,711	4,211	3,614 - 5,009
Lithuania	8,340	7,737 - 9,845	2,410	1,509 - 3,294
Poland	67,621	53,009 - 76,297	26,129	20,080 - 31,947
Germany	24,388	21,368 - 27,969	11,810	8,707 - 13,388
Total	279,245	-	107,456	-

The spatial distribution of the catch value of fishery by Denmark, Sweden, Finland, Estonia, Latvia, Lithuania, Poland and Germany along the ICES rectangles that follow or are adjacent to the NSP2 pipeline transect is shown in Figure 7-57.

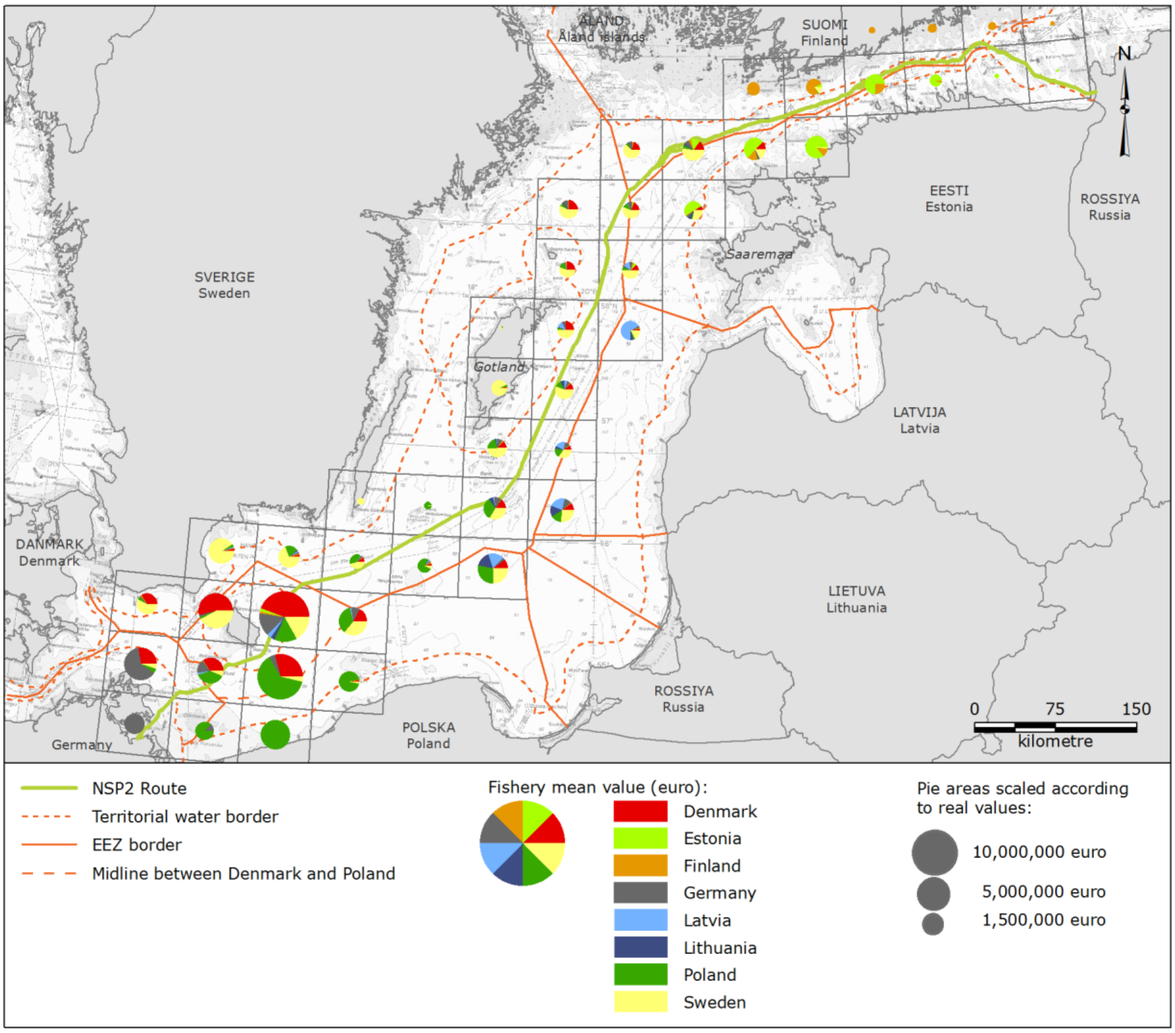


Figure 7-57 Ratio of the mean distribution of catches by value of fishery by eight countries in the ICES rectangles that follow or are adjacent the NSP2 pipeline transect. (Source: derived from data obtained from fishery authorities in each country)

7.17 Cultural heritage

The maritime cultural heritage objects (CHO) in the Baltic Sea primarily consists of two broad categories: submerged Stone Age settlements and man-made cultural heritage objects including shipwrecks, aircraft and other artefacts.

Both submerged Stone Age settlements and man-made cultural heritage objects are of great historical importance and therefore are protected under the Danish Museum Act (§ 29g of LBK no. 358 of 08/04/2014), which covers objects more than 100 years old. However, in special cases the Danish Agency for Culture and Palaces may decide that more recent wrecks (i.e. aircraft or ships from WWI or WWII), are also to be protected. Furthermore, Denmark is obliged to protect and preserve archaeological and historical objects found in maritime areas outside of its national jurisdiction (in the Danish EEZ), under the UNCLOS convention of 10 December 1982. Based on the above obligations to protect cultural heritage it is considered an important socio-economic receptor.

7.17.1 Submerged settlements and landscapes

Due to changing sea levels since the last glaciation, some former land areas, including human settlements and monuments, are today submerged, particularly in the southern part of the Baltic

Sea. In most cases, submerged settlements and landscapes are not only submerged but are also totally or partially covered by sediments. In recent decades, the 'fishing-site model' has been used successfully to predict locations of submerged Stone Age settlements. The model is based on the knowledge that the Stone Age population was largely dependent on food from the sea /260/ and as such the Stone Age people demonstrated a clear preference for building settlements in specific areas that were favourable to fishing /261/.

Within the Baltic Sea, it is unlikely that submerged settlements are present at latitudes north of approximately 55.5°-56° N, as these areas were not dry land during the Stone Age /262/. The area around Bornholm is situated south of this latitude and as a result of Bornholm's geological history, of numerous regressions and transgressions since the last glacial period, vast former dry land areas around Bornholm are now submerged /263/. According to the local museum (Bornholm Museum), submerged settlements and ancient submerged forests may be encountered in waters shallower than approximately 40m in the nearshore area around Bornholm. Figure 7-58 shows the areas which are most likely to contain the remains of submerged Stone Age settlements, as identified by the Danish Conservation Agency (now the Agency for Culture and Palaces) in 1986. The areas are mainly along the south coast of Bornholm (see Figure 7-58).

It is highly unlikely that submerged Stone Age settlements are to be found in the vicinity of the pipeline route since in Danish waters, the pipeline stays at depths that were inundated at all times of potential human habitation.

7.17.2 Shipwrecks and other man-made objects

Shipwrecks reflect a diverse group of vessels that vary in age, size and type. Not all shipwrecks have the same cultural heritage value.

Once settled on the seabed, wrecks are prone to physical destruction by natural occurrences, such as storms, or human activities, such as bottom trawling. Nevertheless, a shipwreck does not necessarily need to be fully intact to be of archaeological interest. Even some highly degraded shipwrecks can yield valuable information after thorough investigations of hull remains, equipment, cargo and other artefacts belonging to the wreck. It is therefore important to recognise that the 'ancient monument area' of a wreck site is not only the hull itself, but includes the total deposit and distribution area of the remains from a broken wreck, which in many cases is substantially larger than the actual hull.

Due to physical conditions in the deeper parts of the Baltic Sea (low salt content, relatively low temperatures, low oxygen content, etc.) and the absence of shipworm, the decomposition of wood and other organic materials progresses slowly. Consequently, the preservation of organic materials is exceptional. The preservation value and scientific potential of underwater cultural heritage remains are therefore particularly high in the Baltic Sea. The fact that the underwater cultural environment has been exempt from much of the exploitation that has taken place on land only adds to the potential archaeological value of underwater cultural remains.

The Danish Agency for Culture and Palaces keeps a national register of shipwrecks, together with all known sites, monuments and archaeological finds. The current register holds information on approximately 17,000 shipwrecks and submerged Stone Age settlements. Locations of the registered shipwrecks in Danish waters are shown in the Figure 7-58.

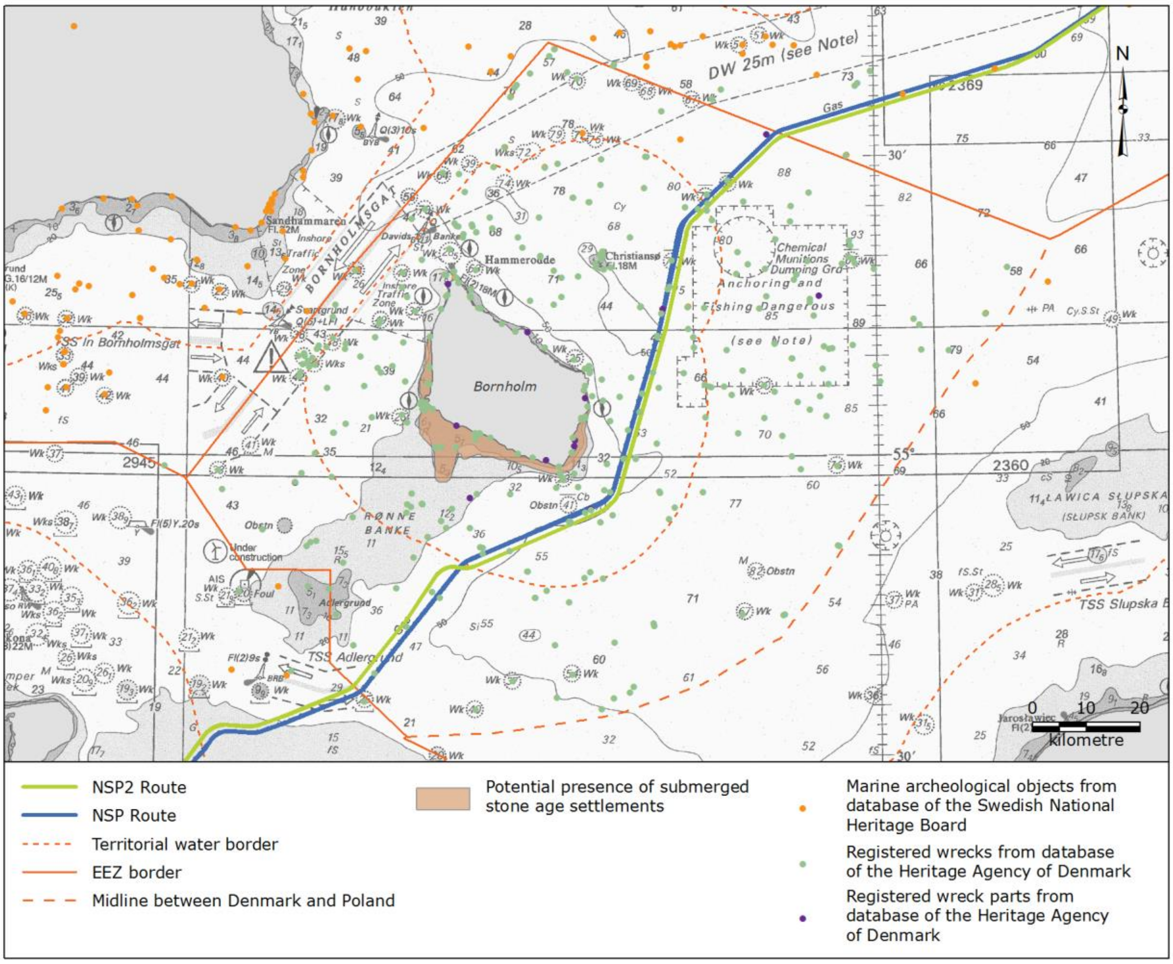


Figure 7-58 Locations of registered shipwrecks in Danish waters.

7.17.3 Experience from NSP

Detailed surveys conducted by Nord Stream AG prior to the NSP pipeline installation led to the discovery of a number of wrecks and cultural heritage sites east and south of Bornholm.

Eight wreck sites were identified during the baseline survey along the NSP pipeline route alignment in Denmark, including a wooden rudder from the 17th century that was successfully retrieved from the seabed. A subsequent anchor-corridor survey revealed 41 objects of potential cultural importance, following inspection these objects were classified as 22 wrecks and 19 singular objects.

Not all of the identified wrecks are protected under the Danish Museum Act. Based on consultations with the relevant Danish authorities (Danish Agency for Culture and Palaces) a number of shipwrecks were investigated during the NSP project and registered in the national register of the shipwrecks (Figure 7-58). This resulted in new knowledge on cultural heritage sites in Danish waters /380/.

7.17.4 Cultural heritage objects in Danish waters

A number of surveys including geophysical reconnaissance survey of the proposed NSP2 route corridor and a detailed route survey, were performed between November 2015 and April 2016. These surveys included investigations of the seabed with multibeam echosounder (MBES), side-scan sonar (SSS), sub-bottom profiler and magnetometer /61/.As recommended by the The Danish Agency for Culture and Palaces, the geophysical data will be screened by a recognised marine archaeology agency with the aim of identifying cultural heritage objects (CHOs) of potential importance. Where required, objects will be subjected to further visual inspection and/or assigned an exclusion zone to be respected during pipe-lay. The need for further inspection and exclusion zones will be agreed in consultation with the relevant Danish authorities (The Danish Agency for Culture and Palaces).

Seven potential wrecks have been identified during the geophysical reconnaissance survey. They are listed in Table 7-38 and their locations are presented in Figure 7-59. Two of the wrecks were previously found during surveys for NSP and have already been registered in the wreck database (wrecks S-DK-01-461 and S-S33-3807). The other five CHOs are new findings. Figure 7-60 shows images of two of the identified wrecks in Danish EEZ. Further identification of potential CHO for visual inspections and defining the exclusion zones interfering with the pipe-lay/interventions works corridor is currently ongoing.

Table 7-38 Summary of identified possible wrecks

Target ID	Length (m)	Width (m)	Height (m)	Distance to pipeline A (m)	Distance to pipeine B (m)	Comment
S-R37-0036	30.2	8.0	2.8	759	814	-
S-R35-0197	25.1	5.3	2.4	714	658	-
S-R35-0285	22.0	5.0	2.1	226	169	-
S-R35-0653	31.0	7.5	4.0	104	158	-
S-R35-0671	31.8	11.3	2.2	1224	1170	Identified during NSP (S-DK-01-461)
S-R34-1099	14.6	12.1	0.3	435	490	Identified during NSP (S-S33-3807)
S-R34-1127	46.0	23.0	Not measura-ble	295	350	-

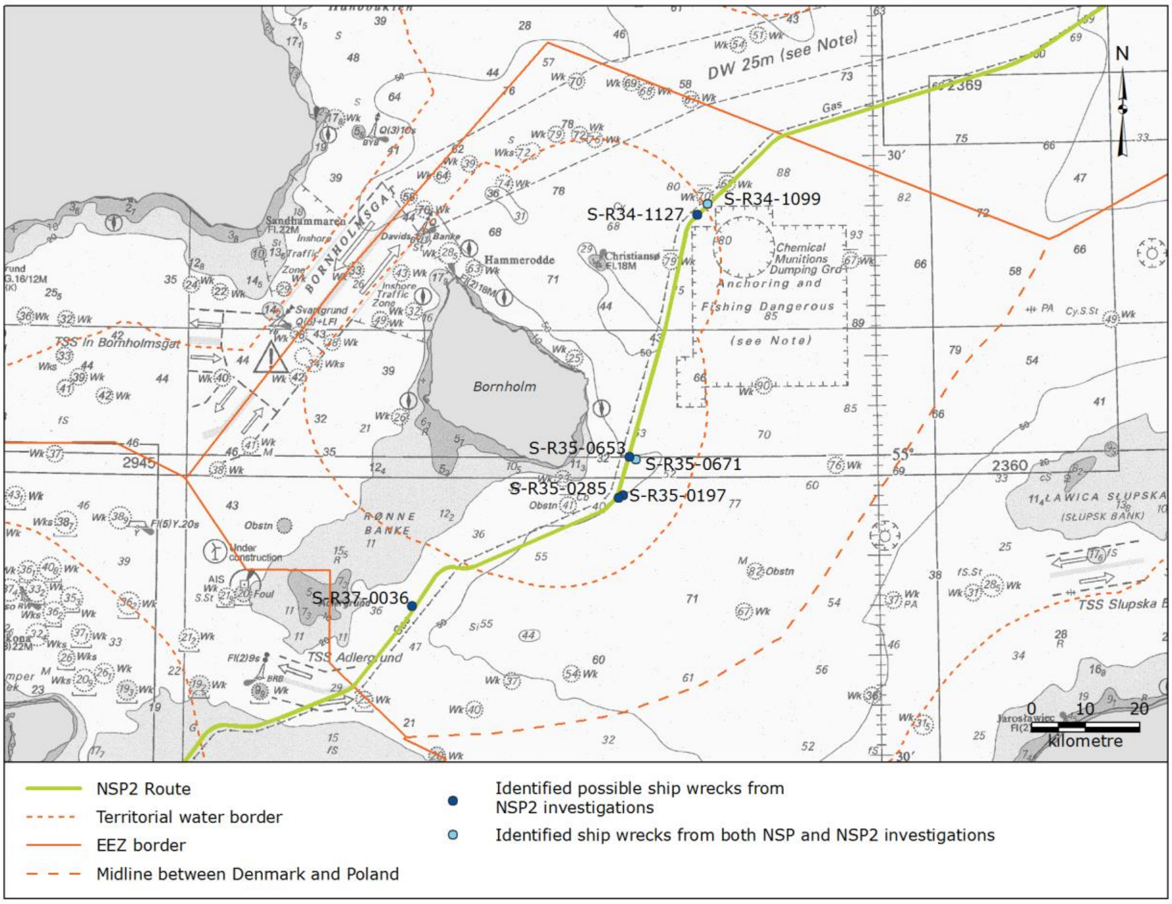


Figure 7-59 Identified possible wrecks during the NSP and NSP2 investigations

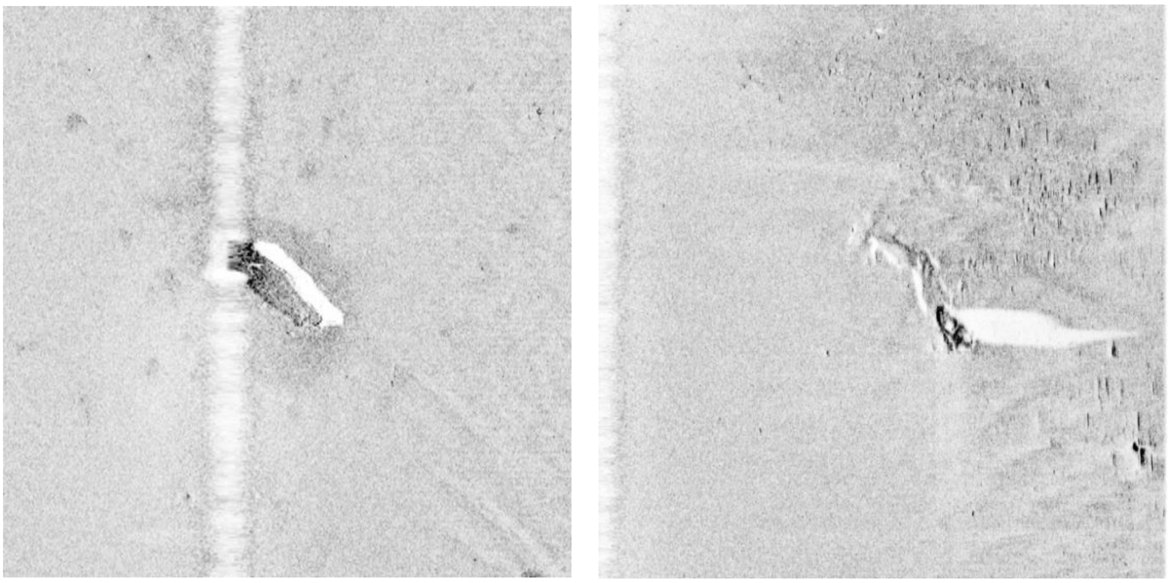


Figure 7-60 Two of five new identified possible wrecks (S-R37-0036, left, and S-R35-0653, right)

7.18 Conventional and chemical munitions

During World War I and II (WWI and WWII) the Baltic Sea was of great naval strategic importance and hence thousands of mines were deployed during and after the wars. Conventional and chemical munitions are therefore considered an important topic in relation to the planning, construction and operation of NSP2 since the possible disturbance of munitions by any project activities may lead to impacts on the environment or present a risk to humans.

During the last stages of WWII and in the post-war period, large quantities of conventional and chemical munitions from the stockpiles of the German and Allied Forces had to be disposed. Owing to time pressure and financial restrictions, dumping at sea was chosen as the disposal method. At that time, environmental implications were not a key consideration.

The southern entrance to the Little Belt (in inner Danish waters) was used for munitions dumping during the last stages of WWII. It is the shallowest of all dumping sites, with a depth of approximately 30 m. In the post-war period, deeper basins at water depths exceeding 70 m south-east of Gotland, east of Bornholm (with depths of 93-137 m) and in the Skagerrak were used for dumping of chemical munitions. Conventional munitions, on the other hand, were regarded as less problematic and were often dumped closer to shore. However, it is possible that conventional munitions were co-dumped with chemical munitions /89//91/.

7.18.1 Conventional munitions

The Baltic Sea was heavily mined during WWII, and even though known mine areas were swept after the war, thousands of mines still rest on the seabed today.

Different types of mines were used, of which contact mines were the most common. Contact mines were built to explode when triggered by contact with an enemy ship or submarine, there are generally three types of contact mines:

- Moored contact mines;
- Bottom contact mines;
- Drifting contact mines.

The largest quantity of mines is located in the Gulf of Finland and in the northern and central parts of the Baltic Sea. Other types of ammunition have also been dumped in the Baltic Sea, the most common types comprise:

- Depth charges;
- Torpedoes;
- Submarine combating rockets;
- Grenades.

It is also possible that munitions from military training could be present in the Baltic Sea. Military exercise materials do not contain explosives, but they can contain firing mechanisms. Exercise materials are in general clearly marked with special colours such that they can be identified.

As the exact locations of munitions (unexploded ordnances, UXO) on the seabed are not known, a geophysical munitions screening survey of the proposed NSP2 route was undertaken as reported in section 6.1.2. The munitions screening surveys along the proposed NSP2 route in Danish waters have not resulted in any finding of conventional munitions, in accordance with findings from NSP, see section 7.18.4.

7.18.2 Chemical munitions

Chemical munitions are munitions containing chemical warfare agents (CWA), whose toxic properties were designed to kill, injure or incapacitate humans. Chemical munitions were first used in significant amounts during WWI and proved to be powerful weapons. In 1925, the use of chemical munitions was declared illegal in the Third Geneva Convention. Chemical munitions were not used during WWII, but both the Allied and German forces stockpiled large quantities of chemical munitions. After the war, the Bornholm Basin and the Gotland Deep were selected as dumping sites for chemical munitions, as they are the deepest locations in proximity to the German harbours (Peenemünde and Wolgast) from which the munitions were shipped. HELCOM has concluded that at least 40,000 tonnes of chemical munitions, containing approximately 15,000 tonnes of CWA, were dumped in the Baltic Sea /89/.

Due to their sensitivity, chemical munitions of German manufacture were usually stored in special protective storage and transport containers. Chemical grenades were stored singularly in non-hermetical wooden or wicker basket encasements and chemical bombs were stored in wooden crates. In general, the crates were sturdy and well built, sealing the contents off from the environment.

In some cases, warfare materials were loaded onto various types of vessels (ships, barges and hulks), which were sunk at the dumping site. In other cases, munitions or wooden crates with munitions and bulk containers with CWA were disposed of individually.

Chemical munitions transported to the dumping sites were not armed, as the detonators for the explosives were not inserted.

The main site in Danish waters used for chemical munitions disposal was the southern part of the Bornholm Basin. It is estimated that chemical warfare materials containing 11,000 tonnes of CWA were dumped north-east of Bornholm. The primary designated dumping area was circular with a radius of 3 nm, centred on coordinates located at approximately at 55° 20' N, 15° 37' E. The designated area is marked on sea charts. However, since the navigational equipment at the time of dumping was not very accurate, it is highly possible that dumping vessel may not have been within the predetermined location when being scuttled or did not remain in one place when overboard dumping was carried out. Therefore, chemical warfare materials may have been spread over a larger area. Furthermore, there are indications of individual dumping while travelling to and from the designated dumping area. Thus, a more realistic secondary dumping area is also marked on the sea charts, shown on Figure 7-61 as the area where bottom trawling, anchoring and seabed intervention works are discouraged. Fishermen trawling inside this area are not compensated if their catch is ruined by chemical munitions /264//265/. Fishermen occasionally find yellow or brown lumps of mustard gas in their fish catch. Between 2002 and 2012, 53 incidents were reported /89/.

In the Bornholm Basin, it is most likely that bombs, some in grenades, bulk containers, spray cans and wooden crates were dumped. In the area of the 'primary dumpsite', four metallic, heavily damaged shipwrecks deeply immersed in bottom sediments have been identified. However, the origin and contents (chemical or conventional warfare materials or other cargo) of the discovered shipwrecks remain unclear /264//89/.

The Danish Navy Maritime Surveillance Centre South on Bornholm has designated two emergency dumping areas in the vicinity of the Bornholm dumpsite. They are to be used for the emergency disposal of netted warfare materials that are too unsafe to be brought ashore for handling.

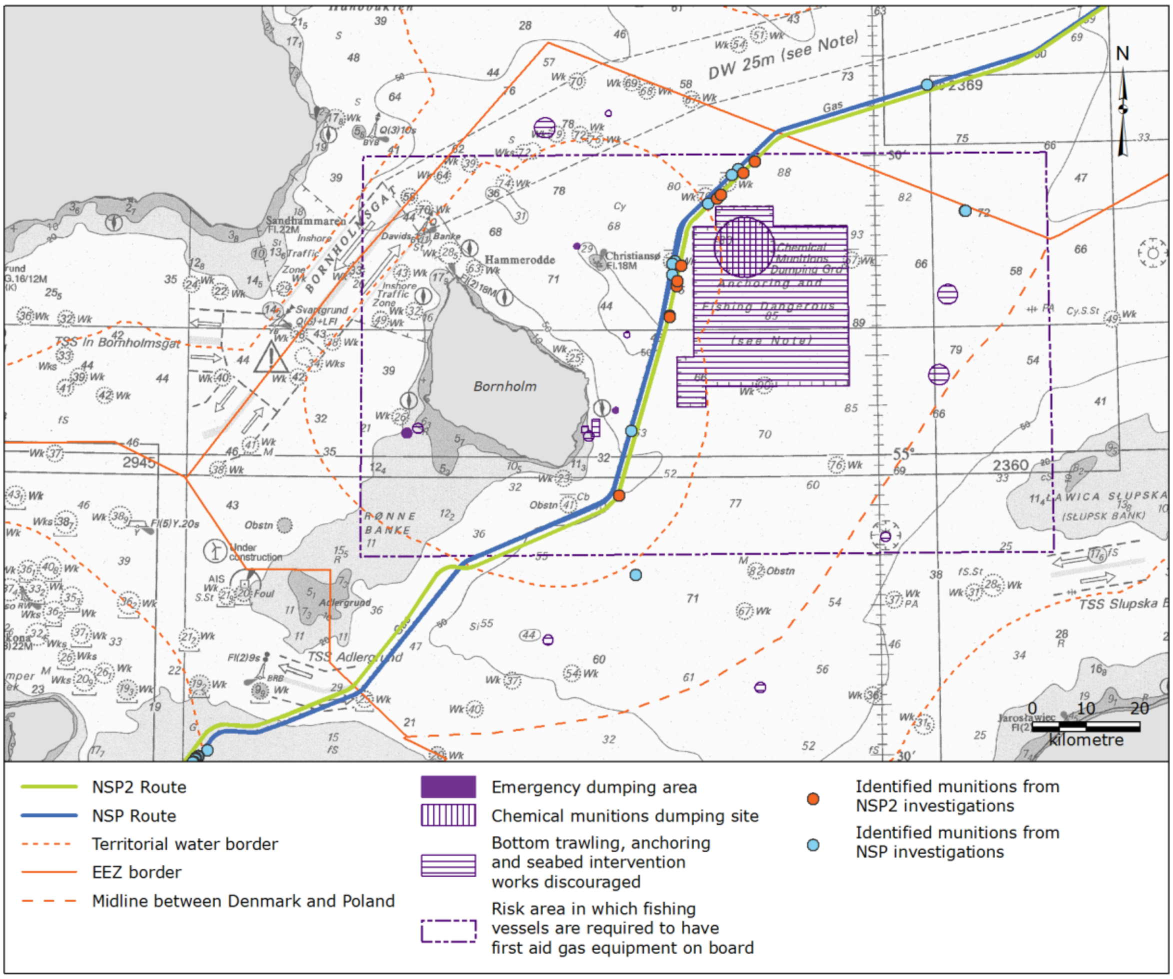


Figure 7-61 Chemical munitions dumping sites and risk areas in Danish waters.

A variety of different chemical munitions containing different types of CWA were dumped in the Bornholm Basin. The different CWA substances and the amounts of CWA dumped east of Bornholm are described in section 7.3.

Munitions have been resting on the seabed and in the sediment of the Baltic Sea for more than 65 years now. Over time, the metal casings of the munitions as well as the bulk containers rust and are subject to mechanical erosion. Some shells will have leaked their contents, whereas others may still be intact. The ratio between corroded and empty munitions versus intact munitions is not known. It is clear, however, that oxygen is needed for corrosion of the metal casing of the munitions, and that munitions in anoxic sediments will be better conserved than munitions exposed to oxygen in either sediment or water.

7.18.3 Munitions in Danish waters

Identification of magnetic anomalies potentially associated with UXO was one of the objectives of the geophysical reconnaissance survey along the proposed NSP2 route corridor carried out between November 2015 and January 2016. A dedicated munitions screening survey of the proposed NSP2 pipe-lay corridor was undertaken between May 2016 and August 2016 to confirm that no magnetic anomalies were present along the proposed NSP2 route.

Seabed features and objects have been interpreted from SSS, MBES and magnetometer data as well as from visual inspections. Fifty-two objects were identified as possible munitions/61/. These objects were visually inspected by an ROV and twelve objects were assessed to be munitions related. All of the 12 objects were evaluated by a Danish munitions expert to be possible chemical munitions relating to aerial mustard gas bomb type KC 250. No conventional munitions were identified in Denmark.

Locations of identified chemical munitions in Danish waters are in shown in the Figure 7-61 on the Atlas map MU-02-D.

7.18.4 Previous investigations as part of the NSP project

Baseline investigations for munitions along the NSP pipeline in Denmark were also carried out as part of the EIA work in 2007 and 2008, with follow-up surveys in 2010-2012.

No conventional munitions were identified in Denmark. Hence, no munitions clearance was necessary in Danish waters for the construction of NSP. In total, seven chemical munitions were identified in the vicinity of the NSP pipeline route in Denmark. All finds were reported to ADF, and it was agreed between Nord Stream AG and ADF that the chemical munitions were to be left on the seabed.

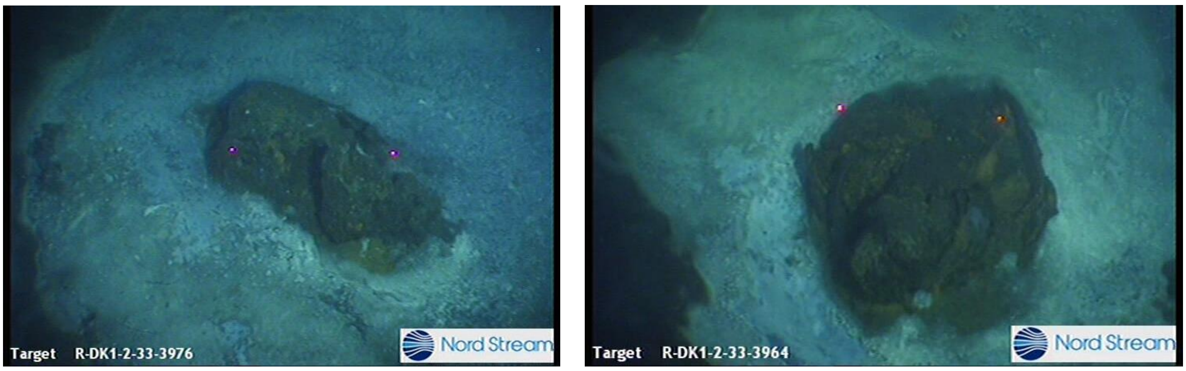


Figure 7-62 Underwater images of two of the seven chemical munitions objects identified during the NSP. The object to the left is a chemical mustard gas bomb with heavily corroded casing, and the object on the right is a corroded German KC250 mustard gas bomb.

Identified chemical munitions were monitored during and after construction of the NSP. The monitoring of munitions in Danish waters has shown that the conditions of all seven munitions objects were unchanged /266/.

7.19 People and health

The closest human receptors are located on the islands of Bornholm and Ertholmene which are approximately 10 km and 15 km (shortest distances) west of the proposed NSP2 route respectively. People and health is inherently considered an important socio-economic receptor.

Bornholm is part of the Capital Region of Denmark and has a population of approximately 39,830 people/268/. Residential receptors are located both inland and along the coast. The health statistics of people on Bornholm have been evaluated based on the Health Profile 2013 of the Capital Region /267/ and data from the municipality of Bornholm /268/. The average age of the people of Bornholm is higher than in the rest of the Capital Region. Furthermore, the behaviour in relation to health aspects, such as habits of exercise, is poorer in this municipality, resulting in slightly poorer physical health than the average of the rest of the Capital Region. The fraction of people with problems related to mental health and stress, however, is similar to the rest of the Capital Region /267/.

Ertholmene is not part of any municipality, the two main islands are Christiansø and Frederiksø, with a total population of approximately 90 people. Given its size, residential receptors are located primarily along the coast. No data about the health of the residents on the island is available.

7.20 Tourism and recreational areas

Given the role of tourism and recreation in the Danish economy, as well as its importance for people's amenity, tourism and recreational areas are considered an important socio-economic receptor.

The following section focuses on the islands of Bornholm and Ertholmene (being the closest onshore receptors to the proposed NSP2 route). Given that the proposed NSP2 route will run to the east of Bornholm, the descriptions of accommodations, attractions and recreational areas are focused on the eastern and southern parts of this island.

Tourism and recreational interests on Bornholm are described on the basis of data from the 2013 Municipal Plan, VisitDenmark, Destination Bornholm and Centre for Regional & Tourism Research /269//270//271//272//274/ whilst interests on Ertholmene have been described based on VisitDenmark and the webpage “Søfæstning Christiansø” /272//272/.

Although much of the information presented in this section is based on previous years, the overall trends are expected to remain valid.All areas of interest in relation to tourism and recreation specified in the municipal plan /269/ are presented in Figure 7-63.

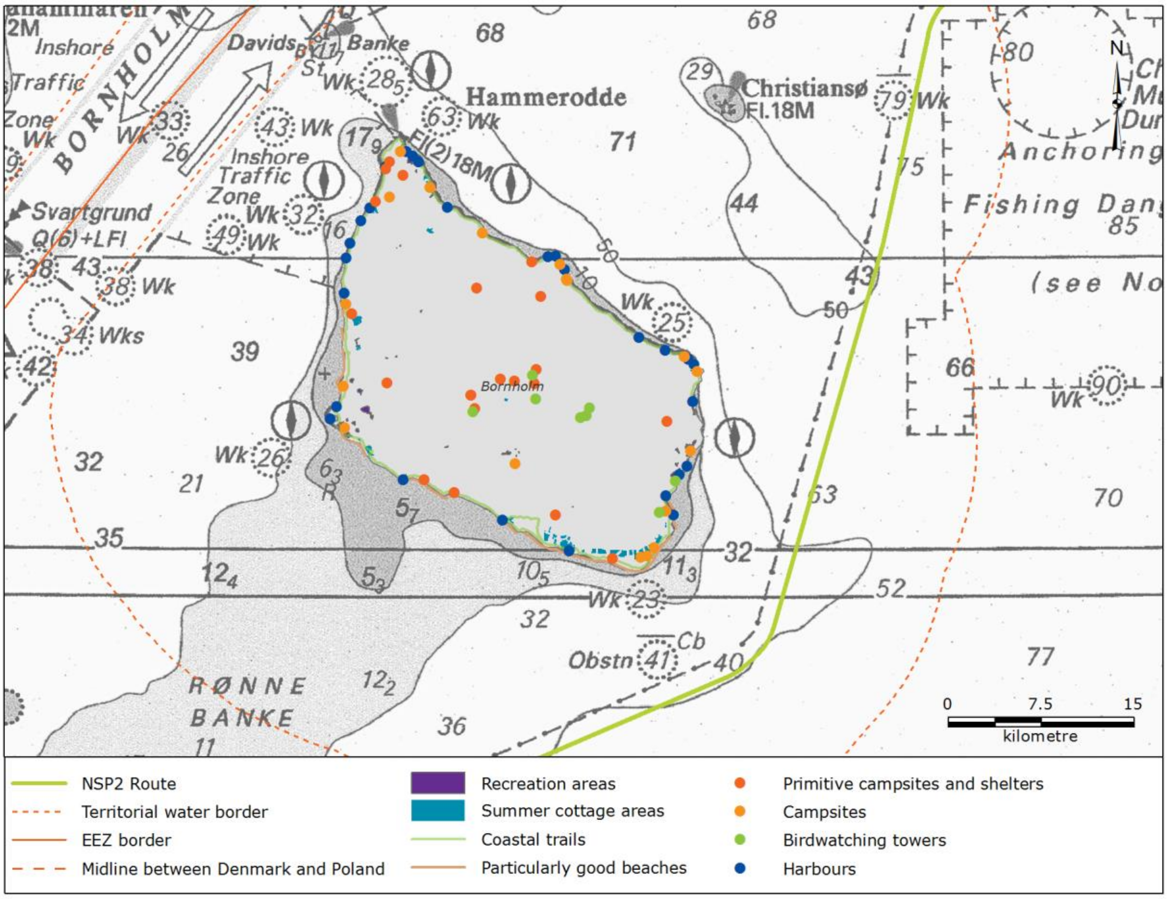


Figure 7-63 Recreational interests and areas of interest in relation to tourism on Bornholm /269/.

7.20.1 Tourism

The tourism industry is important for occupational and business-related development on Bornholm and Ertholmene (Christiansø and Frederiksø). Therefore, tourism is important receptor contributing to the economy of the islands.

To secure the development of this industry, the municipal council has prioritised the promotion and improvement of accommodation capacity, tourist attractions and activities, and recreational and outdoor opportunities /269/.

In 2007, 650,000 people visited Bornholm as tourists (excluding cruise ships and people arriving on private boats), and the number of tourists visiting Bornholm has since been increasing /269//270/. A majority of the tourists visit the island during the summer months, with almost 75% of the overnight stays occur in June, July or August. Most tourists visiting Bornholm are Danish or German, but Swedish, Norwegian and Polish tourists also frequently visit the island /271/. In 2012, the average Danish tourist stayed approximately 7 days, while the average foreign tourist stayed approximately 9 days /269//270/.

According to the data, most people visit Ertholmene on a one-day-trip /272/. However, there are still several small businesses on the islands which are considered to be dependent on non-residents visiting. Each year, approximately 40,000 guests visit Ertholmene to experience the small island community and the nature and birds of the islands /273/.

7.20.2 Transportation and accommodation

In 2007, 70% of the people traveling to Bornholm were non-residents. Of these, 71% arrived by ferry, while 13% arrived by airplane /269/. There are ferry connections to Rønne from Ystad

(Sweden), Køge (Denmark), Sassnitz (Germany) and Swinoujscie (Poland) /272/, but the ferry between Ystad and Rønne was by far the most used mean of transportation to and from Bornholm in 2012 /270/.

In 2009, most tourists stayed in holiday homes (46%) or hotels and holiday centers (30%) when visiting Bornholm, but campsites were also a popular choice (18%) /271/. Only a few of the island's hotels are located on the eastern part of Bornholm, but most of the holiday homes are located on the south-eastern coast from Sømarken to Snogebæk. There were 18 campsites on Bornholm in 2013, and 7 of these sites were located on the east coast. Furthermore, it is also possible to stay overnight at more primitive campsites, in shelters on the island or on a boat at some of the harbours /269/.

Most people travelling to Ertholmene arrived by ferry from Gudhjem. On Ertholmene it is possible to stay overnight on the island of Christiansø at the inn, the hostel, on a boat at the harbour or at the campsite /275/.

7.20.3 Attractions and activities

Bornholm has a large variety of activities and attractions, such as nature experiences, historical sites and zoos. The most visited attractions on Bornholm are Hammershus Castle Ruins, NaturBornholm and Bornholm Butterfly Park. Only the latter is located on the east coast, in Nexø /272/.

Ertholmene is a popular site for tourists. The main attraction is considered to be the small community, nature and wildlife of the island /223/.

7.20.4 Recreational interests relevant to NSP2 construction

A coastal trail runs around the entire island of Bornholm, and several of the beaches are suitable for bathing. On the eastern coast, the beaches between Balka and Snogebæk, the beaches south of Snogebæk and the beaches around Dueodde are all identified as "particularly good beaches" in the 2013 municipal plan /269/. "Particularly good beaches" is a term used in the municipal plan, and is not related to any other classification of beaches. Furthermore, there are several beaches where bathing is possible on the coast of the islands Christiansø and Frederiksø of Ertholmene /275/.

In connection with the coastal cities Svanek, Årsdal, Nexø and Snogebæk on Bornholm, the municipal plan furthermore identifies several areas where recreational activities are possible /269/.

The water around Bornholm is well suited for recreational activities such as diving and recreational fishing. Recreational fishing is a popular activity for both residents and tourists. Many spots along the coastline provide good conditions for coastal fishing, but in several marinas it is possible to launch a boat or make use of guided fishing trips by boat to fishing areas further from the coast /273/.

When fishing in the waters around Bornholm, both trolling and jig fishing are popular activities. These activities are performed at least 1 nm (1.85 km) from the coast but most often even further out /276/.

Several diving activities are possible in the waters around Bornholm and Ertholmene, with recreational diving and spearfishing accessible from the coast. Often divers stay close to the coastline of Ertholmene and Bornholm, where sites such as Listed and Hullehavn near Svaneke or Svenskehavn are popular. However, residents and tourists also take diving excursions to visit underwater caves or the many well-preserved shipwrecks further from the coast /273/;. it is not uncommon for divers to visit locations 5-10 km or further from the coast, depending on where the wrecks are located /277/.

7.21 Existing and planned installations

There are several existing and planned installations in Danish waters in close proximity to the proposed NSP2 route. Due to their economical importance, these installations are considered an important receptor.

The majority of existing installations consist of cables of various origins, but pipelines and planned wind parks also take up relatively large areas. Various published maps, together with communication with owners, have been used to assemble and verify the locations of these existing and planned installations. These installations are displayed in Figure 7-64.

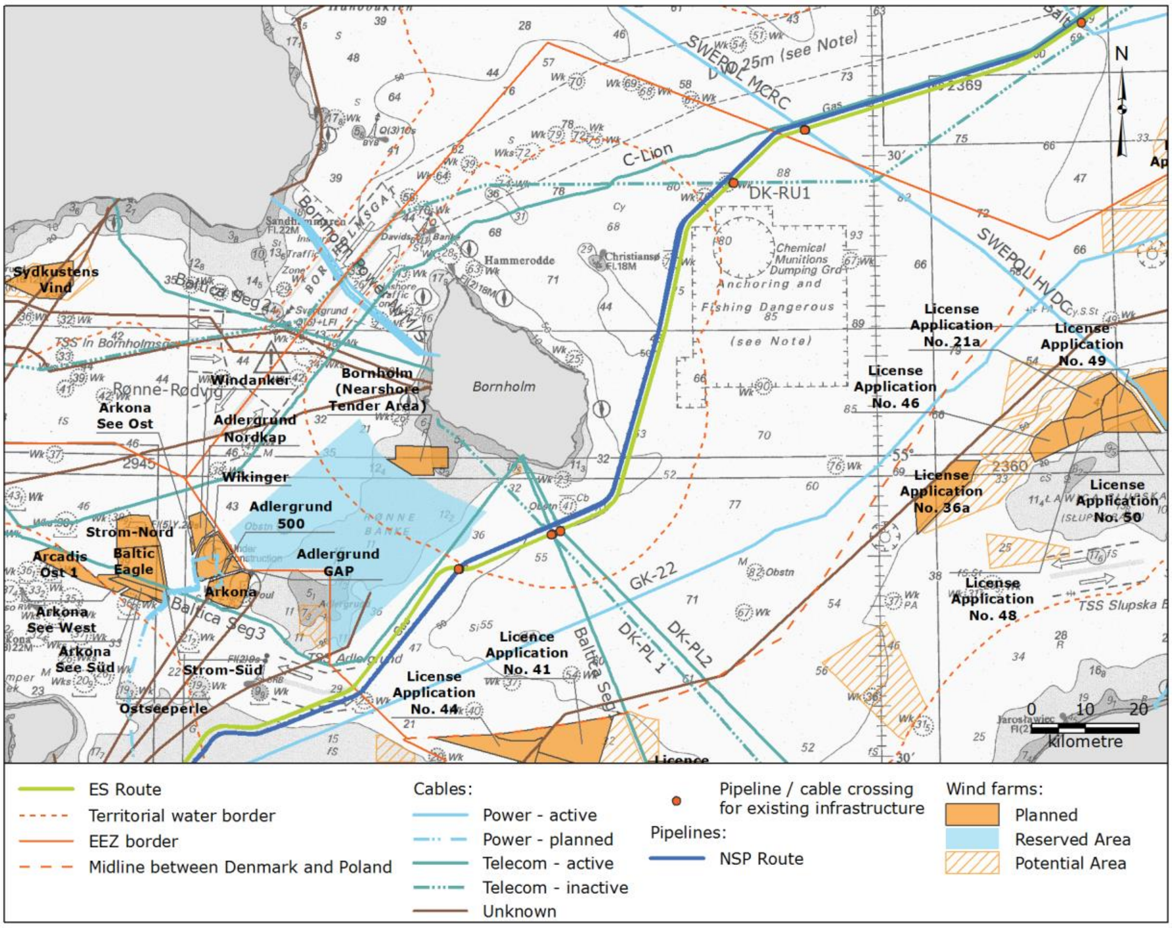


Figure 7-64 Existing and planned installations within Danish waters (a larger version of this figure can be seen in NSP2 Atlas Map IN-01-D).

The proposed NSP2 route would cross four existing cables and the NSP pipelines within Danish waters, as shown in Table 7-39. Cable DK-RU1 and DK-PL1 is out of use and owned by TDC. The proposed NSP2 route does not cross any planned cables or pipelines within Danish waters. A pipeline for natural gas is proposed between Poland and Denmark (Baltic Pipe). The Baltic Pipe project is however in the early planning phase and the route of the pipeline has not been desided at this stage.

Table 7-39 Existing installations crossed by the proposed NSP2 route in Danish waters

Name	Type	Owner	Status
DK-RU1 Karlslunde-Kingisepp	Telecom	TDC	Out of service
DK-PL2	Telecom	TDC	Active
Baltica Seg1	Telecom	Polish Telecom	Active
DK-PL1	Telecom	TDC	Out of service
NSP pipelines	Natural gas pipeline	Nord Stream AG	Active

The proposed NSP2 route does not cross any areas where development of wind farms has been planned, as shown in Table 7-40. This includes the reserved area south-west of Bornholm (Bornholm (Nearshore Tender Area)) which is being investigated by the DEA as an area which may be suitable for developing an offshore wind farm. The status of the investigations is currently classified as early planning, and it has not been decided yet if the area should be developed nor has a tender process been initiated to find a possible developer.

To the south-west of Bornholm, almost the entire area known as Rønne Banke has been identified by the Danish Government as the most suitable area for future large offshore wind farms. Any wind farm projects inside this area will however need to be approved through a government-led tender process. The proposed NSP2 route will not cross the area.

Table 7-40 Potential wind farms in Denmark, Germany and Poland

Planned Project Name	Project Location	Owner / developer	Development Status
Bornholm (Nearshore tender area)	Denmark	DEA	Early planning
Rønne Banke	Denmark	NA	Pre-feasibility. Area defined as potentially relevant.
Arkona	Germany	E.ON Energy Projects GmbH	Pre-Construction
Adlergrund GAP	Germany	BEC Energie Consult GmbH	Consent Application Submitted
Wikinger	Germany	ScottishPower Renewables (Iberdrola Renovables Energia, SA)	Under Construction
Adlergrund Nordkap	Germany	BEC Energie Consult GmbH	Consent Application Submitted
Adlergrund 500	Germany	BEC Energie Consult GmbH	Consent Application Submitted
Windanker	Germany	Iberdrola Renovables Deutschland GmbH	Consent Application Submitted
ArkonaSee Ost	Germany	ArkonaSee Ost GmbH	Concept/Early Planning
Baltic Eagle	Germany	Sea Wind Holding AG	Consent application Submitted
Strom-Süd	Germany	Iberdrola Renovables Energia, SA (Iberdrola S.A)	Concept/Early Plannning
Strom-Nord	Germany	Iberdrola Renovables Energia, SA (Iberdrola S.A)	Concept/Early Planning
Ostseeperle	Germany	Financial Insurance GmbH (Windreich AG)	Consent Application Submitted
ArkonaSee Süd	Germany	Arkona Sud GmbH	Concept/Early Planning
ArkonaSee West GmbH	Germany	ArkonaSee West GmbH	Concept/Early Planning
Licence Application no. 41	Poland	ENERGA SA	Concept/Early Planning
Licence Application no. 44	Poland	NA	Concept/Early Planning
Licence Application no. 52	Poland	NA	Concept/Early Planning
Licence Application no. 54	Poland	NA	Concept/Early Planning
Licence Application no. 56	Poland	NA	Concept/Early Planning
Licence Application no. 57	Poland	NA	Concept/Early Planning
Licence Application no. 46	Poland	NA	Concept/Early Planning
Licence Application no. 36a	Poland	NA	Concept/Early Planning
Licence Application no. 48	Poland	NA	Concept/Early Planning
Licence Application no. 21a	Poland	NA	Concept/Early Planning

7.22 Raw material extraction sites

The marine sediment in the Baltic Sea may contain valuable raw materials, especially for construction purposes. For this reason, several countries bordering the Baltic Sea have an interest in extracting marine sediments and raw material extraction areas are considered an important socio-economic receptor.

Raw material extraction activities are however limited by increasing water depth owing to technical and mechanical constraints as well as operational costs. As such, most exploration of sediments occurs at water depths no more than 20 m, which restricts such activities to coastal areas.

In Danish waters, there are nine areas designated for extraction of raw materials and one area designated for sediment dumping. The areas are mainly located south-west of Bornholm at Rønne Banke see Figure 7-65. The proposed NSP2 route does not cross any of the areas designated for extraction of raw materials, nor the area for sediment dumping.

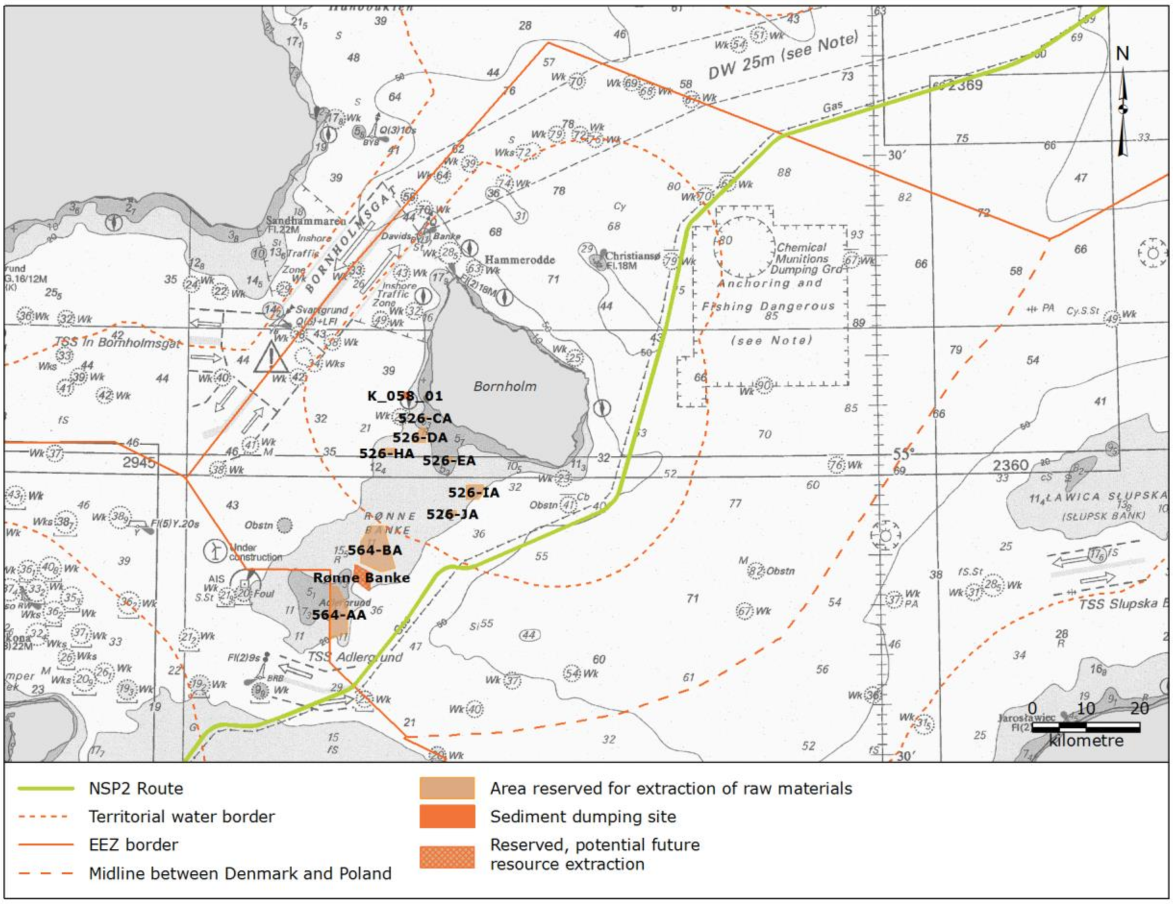


Figure 7-65 Designated areas for raw material extraction in Danish waters (a larger version of this figure can be seen in NSP2 Atlas Map IN-02-D).

The Danish authorities require that all extracted marine sediments be transported to Bornholm. This means that at times there could be an increase in ship traffic at and between an extraction area and Bornholm when extraction activities are under way. A permit for extraction, however, specifies that extraction work and transportation of the material to land should be planned in a manner that minimises negative effects on maritime traffic. The extraction activities must furthermore not result in decreased water depth.

7.23 Military practice areas

The Baltic countries have military practice areas of various types in the Baltic Sea. Due to the role of these areas in national security, it is considered an important receptor.

Military practise areas may be restricted in regard to navigation and other rights. Permanent restriction of access to areas used for military purposes may be applied by countries within their territorial waters. Temporary practice and exercise areas may not be mapped.

There are three military practice areas within Danish waters which are relevant to the proposed NSP2 route. All three are temporary shooting areas. The two areas directly to the east of Bornholm are identified as ES D 138 and ES D 139, are used for naval shooting exercises, and are managed together with Sweden. A proportion of the proposed NSP2 route crosses these areas.

The third area, identified as EK D 396, is located directly south of Bornholm. This area is very active and mainly used for live fire practice from the island. The firing danger area is used by the Danish Armed Forces and the Danish Home Guard, and firing can occur 24 hours a day.

During exercises, ships are officially forbidden to enter these areas.

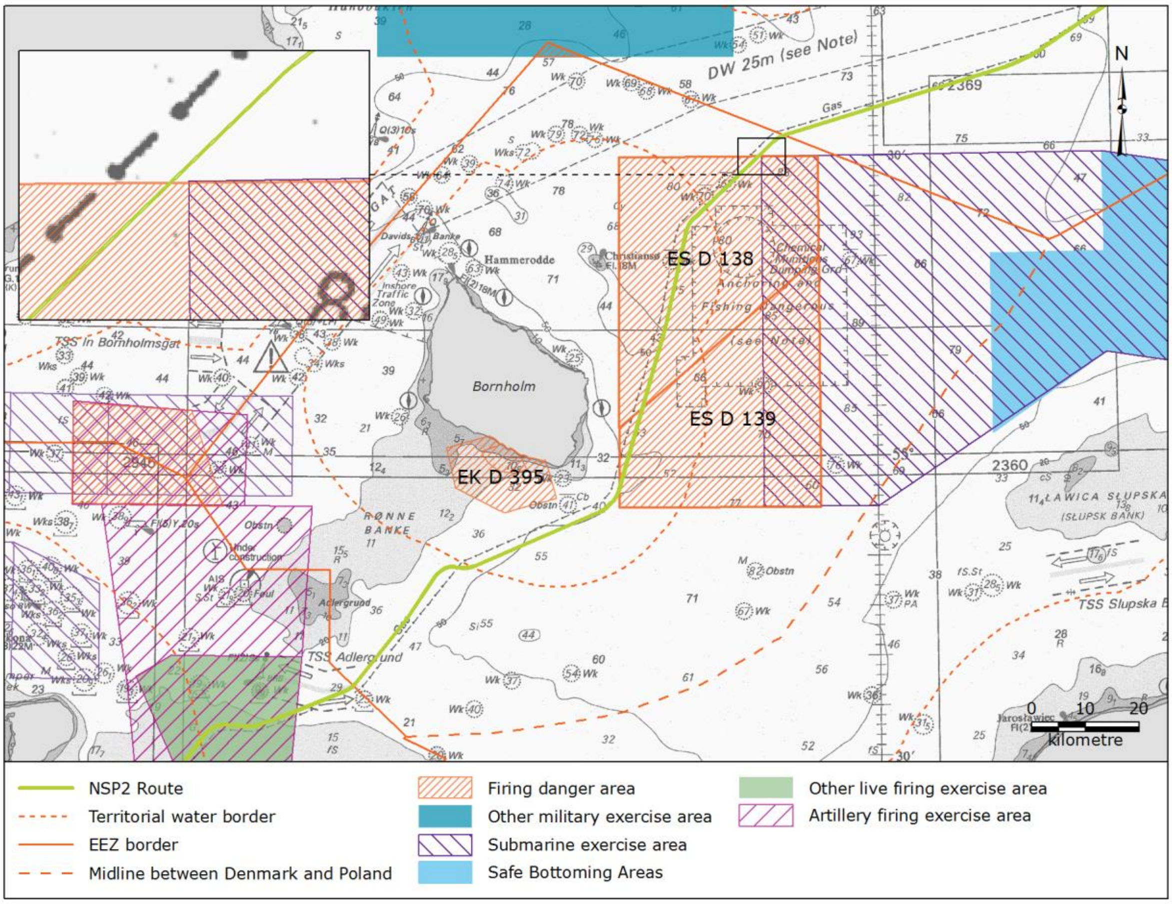


Figure 7-66 Military practice areas in the Danish EEZ and TW in the Baltic Sea.

The Naval District Bornholm is the local authority on behalf of the Danish Navy and is also responsible for informing the public, either with signs or via radio announcements, when the firing danger areas are active. To reach as broad an audience as possible, the Danish Maritime Authority also has access to a number of different broadcasting channels such as a mobile app ("sejlsikkert"), a webpage and a telephone call service.

Submarine exercise areas used by the German military are located to the east of Bornholm. Furthermore two Safe Bottoming Areas are located in the most eastern part of the Danish EEZ. The relevant German military authorities have been contacted and the data they have provided has been used to update the location of the areas accordingly. The NSP2 route will not cross any reported submarine exercise areas.

7.24 Environmental monitoring stations

Long-term trends in physical, chemical and biological variables are being monitored at selected locations throughout the Baltic Sea, so-called environmental monitoring stations. At each of these stations, different parameters are being monitored according to various national and international initiatives thus contributing to the scientific knowledge on Baltic Sea. These stations form part of a procedure to harmonise monitoring throughout the Baltic Sea which has been agreed upon by the Baltic countries to support the implementation of the HELCOM objectives. On this basis, environmental monitoring stations are considered an important socio-economic receptor.

The monitoring stations in the Danish waters around Bornholm are Swedish, Finnish and HELCOM monitoring stations as shown in Figure 7-67. The closest monitoring stations in Danish waters are located at a distance of more than 7 km from the proposed NSP2 route.

A Swedish monitoring station (SE-11) in the northern part of the Bornholm Basin had to be replaced during NSP. The Geological Survey of Sweden carried out investigations of the seabed around station SE-11 in 2010 and found a new location for the station 10 km from the NSP route, where there would be no risk of impact on the station from construction activities. The relocation was agreed with competent Swedish authorities.

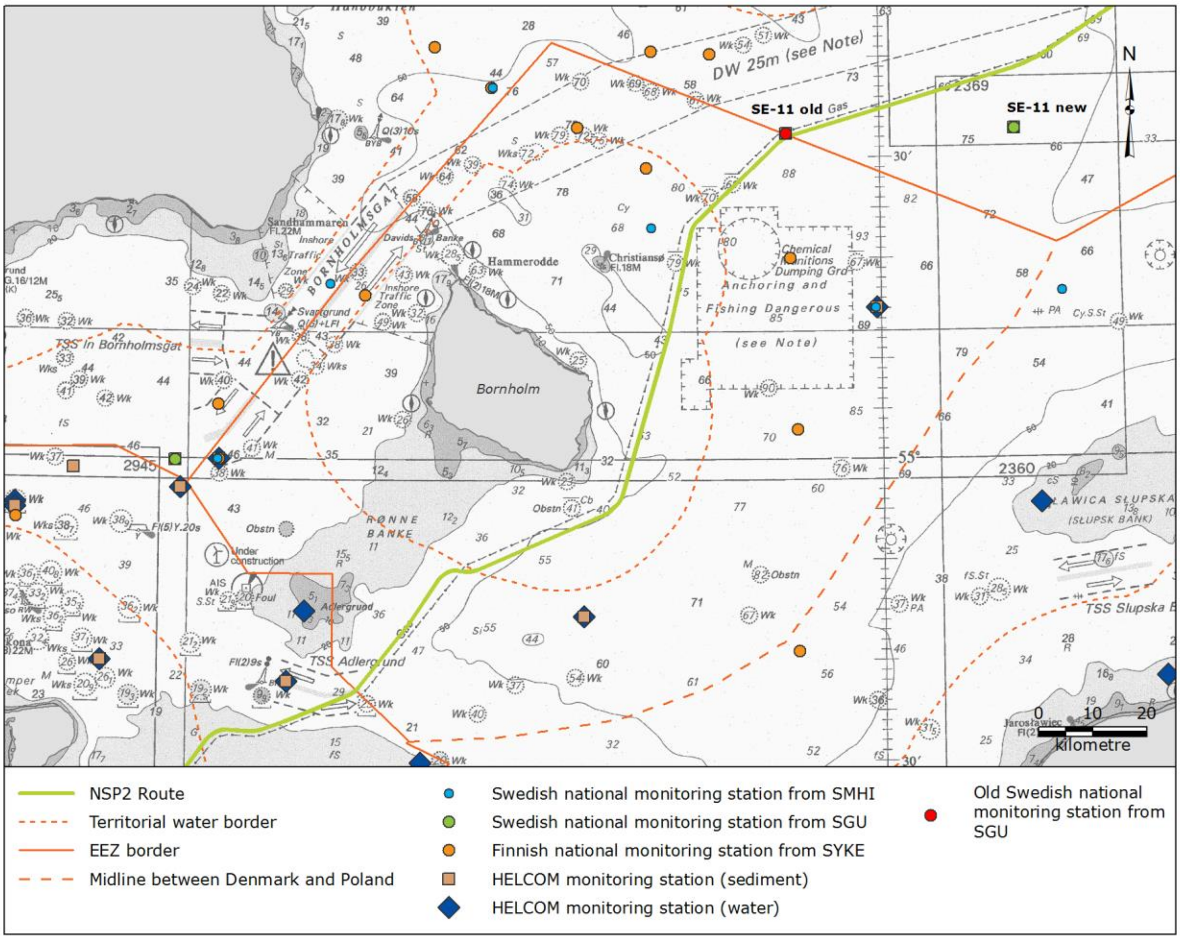


Figure 7-67 Offshore monitoring stations around Bornholm. The old Swedish monitoring station is out of service.

8 ASSESSMENT METHODOLOGY AND ASSUMPTIONS

In this section the assessment methodology (section 8.1 to section 8.3) as well as modelling and assumptions (section 8.4) applied in the EIA will be described.

As set out in section 4, the EU EIA Directive and the Offshore EIA Administrative Order aims to identify, prevent, mitigate and monitor potentially significant environmental impacts of a project. In order to do so, a systematic assessment approach has been developed for NSP2 and has been applied in this EIA. The main objective has been to identify and evaluate the potential impacts which NSP2 may have on the physical-chemical, biological and socio-economic environment and to describe mitigation measures to avoid, minimise or reduce any potentially adverse impacts to acceptable levels. The methods described below address the requirements of EU and Danish legislation and are in accordance with the EIA practice generally accepted by Danish authorities.

8.1 General approach

In order to meet the requirements of EU and Danish legislation the following sequential steps have been undertaken and are discussed in more detail in the sections below unless otherwise stated:

- Scoping and identification of potential environmental impacts;
- Baseline characterisation of the resources and receptors of the environment that could potentially be impacted (see section 7):
- Assessment of potential impacts;
- Developing mitigation measures to address potentially significant environmental impacts;
- Assessment of potential transboundary impacts; and
- Assessment of potential cumulative impacts.

8.2 Scoping and identification of potential environmental impacts

8.2.1 Scope of assessment

The initial step undertaken in the EIA was to identify the scope of the assessment, i.e. to identify the range of environmental and socio-economic components (resources or receptors) to be studied, the geographical area to be covered and the time frames over which the impacts may occur. The scope of assessment is a refinement of the scope developed as part of the EIA programme presented to the Danish authorities and public in 2013, see section 4.4.

8.2.1.1 Technical Scope

The environmental and socio-economic resources or receptors which NSP2 may potentially impact (as a result of construction, operation and/or decommissioning activities within Danish waters) are identified in Table 8-1. These have been established through a review of the project description (section 6), which defines and describes the various components of NSP2 relevant to Danish waters (during the construction, operation and decommissioning phases).

The current state (baseline) of these resources and/or receptors has been determined through desk studies, surveys and review of secondary information, as described in section 7.

The potential sources of impact and potential interaction with these resources and/or receptors have been determined on the basis of the spatial and temporal scope of NSP2 (see section 8.2.1.2) and are identified in section 8.2.2 and 8.2.3, whilst the resulting impacts are assessed in section 9.

Although conventional and chemical munitions are not an environmental resource or receptor, and therefore not included in Table 8-1, the topic was identified during consultation as an issue requiring particular consideration, it is therefore included in section 7 and 13.

Table 8-1 Receptors susceptible to potential impacts associated with NSP2 in Danish waters Sector

Resource or receptor type		Resource or receptor
Environmental	Physical-chemical	Bathymetry
		Sediment quality
		Hydrography
		Water quality
		Climate and air
	Biological	Plankton
		Benthic flora and fauna
		Fish
		Marine mammals
		Birds
		Protected areas
		Natura 2000 sites
		Biodiversity
Socio-economic	Socio-economic	Shipping and shipping lanes
		Commercial fishery
		Cultural heritage
		People and health
		Tourism and recreational areas
		Existing and planned installations
		Raw material extraction sites
		Military practice areas
		Environmental monitoring stations

In addition to analysing potential impacts on specific resources/receptors, it is also important to consider the compliance of NSP2 in the context of relevant EU legislation designed to protect the marine environment (i.e. Marine Strategy Framework Directive, Water Framework Directive and Baltic Sea Action Plan). This has been addressed in section 10.

8.2.1.2 Spatial and temporal scope

The proposed NSP2 route is approximately 1,200 km in length (of which approximately 139 km is within Danish waters). The geographical area that may be affected by the project varies dependant on the source of impact arising from each activity i.e. the component interacting with the environment (noise generation, sediment mobilisation etc.) propagates spatially. As such, the locus of potential impacts may be limited to the immediate footprint of the NSP2 route or extend several kilometres from the pipelines.

In Denmark, NSP2 has been defined by three project phases as follows:

- Construction phase;
- Operational phase;
- Decommissioning phase.

Project activities associated with the pre-commissioning and commissioning will have no impacts on resources or receptors in Danish waters as the hydrotest water for pressure testing will be sourced and discharged in Russia and Germany respectively, with no discharges in Danish waters. Therefore pre-commissioning and commissioning phases have not been assessed within this EIA; impacts for the NSP2 project as a whole are assessed in the overarching Espoo report.

The construction phase in Danish waters is expected to last a total of approximately 135 days based on sequential installation of the two pipelines, meaning that one pipeline will be installed at a time in Danish waters. It is noteworthy that impacts during the construction phase will not occur along the full length of the route at the same time, but will be restricted to those areas where activities are occurring at a specific point in time (e.g. the area affected by pipe-lay impacts will move in unison with the pipe-lay vessel as it progresses along the pipeline route).

The operational lifetime of the pipelines is designed to be at least 50 years. The time frames and methods used for decommissioning will be determined during the operational phase to allow due consideration to be given to legislation and guidance available at the time, as well as utilise good international industry practise (GIIP) and technical knowledge gained over the lifetime of the NSP2 pipelines. Under all circumstances, decommissioning will take place in agreement with the Danish authorities and in compliance with the applicable legal requirements at the time.

8.2.2 Identification of potential sources of impacts

Potential sources of impact have been identified by considering how the various project activities within Danish waters (section 6) may interact with resources and receptors. This has required detailed understanding of the various project activities and of the baseline environmental and socio-economic conditions. Furthermore, experience and knowledge gained from the monitoring of NSP have served as important input to the identification of potential impacts for NSP2.

Table 8-2 and Table 8-3 present a list of planned project activities relevant to the Danish sector and the associated sources of potential impact for the construction and operation phases respectively. Given the uncertainty on the method to be used for decommissioning (see section 6), it has not been possible to identify project activities, nor potential interactions of such activities with resources/receptors; therefore, a qualitative assessment of potential impacts is provided in section 11. Potential impacts from unplanned events are identified and evaluated in section 13.

Table 8-2 Project activities in Denmark and associated sources of impacts during the construction phase

Project activities during construction	Source of potential impact
Ship operations - Anchor handling - Vessel/ship thrusters - Vessel movements/presence Seabed intervention* - Offshore pipe-lay - Post-lay trenching - Rock placement - Installation of support structures - Potential above water tie-in (AWTI)	Physical disturbance on seabed
	Release of sediments into the water column
	Release of contaminants into the water column
	Release of chemical warfare agents (CWA) into the water column
	Sedimentation on the seabed
	Generation of underwater noise
	Physical disturbance above water**
	Imposition of safety zones around vessels
	Emissions of air pollutants and GHGs
	Introduction of non-indigenous species

* No advance works (e.g. munitions clearance, wreck or boulder removal) is planned in Danish waters

** E.g. from presence of vessels, noise and light

Table 8-3 Project activities in Denmark and associated sources of impacts during the operational phase

Project activities during operation	Source of potential impact
Pipeline system - Presence of pipelines Inspection and monitoring - Vessel movements	Physical presence of pipelines and structures on the seabed
	Changes of habitat
	Physical disturbance above water *
	Imposition of safety zones around survey vessels
	Emissions of air pollutants and GHGs
	Generation of heat from gas flow through the pipelines
	Release of metals from anodes
	Introduction of non-indigenous species

* E.g. from presence of vessels, noise and light

8.2.3 Interactions between project activities and resources/receptors

Identification of the interactions between the project activities, their associated sources of impact and the relevant resources and/or receptors has allowed for a systematic identification of all potential impacts of NSP2. The outcomes of this process are summarised in Table 8-4 and Table 8-5 and have formed the basis for this EIA.

Interactions that have been deemed not to have the potential for significant impacts have been screened out, based upon available knowledge and professional judgment. The sources of potential impacts that have been considered for further detailed assessment (identified by an 'X' in Table 8-4 and Table 8-5) are assessed in section 9.

Table 8-4 Interactions between sources of potential impact and physical-chemical and biological resources or receptors

Source of potential impact		Physical-chemical					Biological							
		Bathymetry	Sediment quality	Hydrography	Water quality	Climate and air quality	Plankton	Benthic flora and fauna	Fish	Marine mammals	Birds	Protected areas	Natura 2000	Biodiversity
Construction phase	Physical disturbance on seabed	X	X					X	X					X
	Release of sediments into the water column				X		X	X	X	X	X	X	X	X
	Release of contaminants into the water column				X		X	X	X	X	X	X	X	X
	Release of chemical warfare agents (CWA) into the water column				X		X	X	X	X	X	X	X	X
	Sedimentation on the seabed	X	X	X				X	X		X	X	X	X
	Generation of underwater noise								X	X			X	X
	Physical disturbance above water (e.g. from presence of vessels, airborne noise and light)										X	X	X	X
	Emissions of air pollutants and GHGs					X								X
	Introduction of non-indigenous species											X		X
Operational phase	Physical presence of pipelines and structures on the seabed	X	X	X								X	X	X
	Changes of habitat							X	X	X				X
	Physical disturbance above water (e.g. from presence of vessels, noise and light)											X	X	X
	Emissions of air pollutants and GHGs					X								X
	Generation of heat from gas flow through the pipelines				X									X
	Release of metals from anodes				X		X	X	X			X		X
	Introduction of non-indigenous species											X		X

Table 8-5 Interactions between sources of potential impact and socio-economic resources or receptors

Source of potential impact		Socio-economic								
		Shipping and shipping lanes	Commercial fishery	Cultural heritage	Environmental monitoring stations	People and health	Tourism and recrea-tional areas	Existing and planned installations	Raw material extraction	Military practice areas
Construction Phase	Physical disturbance on seabed			X				X		
	Release of sediments into the water column				X		X			
	Release of contaminants into the water column				X					
	Sedimentation on the seabed				X					
	Physical disturbance above water (e.g. from presence of vessels)		X			X	X			X
	Imposition of safety zones around vessels	X	X				X			
Operational phase	Physical presence of pipelines and structures on the seabed		X	X				X	X	
	Physical disturbance above water (e.g. from presence of vessels)					X				
	Imposition of safety zones around vessels	X					X			

8.3 Impact assessment

The impact assessment methodology serves to provide a means of characterising the impacts identified (see section 8.1) and assess their overall significance. The impacts include direct and indirect impacts as well as cumulative and transboundary impacts.

The impact assessment methodology for planned activities takes into consideration the nature and type of impact, as well as the magnitude of the impact and receptor/resource sensitivity, as shown in Figure 8-1.

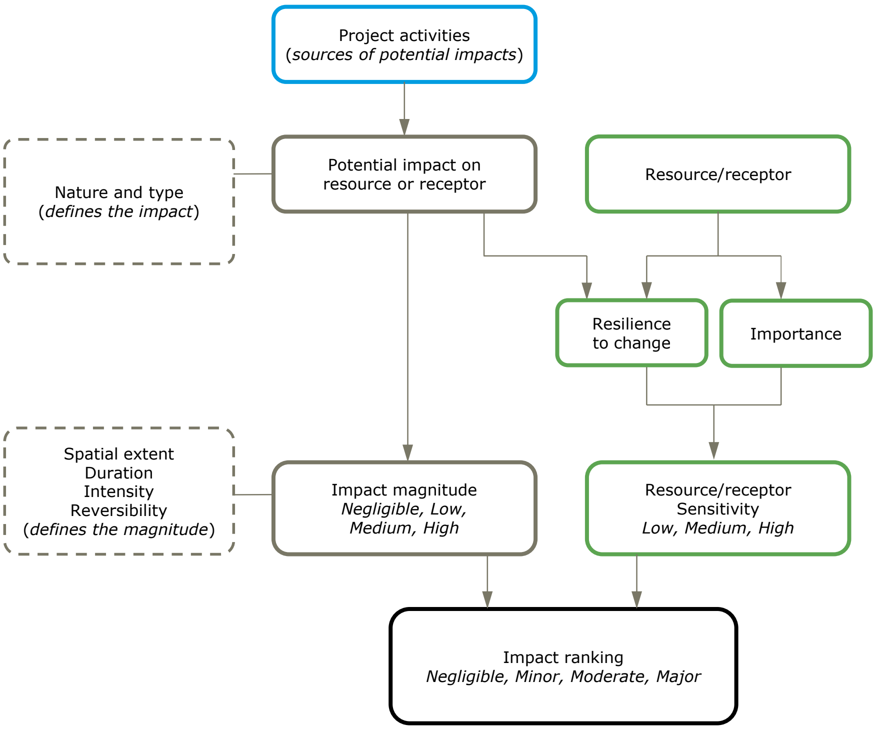


Figure 8-1 EIA methodology for potential impacts

Potential impacts from unplanned events are assessed either using a similar methodology or an established risk-based methodology, as appropriate. The methodology applied to unplanned events is further described in section 13. The methodology for assessment of potential impacts on Natura 2000 sites is outlined in section 8.3.7.

8.3.1 Impact nature and type

Impacts are defined according to their nature (negative or positive) and their type (direct, indirect, cumulative or transboundary) as outlined upon in Table 8-6.

Table 8-6 Nature and type of potential impacts

Nature of impact Negative[1]: an impact that is considered to represent an adverse change from the baseline or to introduce a new, undesirable factor. Positive[1]: an impact that is considered to represent an improvement to the baseline or to introduce a new, desirable factor. **Type of impact** Direct: impacts that result from a direct interaction between a project activity and the receiving environment (e.g. the loss of a habitat during pipeline installation). Indirect: impacts that result as a consequence of direct impacts or other activities that are encouraged to happen as a consequence of the project, including secondary impacts (e.g. an increase in fishery activity along the pipeline route due to the creation of an artificial habitat favourable to certain target species). Cumulative: impact which may occur as a result of a planned project activity in combination with other planned infrastructure or activities. The individual projects may generate their own individually insignificant impacts, but when considered in combination, the impacts may have an incrementally significant impact on receptors. Transboundary: impact which may occur within one EEZ/TW as a result of activities in the EEZ/TW of another country (e.g. the propagation of noise across national borders).
[1]: In certain circumstances, it can be argued that an impact can be classified as negative and/or positive. Whether the impact is one or the other depends largely on expert opinion. In such cases, both classifications are argued.

8.3.2 Impact magnitude

The magnitude of an impact is a measure of the change in the baseline conditions and is described in terms of a number of variables, including the spatial extent, duration, intensity and reversibility of the impact, as presented in Table 8-7. The evaluation of magnitude has adopted a qualitative ranking of negligible, low, medium and high.

Table 8-7 Impact magnitude

Spatial extent of impact Local: impacts affecting the pipeline route corridor and/or the immediate vicinity of the pipelines/construction site (<5 km). Regional: impacts affecting an area between 5-20 km from the pipeline route corridor. National: impacts affecting an area >20 km outside the pipeline route corridor, but restricted to country waters (TW/EEZ). Transboundary: impacts that are experienced outside the Danish EEZ/TW as a result of activities within the Danish EEZ/TW (e.g. the dispersion of resuspended sediment in the water column during construction activities). **Duration of impact** Temporary: impacts predicted to be of very short duration and/or intermittent/occasional in nature and will cease within days of completion of the activity (e.g. reduced water quality as a result of suspended sediment, fish (avoidance reaction) during pipe-lay). Short-term: impacts that are predicted to be of short duration and will cease within a few years (≤3 years) of completion of the activity, either as a result of mitigation/reinstatement measures or natural recovery (e.g. impacts and re-establishment of benthic fauna communities after trenching pipeline into the seabed and after re-instatement of the seabed). Long-term: impacts that are predicted to continue over an extended period (>3 years), (e.g. presence of the pipeline on the seabed, release of metals from anodes). **Intensity of impact** Low: impacts may be forecast but are frequently at the detection limit and do not lead to any permanent change in the structures or functions of the resource/receptor concerned. Medium: impacts are forecasted to be above detection limit and may lead to some detectable alterations to the resource/receptor concerned, but their basic structure/function is retained. High: the structures and functions of the resource/receptor are affected partially/completely.

The criteria that determine the magnitude of an impact differ by resource and/or receptor. Therefore, specific definitions have been used for the physical-chemical and biological environment compared to the socio-economic environments, as presented in Table 8-8 and Table 8-9.

Table 8-8 Impact magnitude – physical-chemical and biological environment

Impact magnitude	Definition
Negligible	Temporary impact on a resource/receptor that is localised and detectable within natural variations but does not result in discernible change. The environment will revert to pre-impact status immediately after the activity is completed.
Low	A temporary or short-term impact on a resource/receptor that is localised and detectable above natural variations but not regarded as imparting an order of magnitude change or an impact on a species that affects a specific group of localised individuals within a population but does not affect the population itself or other trophic levels. The environment will revert to pre-impact status once the impact ceases.
Medium	A temporary or short-term impact on a resource/receptor that may extend beyond the local scale and may bring about an order of magnitude change in the quality or functionality of a resource/receptor or an impact on a species that affects a portion of a population and may bring about a change in abundance and/or a reduction in the distribution over one or more generations. The environment will revert to pre-impact status once the impact ceases.
High	A long-term impact on a resource/receptor that results in an order of magnitude change on the local or larger scale that is irreversible and above any applicable limits. The environment will not revert to pre-impact status immediately after the activity is completed.

Table 8-9 Impact magnitude – socio-economic environment

Impact magnitude	Definition
Negligible	Barely noticeable, temporary impact on a socio-economic resource/receptor which do not lead to discernible changes.
Low	Impact on socio-economic resource/receptor leading to very limited, temporary damage or changes.
Medium	Impact on socio-economic resource/receptor that may bring about change in status but does not threaten the overall stability of socio-economic resource/receptor.
High	Impact on one or more socio-economic resource/receptor of sufficient magnitude to bring about a long-term or permanent (intergenerational) change in status.

The magnitude of potential impacts is outlined in section 9.

8.3.3 Sensitivity of a resource or receptor

The sensitivity of a resource or receptor describes how a resource or receptor may be more or less susceptible to a given impact. The evaluation of sensitivity has adopted a qualitative ranking of low, medium or high, based on consideration of the following two criteria:

- **Resilience to change**, describing the degree to which a resource or receptor is resilient to change (i.e. lower sensitivity) in regard to the specific source of impact. Determination of the resilience to change includes evaluation of the specific receptor's adaptability, diversity, and whether a resource or receptor is present in the area impacted by the project activity i.e. is a specific source of impact interacting with the resource or receptor. Resilience to change is thus a characteristic of a receptor but is not inherent to it, as it is also influenced by the nature of the impact to which it is subject to.

- **Importance**, describing the receptor's qualities or its importance as recognised for example by its conservation status (e.g. IUCN, protection or prioritisation under EU or Baltic State legislation, plans, policies etc.), its ecological, cultural and social importance or economic value, or through its identification by stakeholders with a valid interest in the project. The importance of a receptor is an inherent characteristic, irrespective of project activities.

Criteria for determining the sensitivity are elaborated upon in Table 8-10 and Table 8-11 for the physical-chemical, biological and socio-economic environment, based on expert judgement and stakeholder consultation. This combination ensures a reasonable degree of consensus on the intrinsic sensitivity of a resource or receptor.

The criteria for the biological environment are applied with a degree of caution in that seasonal variation and species lifecycle stages must be considered. Bird species, for example, may be deemed more vulnerable during the breeding season but also, for some species, during passage and migration, particularly moulting birds at sea. Scientific knowledge and expert judgement has been applied to ensure these aspects are considered.

Table 8-10 Sensitivity criteria – physical-chemical and biological environment

Sensitivity	Definition
Low	A resource or receptor that is of low importance or one that is important but resilient to change (in the context of project activities) and will naturally and rapidly revert back to pre-impact status.
Medium	A resource or receptor that is important. It may not be resilient to change but can be actively restored to pre-impact status or will revert naturally over time.
High	A resource or receptor that is important, not resilient to change and cannot be re-stored to pre-impact status, nor revert naturally over time.

Table 8-11 Sensitivity criteria – socio-economic environment

Sensitivity	Definition
Low	An asset which is not considered to be important in terms of their resource, economic, cultural or social value.
Medium	An asset which is considered not to be important on a regional level but are of local importance to the asset base, livelihoods, etc.
High	An asset which are specifically protected by national or international policies or legisla-tion and are of importance to the asset base, livelihoods etc.

The sensitivity of a resource and/or receptor is outlined in section 9, though the importance is identified in section 7.

8.3.4 Impact ranking and significance

As noted in Figure 8-1, impact ranking is determined through a combination of impact magnitude and the sensitivity of a receptor and/or resource. A qualitative ranking of negligible, minor, moderate or major has been assigned, as shown in Table 8-12. However, it should be noted that the matrix is considered as a guideline for the assessments in this EIA, and as such the ranking of a given impact on a particular resource or receptor will also be subject to expert judgement and deviations from the matrix may occur.

Subsequently, impacts have been determined as either a 'Significant' or 'Not Significant' impact. There is no statutory definition of a 'Significant' impact and therefore the determination is necessarily subjective. For the purposes of this EIA, a significant impact is one which should be taken into account by the relevant authority when determining the acceptability of a project.

The impact matrix presented in Table 8-12 is used to assess negative impacts. Positive impacts have not been assessed using the framework set out above, but rather described qualitatively.

Where, following assessment, no impact is anticipated, this is stated and no further discussion provided.

Table 8-12 Impact ranking and significance matrix

Impact Ranking[1]		Impact magnitude			
		Negligible	Low	Medium	High
Sensitivity of receptor/resource	Low	Negligible	Minor	Minor	Moderate
	Medium	Negligible	Minor	Moderate	Major
	High	Negligible	Moderate	Moderate	Major

[1] The matrix is considered as a guideline for the assessments. However, assessment of a given impact on a resource or receptor will be subject to expert judgement and deviations from the matrix may occur.

Negligible	Impacts that are indistinguishable from the background/natural level of environmental and socio-economic change. Impacts are considered 'Not Significant'.
Minor	Impacts of low magnitude, within standards and/or associated with low or medium importance/sensitivity resources/receptors, or impacts of medium magnitude affecting low importance/sensitivity resources/receptors. Impacts are considered 'Not Significant'.
Moderate	Broad category within standards, but impact of a low magnitude affecting high importance/sensitive resources/receptors, or medium magnitude affecting medium or high importance/sensitivity resources/receptors, or of high magnitude affecting low sensitivity resources/receptors. These impacts may or may not be significant, depending on the context, and additional mitigation may thus be required in order to avoid or reduce the impact to non significant levels.
Major	Exceeds acceptable limits and standards and is of high magnitude affecting medium or high importance/sensitivity resources/receptors. Impacts are considered 'Significant'.

8.3.5 Mitigation measures

The EIA Directive (Article 5(3) requires an EIA Report to include *"a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects"*. For NSP2 such measures are termed mitigation measures. A mitigation hierarchy approach has been adopted (descried further in section 15, whereby priority has been given to:

- avoiding or preventing impacts;
- if this was not possible, to reducing or abating them;
- only if the above is not possible, to offsetting them through repair (restoration or reinstatement) or as a last resort compensation.

This approach is driven by the Nord Stream 2 AG policies, notably those relating to the Approach to Environmental and Social Management, which specifies the requirement to "adopt a mitigation hierarchy".

In this EIA, impacts have been assessed assuming implementation of all identified mitigation measures, see section 6, 9 and 15. Should impacts be assessed to be "major" or "moderate" after the application of the intended mitigation measures, these impacts will be subject to ongoing management and monitoring during the various project phases. These instances are identified within this EIA as applicable.

8.3.6 Cumulative impacts

While all potential impacts of the NSP2 project will be described and assessed in section 9, there is also a need to consider the potential for interaction between the impacts arising from NSP2 with those of other foreseeable or planned projects which are not yet in existence, but are likely to be under construction or to have been completed by the time NSP2 is constructed or it is operational. These other projects may generate their own individually insignificant impacts, but when considered in combination with the impacts from NSP2, the impacts could amount to a significant cumulative impact. For example, combined sediment impacts from two or more (planned) projects which will occur within a certain timeframe and geographical area. Potential cumulative impacts have been described in section 12 following the same assessment methodology as described above.

8.3.7 Natura 2000

An assessment of whether a project may result in significant impacts on Natura 2000 sites is required in accordance with the Article 6(3) and (4) of the Habitats Directive and Danish legislation (section 4). Therefore, an assessment of potential impacts on Natura2000 sites associated with NSP2 has been undertaken in this EIA.

The methodological guidance for Natura 2000 assessment outlined in /283/ has been followed. The methodology sets out four consecutive steps comprising: screening, appropriate assessment, assessment of alternative solutions, and assessment where no alternative solutions exist and where adverse impacts remain.

The initial step of the assessment is a Natura 2000 screening which identifies the potential impacts of a project upon a Natura 2000 site(s), either alone or in combination with other projects or plans, and considers whether these impacts are likely to be significant.

Section 9.12 of this EIA includes a Natura 2000 screening which identifies the potential impacts of NSP2 on Natura 2000 sites within Danish waters in terms of its designation criteria and conservation objectives. The Natura 2000 screening has been informed by the following:

- Natura 2000 plans and standard information sheets;
- Appropriate GIS data;
- Information on EU Habitat Directive and Bird Directive species and habitats that have been identified as grounds for designation of Natura 2000 site(s);
- Results from field surveys conducted for NSP2 (i.e. habitat mapping along the proposed NSP2 route, surveys of seabed sediments and benthos);
- Modelling of sediments and noise propagation.

Potential impacts on Natura 2000 sites as a result of NSP2 in combination with other projects or plans have been identified in section 12, whilst potential impacts on Natura 2000 sites outside Danish waters are considered in section 14.

If significant impacts are likely or some degree of uncertainty remains, further assessment should be carried out, in the form of an appropriate assessment, assessment of alternative solutions and assessment where no alternative solutions exist and where adverse impacts remain (as necessary, and as per /283/.

8.3.8 Protected species (Annex IV)

Articles 12 a of the Habitats Directive are aimed at the establishment and implementation of a strict protection regime for animal species listed in Annex IV(a) of the Habitats Directive within the whole territory of Member States.

In accordance with the Habitats Directive, the following is prohibited for these species:

- (a) all forms of deliberate capture and keeping and deliberate killing;
- (b) the deliberate damage to or destruction of breeding or resting sites;

- (c) the deliberate disturbance of wild fauna particularly during the period of breeding, rearing and hibernation, in so far as disturbance would be significant in relation to the objectives of this Convention;
- (d) the deliberate destruction or taking of eggs from the wild or keeping these eggs even if empty;
- (e) the possession of and internal trade in these animals, alive or dead, including stuffed animals and any readily recognisable part or derivative thereof, where this would contribute to the effectiveness of the provisions of this Article."

In Danish waters, the only marine Annex IV species are marine mammals. An assessment of potential impacts to Annex IV species (in line with the bullets above and as described in section 8.3.3) is therefore included in section 9.9 of this EIA.

8.3.9 Transboundary impacts

The Espoo Convention (Article 1 vii) defines a transboundary impact as:

"*…any impact, not exclusively of a global nature, within an area under the jurisdiction of a Party caused by a proposed activity the physical origin of which is situated wholly or in part within the area under the jurisdiction of another Party.*"

The Convention requires that assessments are extended across borders between Parties of the Convention when a planned activity may result in transboundary impacts. The key objective of an EIA in a transboundary context is thus the rigorous assessment and succinct communication of such anticipated transboundary impacts to affected parties, including the public.

NSP2 crosses the jurisdiction of several countries and is being constructed in a marine environment, where an impact may propagate some distance from its source. Therefore, whilst the impacts arising from construction, operation and decommissioning of NSP2 in the Danish sector will generally be experienced in Danish waters, they may in some instances extend into neighbouring countries, i.e. transboundary impacts.

The assessment of transboundary impacts relies on the prior identification of all potential impacts associated with NSP2 and for these to have been assessed rigorously and consistently in accordance with the methodology described in the sections above. The assessment reported in section 9 therefore specifically identifies where impacts may be transboundary in nature. All such transboundary impacts are then assessed in section 14, to assist in communication of transboundary impacts to each affected party.

8.4 Modelling and assumptions

An early task in the EIA process was to determine the propagation characteristics of the physical changes that arise from NSP2 activities. In the case of sediment release, underwater noise, airborne noise and air emissions, this was achieved through targeted modelling studies as described below. The release of contaminants and nutrients was evaluated on the basis of the sediment release modelling and levels of contaminants and nutrients identified in the field environmental survey (section 7.3). Similarly the release of CWA was evaluated on the basis of the sediment release modelling and the concentrations observed in the field environmental survey (section 7.3). The release of metals from anodes is evaluated based on existing knowledge regarding the toxicity of Al, Zn and Cd ions in the marine environment.

8.4.1 Release of sediment into the water column – seabed intervention works

During construction of NSP2, disturbance or spill of seabed sediments and subsequent suspension in the water column is expected in connection with seabed intervention works, see section 6

(Figure 6-17). The following two types of seabed intervention works are planned within Danish waters:

- Post-lay trenching; and
- Rock placement.

For the purpose of this EIA, it has been assumed that post-lay trenching would be required for stabilisation of the pipelines in Danish waters at three locations, see section 6. In total up to a maximum of 20.5 km post-lay trenching is anticipated for each of the NSP2 pipelines.

Rock placement is proposed where NSP2 pipelines cross existing NSP pipelines and at the location of an AWTI if it is performed in Danish waters. Furthermore, rock placement may also be used to provide support to the pipelines (as a contingency method), should post-lay trenching not be carried out at the three locations referred to above.

8.4.1.1 Modelling methodology

On the basis of the above, modelling has been undertaken for post-lay trenching (at three locations) and for rock placement (at the same three locations, as a contingency, and for the NSP crossing) within Danish waters. Locations for potential intervention works in Danish waters are shown in Figure 6-17. The modelling has been presented in /287/ and /288/ and is summarised below. It is noted that the modelling has been carried out based on the seabed intervention works along one pipeline. This is considered appropriate as no in-combination impacts are anticipated due to the construction of the pipelines in a sequential manner.

The hydrodynamic modelling was delivered by DHI based on the flexible mesh version of the MIKE 3 hydrodynamic (HD) model suite for three-dimensional modelling of currents, water levels and the transport of suspended sediment. The modelling covered the entire Baltic Sea and was specific to the NSP2 project.

As noted above, the model set-up used a flexible mesh that used different mesh sizes throughout the model domain. In the Baltic Sea, the resolution varied depending on the distance from the pipeline corridor. The resolution was approximately 800-1,600 m within a 10 km band along the planned pipeline corridor. Further away from the pipeline corridor, the resolution increased gradually until it reached 3-5 km at some distance from the pipeline. In the Gulf of Bothnia, the resolution was 8-24 km.

The model bathymetry was interpolated into the model mesh on the basis of three different data sets. A general data set of gridded data in 500 m x 500 m resolution was used in the majority of the Baltic Sea (covering the Danish section of NSP2).

The hydrodynamic model had one open boundary towards the North Sea. The model was forced by the hydrodynamic conditions at the open boundary and by the meteorological conditions in the model domain. For further information on the set-up and calibration of the hydrodynamic model, see /288/.

The meteorological input parameters were:

- Wind;
- Air pressure;
- Precipitation;
- Air temperature;
- Clearness (opposite of cloudiness).

These data were provided by StormGEO, a Norwegian company that provides meteorological services and products. The resolution of the data was 1 hour in time and 0.1° in the geographical domain.

Ice coverage fields were also applied as a model forcing. When the ice cover was above 90% in a certain area, the model turned off wind forcing and heat exchange with the atmosphere. The ice coverage data applied were from the Climate Forecast System Reanalysis (CFSR) global reanalysis data set of the United States National Centers for Environmental Protection/National Oceanic and Atmospheric Administration (NCEP/NOAA).

The hydrodynamic model for NSP2 was a development of the existing Baltic Sea model of DHI, which was calibrated and validated in the Danish straits and the western Baltic Sea. For the NSP2 model a dedicated calibration and validation of the model in the Gulf of Finland has also been carried out, using current and salinity/temperature data from the monitoring programme for NSP.

A full year of hindcast data covering 2010 has been produced by the hydrodynamic model for application as the basis for the environmental modelling that was used for the environmental assessments of NSP2. The hindcast data formed the hydrodynamic basis for the modelling of transport of sediment and contaminant spill during the construction phase.

A three-dimensional model was set up for modelling the transport and fate of dissolved and suspended substances. The numerical particle transport model MIKE 3 PT was used for this purpose. MIKE 3 PT requires that the current velocities and water level are prescribed in time and space in a computational mesh covering the model domain. This information was provided based on the hydrodynamic results from the MIKE 3 HD model described above.

The simulated substances could be pollutants of any kind or suspended sediment. The spilled material was represented by a large number of particles, each of a specific mass. The mass could change during the simulation due to decay. The particles were released at a source point for discharge (e.g. the location of trenching) and successively moved as the simulation progresses.

The model used a Lagrangian-type approach, which involved no other spatial discretisations than those associated with the description of the bathymetry, current and water level fields.

Each particle was within a time step moved a distance equal to the current velocity multiplied by the time step, which represented the advection. In the *z*-plane, the particles were also moved a distance equal to the settling velocity multiplied by the time step.

The particles were also successively moved a random distance, representing the dispersion that accounts for the non-resolved flow processes. The dispersion was prescribed in three dimensions. In a Lagrangian model the dispersion coefficients were independent of the time step and the grid size.

Concentrations of the substances were calculated on the basis of the density of particles in the mesh cells in the model domain. The results from the MIKE 3 PT were independent of the calculation mesh of the MIKE 3 HD model and could be saved in a finer mesh than the hydrodynamic input, which may be necessary to resolve the plumes resulting from the spill.

The transport model was run using a scenario-based approach, i.e. the model was run for different hydrodynamic conditions under which the construction works were carried out. The scenario periods representing the different hydrodynamic conditions were chosen from the hindcast data set produced by the MIKE 3 HD model.

The following other input were needed to model the sediment spill:

- Sediment and seabed characteristics;
- Spill rates calculated on the basis of trenching speed [m^3/s], density of the specific sediment type [kg/m3], spill percent (2%), dry matter content in the specific sediment type and proportion of the fraction in the specific sediment type;
- Contaminant content.

For further information on the set-up and calibration of the hydrodynamic model, see /288/.

A conservative approach has been used to model sediment spreading as a result of intervention works since the extent of intervention works (i.e. post-lay trenching) has significantly reduced /63/.

8.4.1.2 Modelling scenarios

Three simulation scenarios were chosen to represent different conditions in relation to particle transport and temperature/salinity stratification:

- Summer scenario (June 2010): Representation of relatively calm current conditions with low particle transport capacity and with relatively high temperature and salinity stratification.
- Normal scenario (April 2010): Representation of average current conditions with average particle transport capacity and with average temperature and salinity stratification.
- Winter scenario (November 2010): Representation of relatively strong current conditions with high particle transport capacity and with relatively low temperature and salinity stratification.

Based on considerations of the plough size used for post-lay trenching, the release was assumed to be confined to a height of 5 m above the seabed during trenching, corresponding to double the ploughing depth. During rock placement, the sediment release was assumed to be confined to an average height of 2 m above the seabed, based on energetic considerations. All results related to the dispersion of suspended sediment after release to the water column are based on average of the lower 10 m of the water column.

8.4.1.3 Results

The modelling results for rock placement and post-lay trenching were presented in /287/, for each of the three scenarios, and for the following parameters:

- Area with concentration of suspended sediment above 2, 10 and 15 mg/l;
- Duration of exceedance above 2, 10 and 15 mg/l, expressed in hours;
- Sedimentation, which is expressed as g/m^2. The corresponding thickness depended on the density, which again depended on the consolidation of the material. For loose/fine sediment, sedimentation of 100 g/m^2 corresponds to 0.6 mm thickness /288/. More consolidated sediment corresponds to a thinner layer;
- Maximum concentration of suspended sediment at specific distances to the pipeline (200 m, 500 m and 1,000 m).

Threshold values of 2, 10 and 15 mg/l have been chosen based on experience from previous projects such the Great Belt link, the Oresund link and the near shore windfarm EIA's. These thresholds have been chosen on the basis of the following, and are accepted by the authorities in Denmark:

- 2 mg/l represents the concentration just above ambient level where the sediment is barely visible in the water column;
- 10 mg/l represents concentrations where vulnerable fish species will flee from the area; and
- 15 mg/l represents the concentration where bird foraging may be impacted due to reduced visibility.

Given typical hydrodynamic conditions (see section 7), the ‘Winter’ condition has been regarded as the most conservative scenario in respect to suspended sediment dispersion because rough conditions will cause transport further away from the point of release. For the same reason, the highest amounts of local suspended sediment concentration (SSC) were obtained during the ‘Summer’ scenario where conditions are calmer. Results from ‘Winter’ scenario are shown in the following figures. Full results for the ‘Summer’ and ‘Normal’ scenarios are presented in /287/.

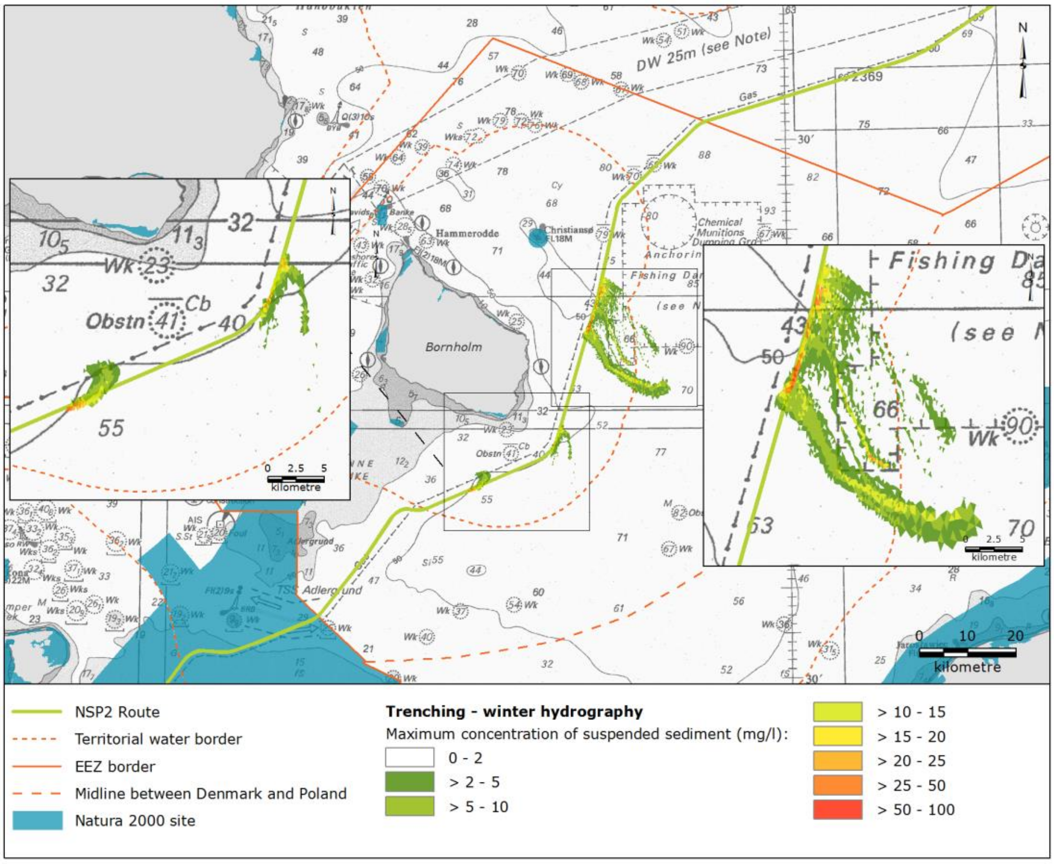


Figure 8-2 Maximum concentration of suspended sediment as a result of trenching under typical winter conditions.

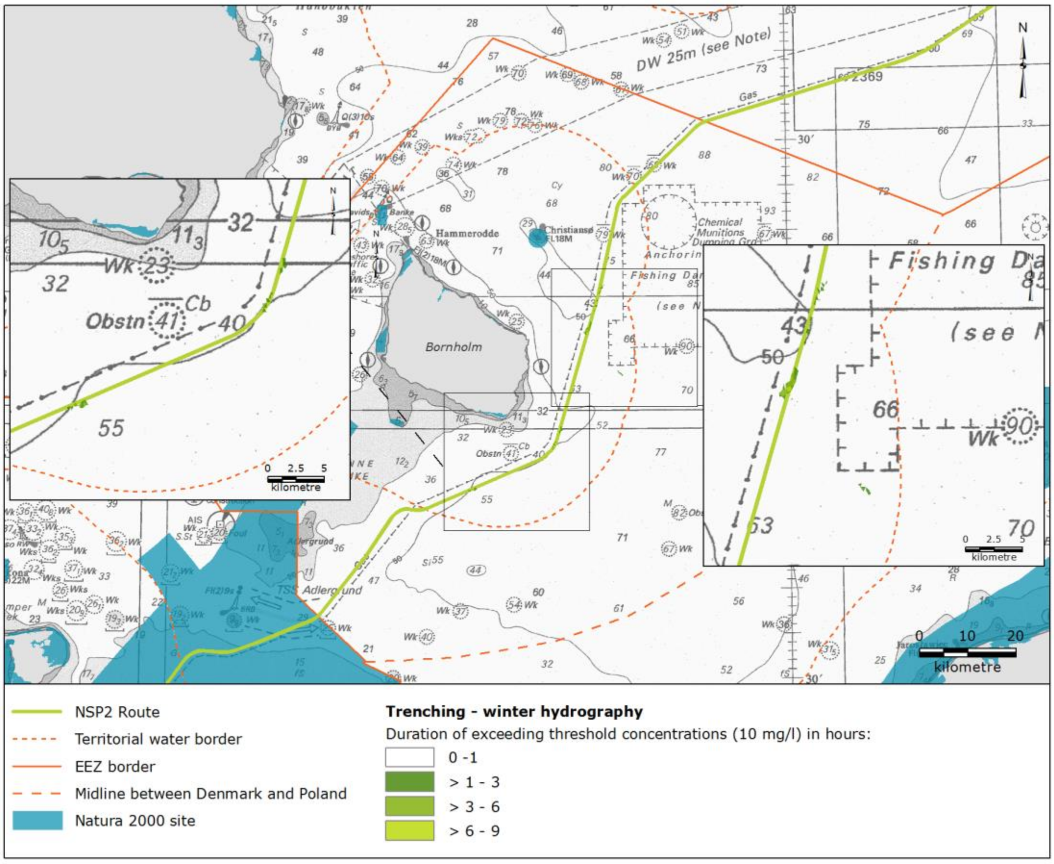


Figure 8-3 Duration of suspended sediment exceeding 10 mg/l as a result of trenching under typical winter conditions.

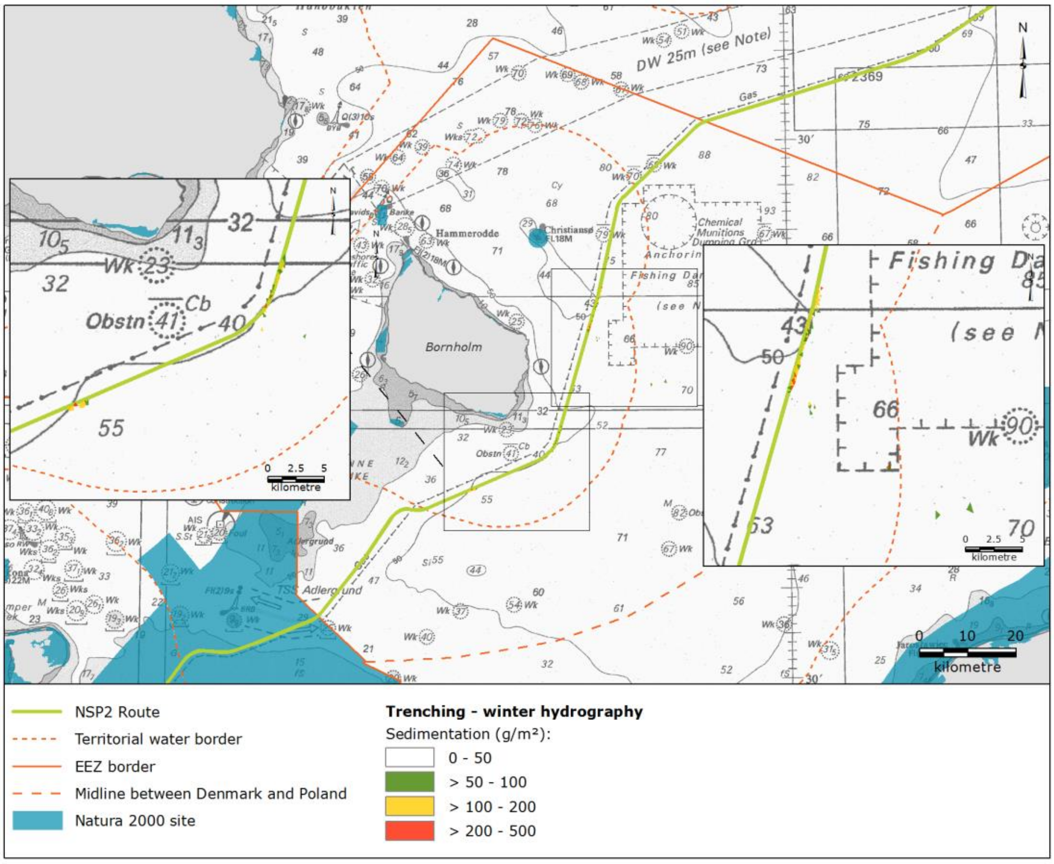


Figure 8-4 Maximum sedimentation levels as a result of trenching under typical winter conditions.

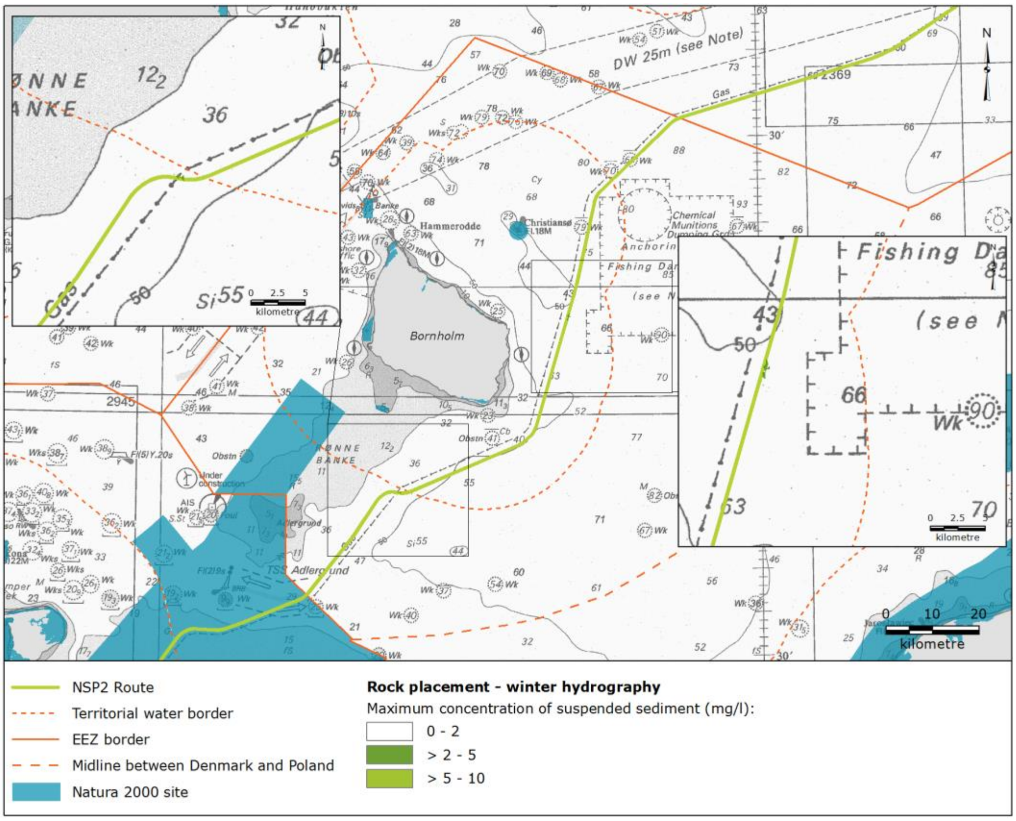


Figure 8-5 Maximum concentration of suspended sediment as a result of rock placement under typical winter conditions.

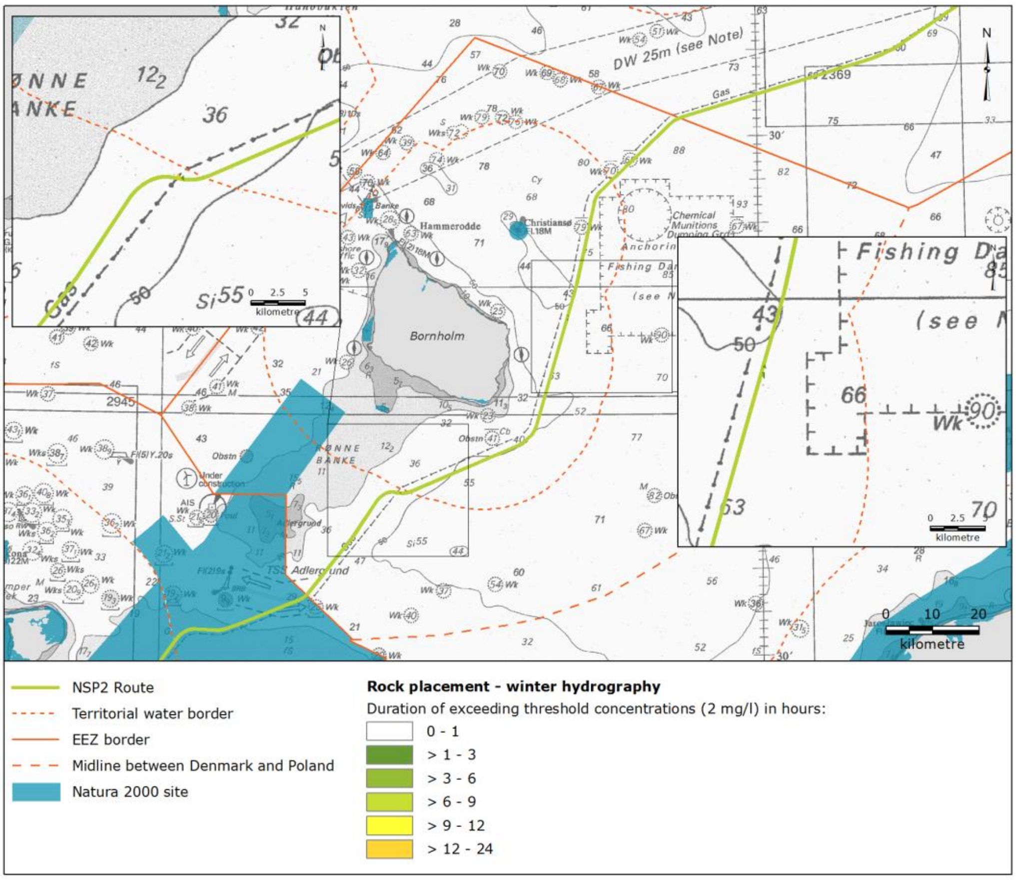


Figure 8-6 Duration of suspended sediment exceeding 2 mg/l as a result of rock placement under typical winter conditions.

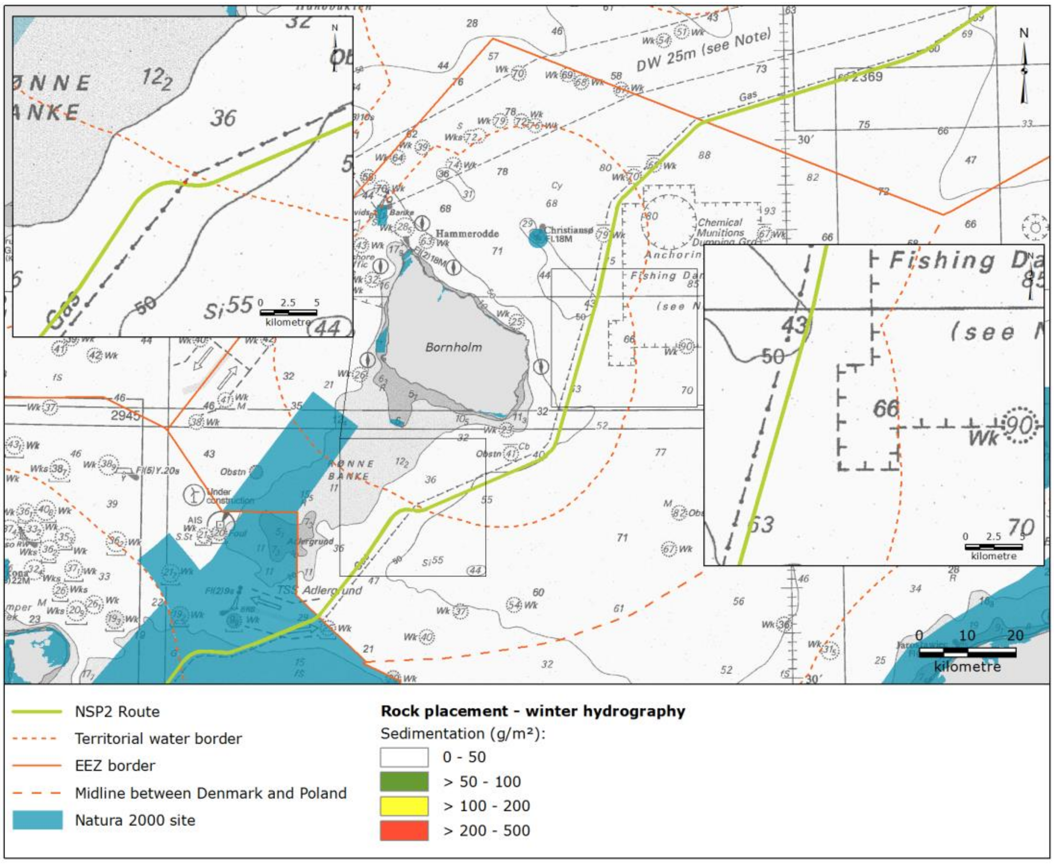


Figure 8-7 Maximum sedimentation as a result of rock placement under typical winter conditions.

8.4.1.4 Summary of results

A summary of the modelling results for winter scenario is presented in Table 8-13, Table 8-14 and Table 8-15.

Table 8-13 Summary of modelling results for suspended sediment in the winter scenario.

		Area with concentration		
Seabed intervention	**Parameter**	**>2 mg/l**	**>10 mg/l**	**>15 mg/l**
Trenching 1	Maximum duration (hours)	11.5	6.5	5.5
	Area (km^2)	118	17.5	6.0
Trenching 2	Maximum duration (hours)	10.0	3.5	2.5
	Area (km^2)	11.5	2.2	0.8
Trenching 3	Maximum duration (hours)	8.0	4.5	3.5
	Area (km^2)	9.4	2.0	0.8
Rock placement (crossing)	Maximum duration (hours)	19.5	0.0	0.0
	Area (km^2)	0.2	0.0	0.0

Table 8-14 Summary of modelling results for sedimentation in winter scenario.

		Area with sedimentation				
Seabed intervention	**Parameter**	**>10 g/m^2**	**>50 g/m^2**	**>100 g0/m^2**	**>150 g/m^2**	**>200 g/m^2**
Trenching 1	Area (km^2)	13.87	3.19	1.80	0.80	0.34
Trenching 2	Area (km^2)	4.43	1.36	0.74	0.20	0.10
Trenching 3	Area (km^2)	3.67	0.75	0.61	0.21	0.10
Rock placement (crossing)	Area (km^2)	0,74	0.11	0.11	0.11	0.11

Table 8-15 Summary of the modelling results for suspended sediment concentrations (winter scenario)

	Suspended sediment	Max concentration at specific distance from pipelines (mg/l)		
Seabed Intervention	**(tonnes)**	**(200 m)**	**(500 m)**	**(1,000 m)**
Trenching 1	771	62.30	33.04	14.14
Trenching 2	270	33.25	20.42	6.77
Trenching 3	202	43.27	23.09	6.91
Rock placement (crossing)	128	5.1	2.0	0.3

8.4.1.5 Monitoring during NSP

Sediment dispersion from pipe-lay and intervention works was monitored during NSP in Danish, Swedish, Finnish, German and Russian waters, with the purpose of validating the assumptions of the NSP EIA. The results of this monitoring are summarised in Table 8-16.

Table 8-16 Summary of monitoring studies of sediment dispersion during NSP

Country	Year	Purpose	Method	Period
Sweden	2010-2011	Monitoring increase in turbidity (SSC) and sedimentation at the border of Hoburgs Banke and Norra Midsjöbanken	Fixed stations	November 2010 to August 2011
	2011	Monitoring sediment plume during trenching in the vicinity of Hoburgs Banke and Norra Midsjöbanken for NSP Line 1	Vessel-based monitoring	January 2011
	2012	Monitoring sediment plume during trenching in the vicinity of Hoburgs Banke and Norra Midsjöbanken for NSP Line 2	Vessel-based monitoring	March 2012
Denmark	2011	To evaluate and document the sediment plume during trenching for NSP Line 1 in Danish waters	Vessel-based monitoring	February 2011
	2012	To evaluate and document the sediment plume during trenching for NSP Line 2 in Danish waters	Vessel-based monitoring	February 2012
Finland	2010	Monitoring water quality during pipe-lay	Fixed sensor	November-December 2010
	2010	Turbidity measurement of water column	Fixed sensor	June-July 2010
	2011	Monitoring water quality during rock placement	Fixed sensors	March-May 2011
Russia	2011	Sediment dispersion monitored in deep-water section	Vessel-based	June, August, September 2011
Germany	2010	Turbidity measurements of water column	Fixed sensors	April – November 2010
	2010	Measurements of sediment plumes	Vessel-based, aerial image analysis	May-November 2010

In Swedish waters, four fixed stations located at the border of two Natura 2000 sites (Hoburgs Banke and Norra Midsjöbanken) were used for monitoring of SSC and sedimentation rates before, during and after post-lay trenching of NSP Line 1 in 2011. Furthermore, the sediment plume generated by the post-lay trenching was monitored from vessels during the trenching of NSP Line 1 in 2011 and NSP Line 2 in 2012 /290//291/.

In Danish waters, vessel-based monitoring of sediment dispersion during post-lay trenching was carried out for NSP Line 1 in 2011 (February) and for NSP Line 2 in 2012 (February). Monitoring during post-lay trenching in Sweden was carried out for NSP Line 1 in 2011 (January) and for Line 2 in 2012 (March) /292//293/.

Together, these monitoring programmes confirmed that the plough created a plume of suspended sediment. The rate of sediment release was conservatively estimated to be in the range of 3-25 kg/s, with a representative release rate of 7 kg/s in Danish waters. The plume was most dense near the plough, with concentrations up to a maximum of 22.3 mg/l observed at a distance of approximately 100 m. The plume widened and concentrations decreased with distance from the plough, with concentrations less than 4 mg/l observed at a distance of approximately 500 m behind the plough. This indicates that a significant quantity of the suspended sediment settled during the initial 500 m of transport. The monitoring results thus indicate that the results of sediment dispersion modelling (presented in Table 8-15) can be considered conservative (i.e. on the safe side).

Sediment dispersion related to rock placement was not monitored in Danish or Swedish waters during NSP. However, monitoring was undertaken in Russia in 2010, as well as Finland in 2010 and 2011. In Russia, the highest concentration (20 mg/l) was measured one hour after rock placement at a distance of 100 m from the placement location. Measurements in Finland (2010) confirmed that the increase in turbidity was limited to the lowermost 10 m of the water column and that the impact distance, taken as the 10 mg/l contour, was less than 1 km from the rock placement site /294/. Subsequent monitoring in Finland (2011) showed SSC peaks above 10 mg/l at only one sensor located 200 m from the construction site, on three occasions with a total duration of 6.5 hours. Together, the monitoring results from Russia and Finland indicated that the maximum values of SSC caused by rock placement were significantly lower than those calculated by numerical modelling (i.e. the numerical modelling presented a conservative scenario) /288/.

8.4.2 Release of suspended sediment into the water column - pipeline installation

In addition to seabed intervention works discussed in section 8.4.1 pipe-lay and vessel operations (anchored or dynamically positioned vessels) can cause physical disturbance of the seabed and consequently lead to sediment dispersion.

8.4.2.1 Pipe-lay

During pipe-lay, sediments from the seabed may be suspended due to the following processes:

- The current generated in front of the pipeline when it is lowered through the water and placed onto the seabed, may bring sediment into suspension;
- The pressure from the pipeline when it hits the seabed may create an upwards movement of sediment.

The pipeline will be laid from a pipe-lay vessel with a low horizontal speed of approximately 2.5 km/day and a low and controlled vertical velocity of the pipeline that decreases towards zero at the seabed. Modelling has shown that only a very small amount of sediment is suspended during pipeline layout directly on the seabed, even for worst-case scenarios /296/. From the calculations it was concluded that suspension caused by pipeline installation is negligible where the pipeline is being laid on firm sediment. In the case of very soft clay sediments where the pipeline is able to sink down, some small suspension of sediment near the bottom can be expected /296/. However, compared with suspension during trenching and rock-placement, the concentration of suspended sediment is considered negligible.

Sediment dispersion during pipe-lay was monitored in the deep-water section in Russia in 2011 (June, August and September) and Finland in 2010 (June and July for anchored vessel; November and December for DP vessel). In Russia, the mean SSCs for all measurements in the surface and bottom layer of the water column were 5.7 mg/l and 8.2 mg/l, respectively, and no negative impacts on water quality were detected /288/. In Finland, insignificant sediment release was observed at fixed sensors located 50 m from the pipeline route (approx. 1.5 – 2 m above seabed), when using an anchored vessel. No increase in turbidity was observed at the location of the farthest sensor, approximately 800 m away from the pipeline route /297/. Similarly there were no SSC recordings above background levels at fixed turbidity sensors, located 50 m from the pipeline route (approx. 1.5 – 2 m above seabed), when using a DP vessel/294/.

Both modelling results and NSP monitoring have shown that suspended sediments caused by the pipe-lay are less compared to those resulted from the intervention works (post-lay trenching and rock placement).

Pipe-lay will be carried out by either anchored or dynamically positioned (DP) pipe-lay vessels in Danish waters. Regardless, these monitoring data support the predictions presented for NSP2 that pipe-lay will cause no, or only negligible sediment release during normal pipe-lay operation.

8.4.2.2 Anchored vessel operation

Anchored vessel operation may cause disturbance of the sediment leading to suspension and dispersion of sediments due to anchors being laid on the seabed, anchors being retrieved from the seabed and/or anchor wires sweeping across the seabed during movement of the lay vessel (see below for further description).

When the lay vessel is moving forward, the anchor wire will sweep across the seabed in a section of a circle as shown in Figure 8-8. However, limited suspension is expected as the chain attached to the anchors moves very slow across the seabed, resulting in most of the sediment material moved over the top of the chain (with opposing gravity force keeping the material near the bottom).

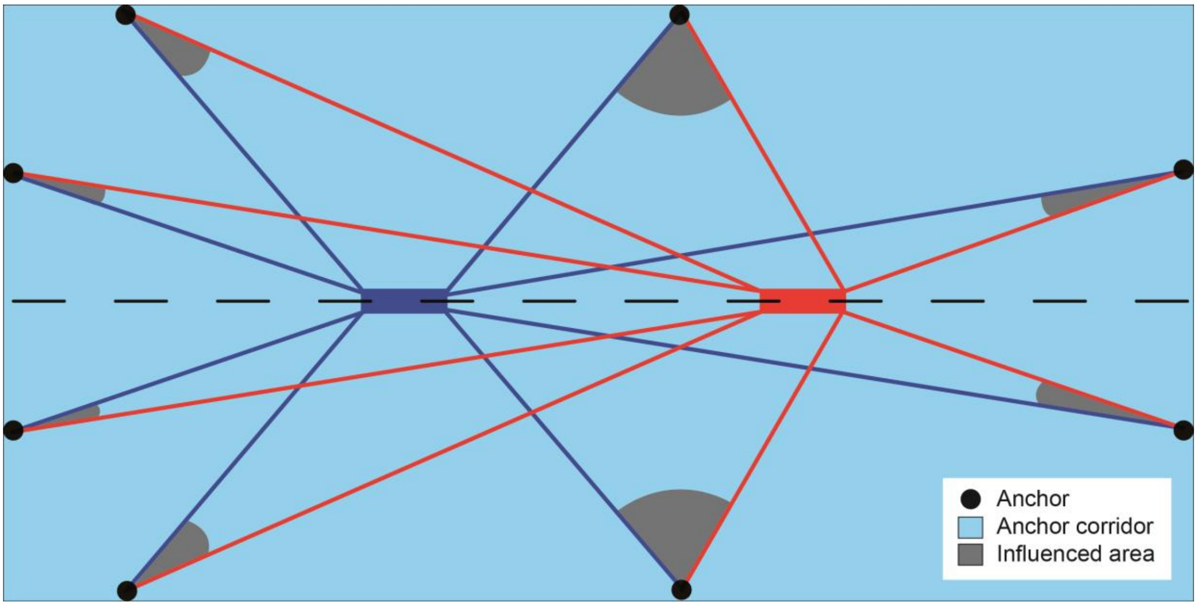


Figure 8-8 Schematic illustration of the areas influenced by the anchor wire (2% of the total anchor corridor of 2 km).Observe that this is an explanatory illustration and that the number of anchors can be up to 12. Red and blue colours represent relocation of the pipe-lay vessel from one position to another one.

As noted above, monitoring in the Finland showed that during pipe-lay of NSP using an anchored pipe-lay vessel, only a minor increase in turbidity was observed at the nearest fixed sensor (50 m from the pipeline route) and no increase was observed at 800 m from the pipeline route /298/.

8.4.2.3 DP vessel operation

DP vessel operation may cause disturbance of the sediment leading to suspension and dispersion of sediments where thruster-jet-induced currents reach the seabed. The extent of sediment disturbance will depend on the magnitude of the current, the water depth and the type of seabed sediment. The current velocity on the seabed has been estimated by analytical methods and by numerical modelling (CFD) in /299/. Based on this, it is evaluated that erosion and suspension of sediment due to vessel positioning with thrusters may occur in shallow areas at water depths <40 m with loose sediment of dry densities <500 kg/m^3 /299/. At water depths between 40 and

50 m it is evaluated that erosion and suspension of sediment due to vessel positioning with thrusters may occur for very loose sediment of dry densities <200 kg/m^3 /299/.

The water depth of the proposed NSP2 route in Danish waters is predominantly >40m (up to approximately 93-95 m in the deepest part) and no impact on the seabed from thruster-jet-induced currents is anticipated. However, in the southern part of the Danish section (the approx. 5 km leading up to the German-Danish EEZ-border) the water depth varies between 28 - 40 m and the seabed may be affected by water currents generated by the DP-vessel.

However, the type of sediment is a major factor affecting the potential for seabed erosion and sediment suspension in these shallower areas. The sediment comprises coarser sediments compared to the deeper areas (see section 7.3.2), characterised as sand/silty sand with a very low silt/clay fraction and a median grain size (D50) of ca. 0.18 mm. Dry density is considered well above 500 kg/m^3. Therefore, it is assessed that there will be no or very limited sediment suspension caused by DP thruster-induced currents in the shallow part of the NSP2 route in Danish waters (<40 m, approx. 5 km). Furthermore, no sediment dispersion is anticipated to occur from the DP thruster-jet-induced currents in the deeper part of the proposed NSP2 route (>40 m, approx. 134 km).

As noted above, monitoring in the Finland showed that during pipe-lay of NSP using a DP vessel, no turbidity recordings above background levels were observed at the closest fixed turbidity sensors (located 50 m from the NSP route) /297/.

8.4.2.4 Conclusion

In conclusion, sediment dispersion during the construction of NSP2 may occur as a result of seabed intervention works (see section 8.4.1), pipe-lay (see section 8.4.2) and/or from vessel-related operations (DP vessel or anchored lay vessel). The highest magnitude is expected to be related to intervention works (post-lay trenching and rock placement), and the assessments performed in section 9 will focus on these activities.

8.4.3 Underwater noise

During the construction of NSP2, activities may generate underwater noise. Rock placement activities are considered to be the nosiest of construction activities within Danish waters and were therefore the focus of the modelling (summarised below). Generation of underwater noise from pipe-lay and post-lay trenching will be less than or similar to rock placement and therefore has not been modelled.

8.4.3.1 Background underwater noise

Ambient noise is sound that is always present and cannot be attributed to any particular source. In addition to ambient noise, anthropogenic noise is also present in the offshore environment from distinct and identifiable sources such as shipping and mechanical installations.

Natural ambient noise in the offshore environment is generated by surface agitation, e.g., rain falling on the ocean, bubbles entrained by breaking waves, wave interaction, as well as the Earth's seismic activity and sounds from marine animals. The noise from these sources comes from all directions and varies in magnitude, frequency, location and time.

The level of ambient noise depends on the sea state (the general condition of the free surface on a large body of water – with respect to wind, waves, swells and density dependent stratification), ranging, in particular, between 200 Hz and 50 kHz.

Figure 8-9 exemplifies the spectral distribution of the sound pressure level of ambient noise in the offshore environment. Low frequency ambient noise from 1 to 10 Hz is mainly comprised of turbulent pressure fluctuations from surface waves and the motion of water at the boundaries.

Between 10 and 100 Hz, distant anthropogenic noise (ship traffic etc.) begins to dominate, with its greatest contribution between 20 Hz and 80 Hz. In the region above 100 Hz, the ambient noise level depends on weather conditions with wind and wave related effects creating sound. The peak level of this band has been shown to be related to the wind speed expressed by Beaufort numbers 1–8 (sea state).

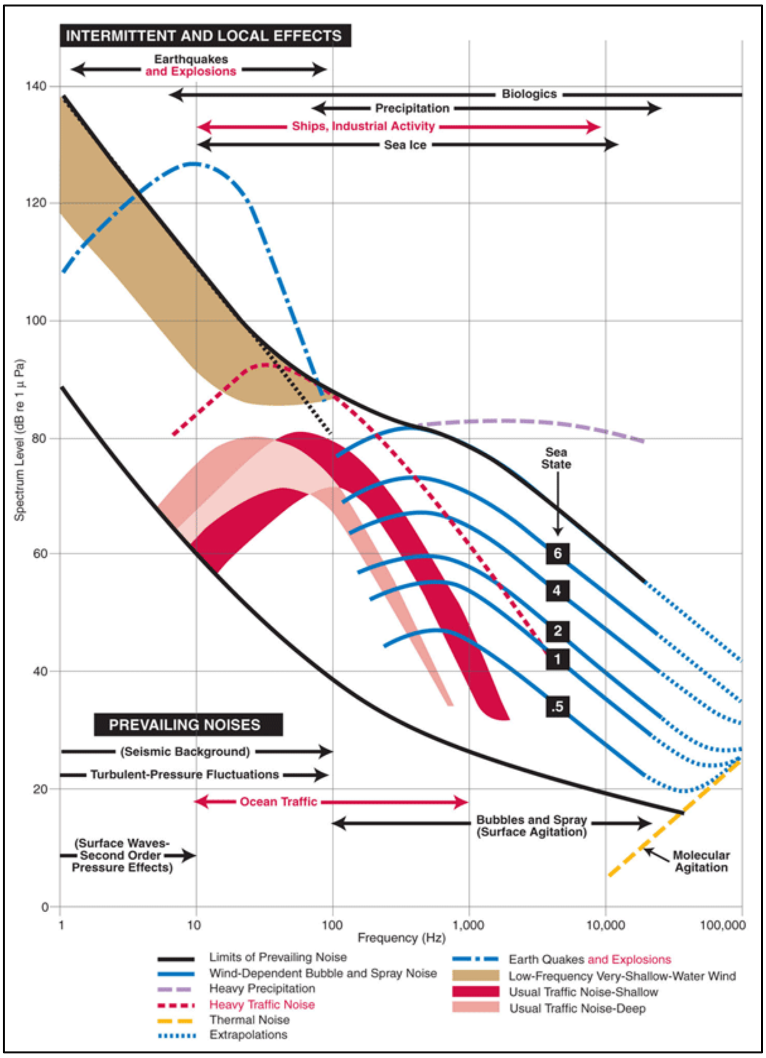


Figure 8-9 General expression of sound pressure spectral distribution in the sea /134/

The main sources of anthropogenic underwater noise are commercial shipping, fishing, military activities, construction activities, seismic explorations, recreational boating and operational wind farms. Underwater noise may carry long distances from known sources and, depending on intensity and frequency, may have the potential to disturb marine mammals and fish /135/.

According to HELCOM, most of the Baltic Sea is impacted at least by a level of underwater noise that has the potential to mask the communication of animals (Figure 8-10). The HELCOM categories have not been presented as actual noise levels, but are divided into different impact levels. In the Danish part of the Baltic Sea, impact level 1 and 2 are presented.

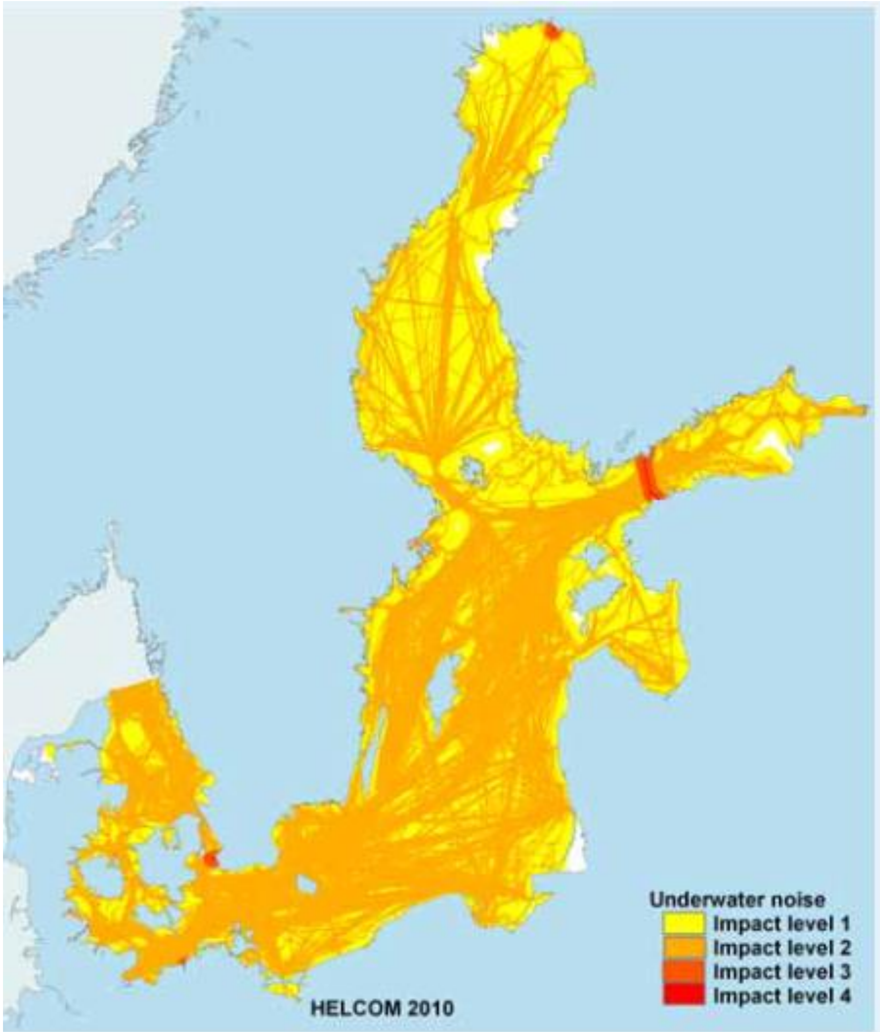


Figure 8-10 Distribution of underwater noise in the Baltic Sea during 2003–2007. Impact level 1 indicates that the noise is audible to biota; level 2 indicates that masking of communication occurs; level 3 indicates an avoidance reaction; level 4 indicates physiological impacts from construction work /136/.

The EU LIFE supported BIAS (Baltic Sea Information on the Acoustic Soundscape) project was established in September 2012 to support a regional assessment of underwater sound in the Baltic Sea. In 2014, the BIAS project deployed 38 autonomous hydrophone rigs all over the Baltic Sea to measure the current levels of underwater noise /137/.

Data from the BIAS project is shown in Figure 8-11. The figure shows the sound pressure level (SPL) for March 2014. The figure shows L10, which is the sound levels exceeded 10 % of the time. In general, for the main shipping lanes in the Danish sector of the Baltic Sea, the noise levels were between 100-130 dB re 1μPa. Areas outside major shipping lanes showed noise levels between 60-90 dB re 1μPa. *These results have been extracted with help of the BIAS soundscape planning tool, which was prepared within the EU LIFE project Baltic Sea Information on the Acoustic Soundscape (BIAS LIFE11 ENV/SE 841); www.bias-project.eu*.

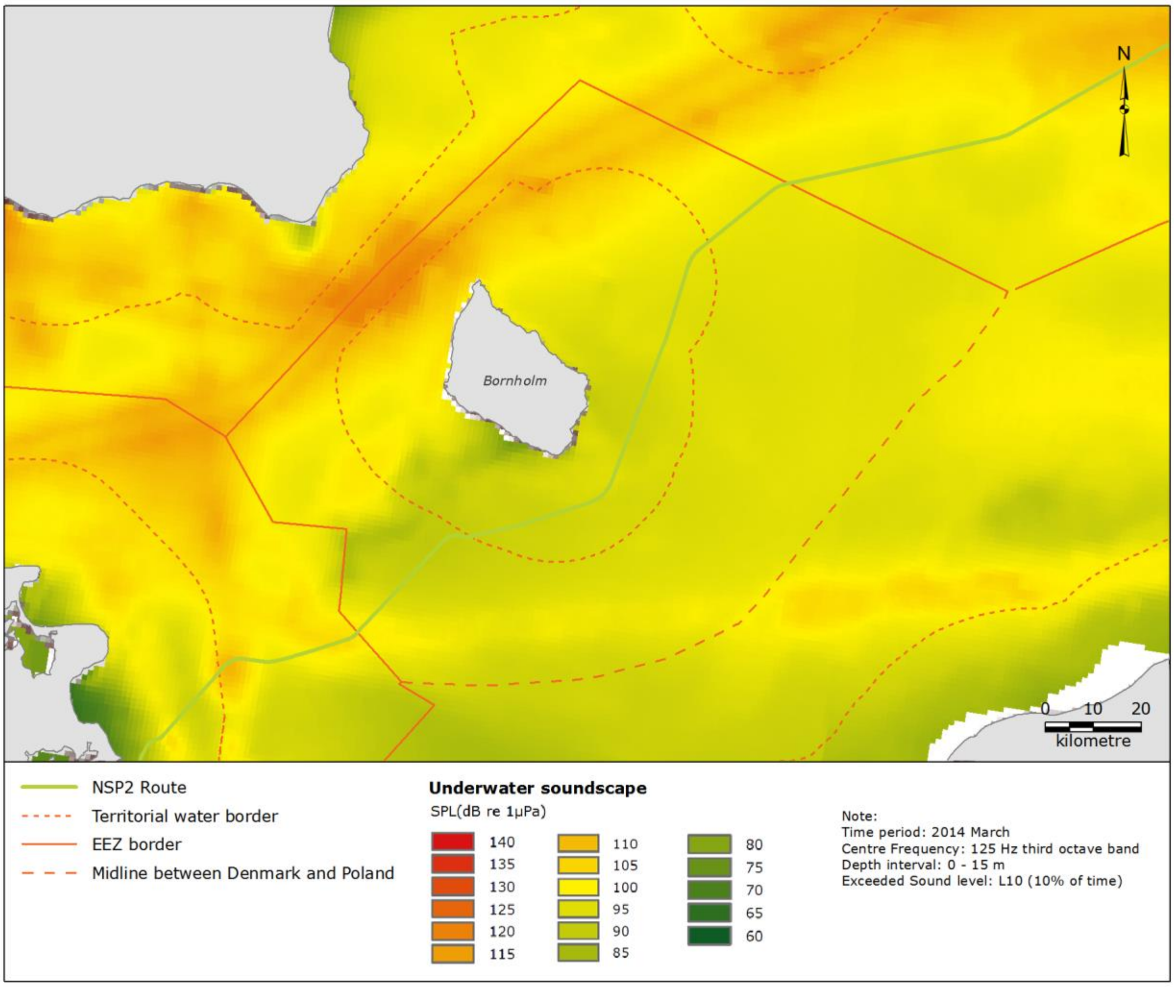


Figure 8-11 Underwater noise levels from BIAS. The figure shows the sound pressure level (SPL) for March 2014. The figure shows L10, which is the sound levels exceeded 10 % of the time. ***These results have been extracted with help of the BIAS soundscape planning tool, which was prepared within the EU LIFE project Baltic Sea Information on the Acoustic Soundscape (BIAS LIFE11 ENV/SE 841);*** **www.bias-project.eu.**

8.4.3.2 Modelling methodology

Modelling of noise from rock placement (including noise from the vessel) was undertaken at two locations, one location (RP1) is located at the point of the planned NSP pipeline crossing, where rock placement is assumed. The other location (RP3) is where rock placement might occur instead of post-lay trenching (see section 6.4) and represents the closest location to the Natura 2000 area Ertholmene (where the grey seal is one of the designated species).

The underwater sound propagation model calculates the sound field generated from underwater sound sources. The modelling results are used to determine the distances of potential impacts (noise maps/contour plots) from the identified significant underwater noise sources for the various identified marine life for the area. Based on source location and underwater source sound level and source location, the acoustic field at any range from the source is estimated using dBSEA's acoustic propagation model (parabolic equation method). The sound propagation modelling uses acoustic parameters appropriate to the specific geographical region of interest, including the expected water column sound speed profile, the bathymetry and the bottom geo-acoustic properties, to produce site-specific estimates of the radiated noise field as a function of range and depth. The acoustic model is used to predict the directional transmission loss from source locations corresponding to receiver locations. The received level at any three-dimensional location away from the source is calculated by combining the source level and transmission loss, both of which are direction dependent. Underwater acoustic transmission loss and received underwater sound levels are a function of depth, range, bearing and environmental properties. The output values can be used to compute or estimate specific noise metrics relevant to safety criteria filtering for frequency-dependent marine mammal hearing capabilities.

Underwater sound source levels are used as input for the underwater sound propagation program, which computes the sound field as a function of range, depth and bearing relative to the source location.

The model assumes that outgoing energy dominates over scattered energy and computes the solution for the outgoing wave equation. An approximation is used to provide two-dimensional transmission loss values in range and depth, i.e. computation of the transmission loss as a function of range and depth within a given radial plane is carried out independently of neighbouring radials (reflecting the assumption that sound propagation is predominantly away from the source).

The received underwater sound levels are computed from the 1/1-octave band source levels. This is done by subtracting the numerically modelled transmission loss (at each 1/1-octave band center frequency) and summing across all frequencies. This is done to obtain a broadband overall value. For this project, the transmission loss and received levels were modelled for 1/1-octave frequency bands between 10 Hz and 3000 Hz. Because the sources of underwater noise considered in this study are predominantly low-frequency sources, this frequency range is sufficient to capture essentially all of the energy output.

Water column data (salinity, temperature, speed of underwater sound/depth) is provided from ICES HELCOM specific measurement stations positioned close to the selected modelling positions.

Seabed conditions (sand, clay/depth) are provided from NSP geological survey data for areas close to the pipeline corridor.

Predictions were performed for both winter and summer water column conditions which have different underwater sound propagation characteristics and show the maximum underwater noise level of the water column. Noise propagation during winter conditions is generally considered to be greater than during summer conditions. The winter scenario is therefore considered worst case.

Based on existing measured underwater sound measurements, source data and studies from NSP, the sound source levels and frequency spectrum for the identified significant sound sources for potential underwater noise impacts have been estimated.

The estimated underwater continuous overall noise source level from rock placement activity is 188 decibels (dB) (1 m[45]). This includes rock movement and placement activities, ship noise and thruster positioning. Rock placement activity is relatively stationary (2 - 24 hour operation).

Further details and specific underwater noise levels are discussed in the methodology statement /300/.

8.4.3.3 Modelling results

The full modelling results for Denmark (both winter and summer conditions) are presented in /301/.

The underwater sound propagation modelling results included the root mean square (RMS), SEL and SELcumulative (2 hour) levels relative to distances and as noise maps. The levels depicted in

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[45] 1 m from the sound source

the noise maps are the maximum predicted level for that location at any depth down to the bottom and include the following acoustic parameters for each of the identified significant sound sources.

Sound pressure level (SPL) refers to the magnitude of a sound at a given point, i.e. how loud the sound is, and is measured in decibels relative to 1 micropascal, hence dB re 1 µPa. SPL does not provide information on the impact on the biological environment but rather presents the maximum sound level that was modelled at a certain distance. The modelling results show that the noise (SPL) from the rock placement activities will be below 110 dB re 1 µPa at a distance of >25-30 km from the source, corresponding to ambient noise level in the Baltic Sea, and the noise from NSP2 activities is equal to the passing ships in the nearby shipping routes (section 8.4.3.1).

The modelling results for rock placement during winter (worst case) are shown for sound exposure level (SEL) in Figure 8-12. Sound exposure level (SEL) is a decibel measure for describing how much sound energy a receptor (e.g. a marine mammal) has received from an event and is normalised to an interval of one second (quoted in dB re 1 μPa^2 s). Cumulative Sound Exposure, SEL(cum), is the time integral of the squared pressures over the duration of a sound or series of sounds. It enables sounds of differing duration and level to be characterised in terms of total sound energy (Pa^2 s).

In Figure 8-12, the cumulative SEL levels are presented and related to threshold levels used to evaluate impact on biological environment. The applied threshold levels for fish and marine mammals relating to TTS (temporary threshold shift) and PTS (permanent threshold shift) are presented in section 9 and Table 8-17. The modelling results show that underwater noise from rock placement did not exceed threshold levels causing PTS, whilst exceedance of threshold levels causing TTS is only detected in the vicinity of the proposed NSP2 pipeline route (80 m or less for marine mammals and 100 m or less for fish).

Table 8-17 RP1 and RP3 Denmark Assessment level limit distances, rock placement

Rock placement , RP1 and RP3$_{Denmark}$		**Assessment levels SEL(Cum*)**	**Threshold distances (summer/winter) SEL(Cum*)**
Marine group	**Effect**	**dB re 1µPa^{2}s**	**dB re 1µPa^{2}s**
Seals	PTS	200 dB	0 meters
	TTS	188 dB	80 meters
Porpoises	PTS	203 dB	0 meters
	TTS	188 dB	80 meters
Fish	Mortality (mortal injury)	207 dB	0 meters
	Injury	203 dB	0 meters
	TTS	186 dB	100 meters
Eggs and Larvae	Injury	210 dB	0 meters
* Cumulative SEL (2 hour rock placement)			

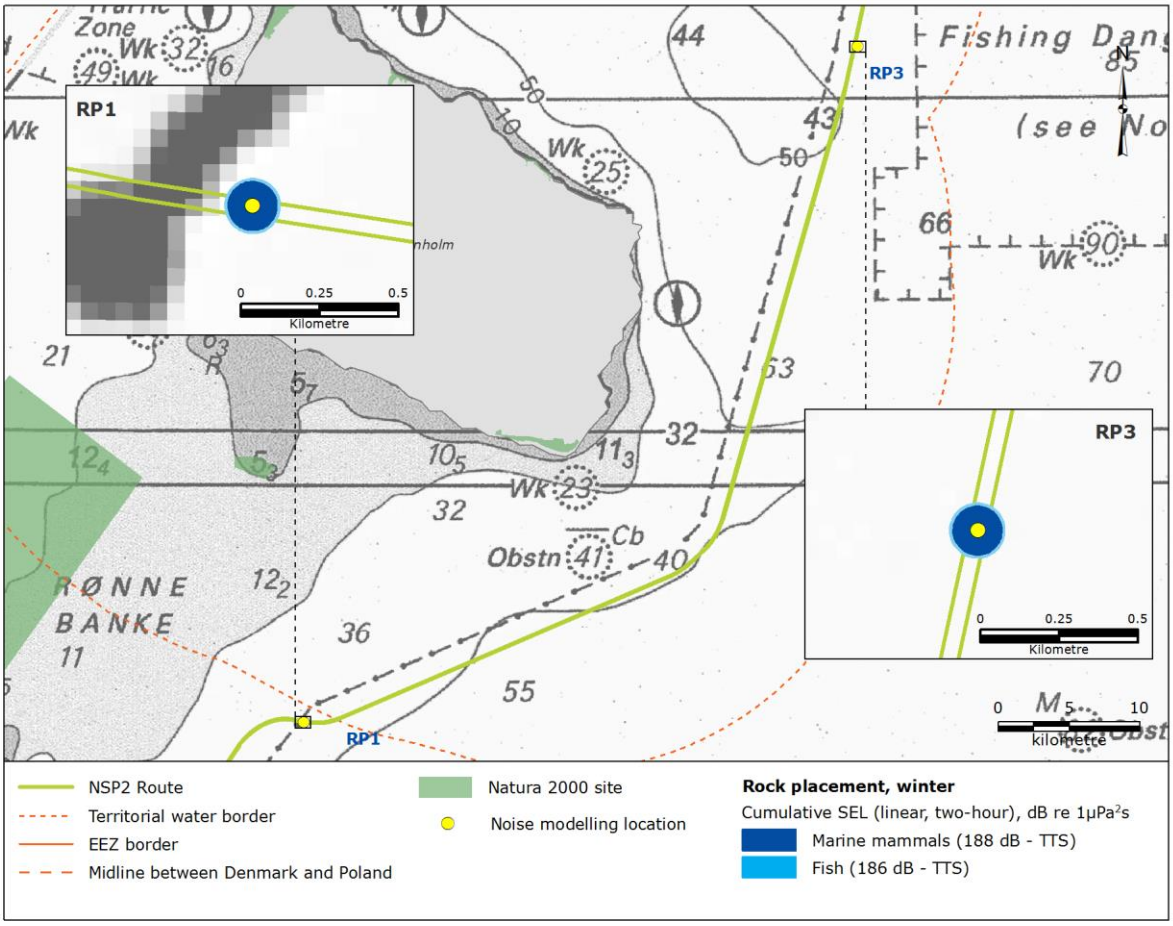

Figure 8-12 Rock placement, underwater continuous noise level contour plots showing cumulative SEL, dB re. 1µPa^2., 1 sec (winter). The SEL levels are related to the threshold levels used in the assessment for fish and marine mammals.

8.4.4 Airborne noise

During construction and operation, there is potential for airborne noise to be generated by vessels (from main and auxiliary engines and from ventilation fans).

8.4.4.1 Modelling Methodology

Modelling was undertaken based on the characteristics which result in the highest noise level. In practical terms: downwind and a moderate negative temperature gradient (lower temperature near the ground). This situation was estimated using the General Prediction Model /302/. This method anticipates a geometrical noise transmission (6 dB reduction in noise levels for each doubling of the distance).

Airborne noise from the pipe-lay vessel (considered worst case) during construction activities was modelled for the existing Nord Stream pipelines.

The General Prediction Model /302/ calculates the noise according to:

$$L_{pA} = L_{WA} - 8 - 20\log(r) - a_i r$$

where:

L_{pA}	is A-weighted noise level [dB]
L_{WA}	is sound power level of noise source [dB]
r	is distance from noise source to receiver [m]
a_i	is air absorption coefficient [dB/m]

8.4.4.2 Modelling Results

The noise levels from construction activities during the installation of NSP2 are assumed to be the same as during the installation of NSP since the same type of construction activities are anticipated.

The calculated noise levels are shown in Figure 8-13 at the location along the NSP2 route closest to land. At a distance of 4,100 m from the vessel, the noise level was assessed to be 33 dB (see ATLAS map NM-01-D). Based on the calculations it is assessed to be unlikely that the noise will be heard on land above ambient levels.

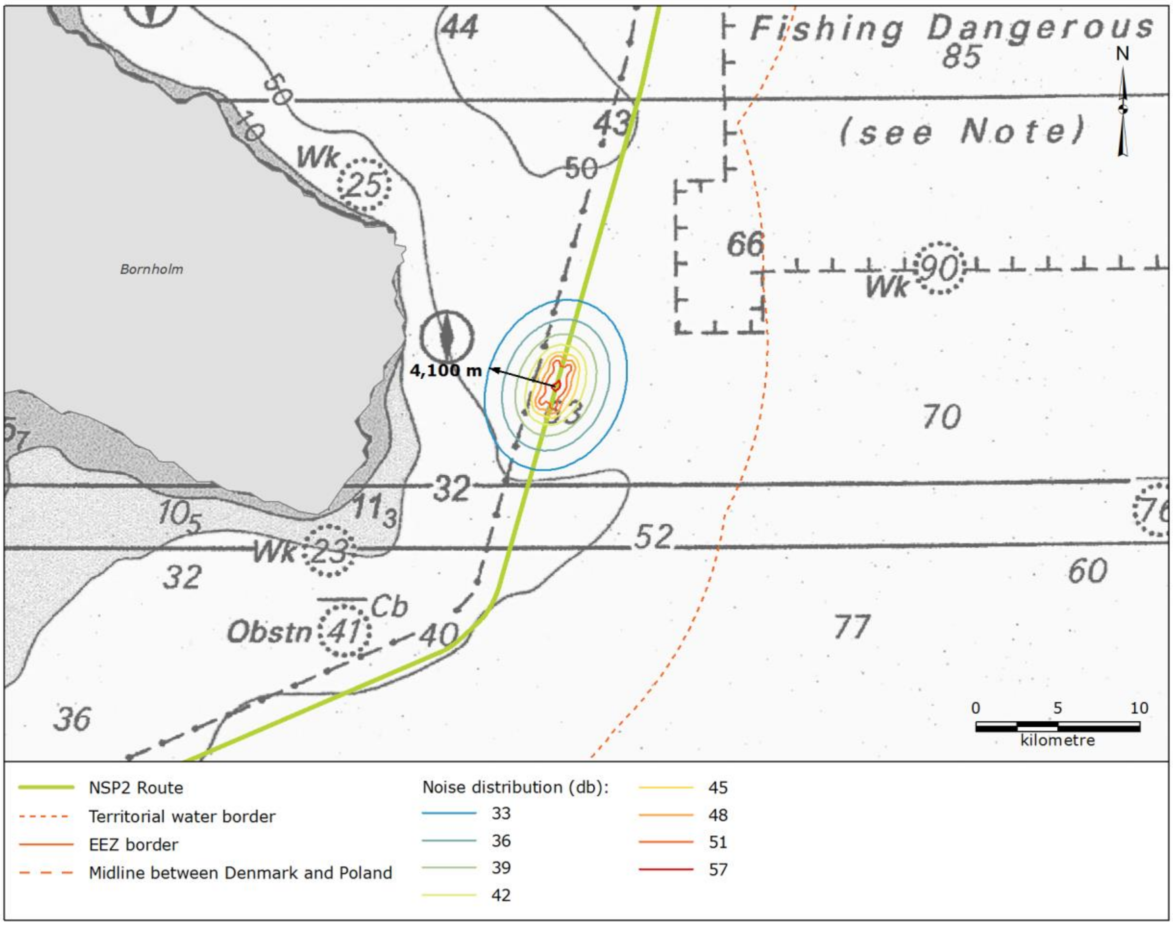

Figure 8-13 Propagation of airborne noise from the pipe-lay vessel

8.4.5 Emissions

Construction and operation of NSP2 will result in emissions to the atmosphere due to the use of machinery, vessels and other equipment that combust fuel while in operation. In order to assess the impact of the project on air emissions, emissions loads from construction and operation have been calculated.

It is noted that the MARPOL convention, Annex VI Prevention of Air Pollution from Ships *"sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances"*. Designated emission control areal set more stringent standards for SO_X, NO_X and particulate matter.

Emission calculations have been undertaken for the construction and operation of NSP2 within Danish waters. The calculations have been presented in /303/ and summarised below.

8.4.5.1 Methodology

The following activities (described in general words) are included in the emission calculations for the Danish section of NSP2:

1. Offshore pipe-lay activities:
   - Crossing installations
   - Transport of coated pipes from interim stockyards to NSP2 route
   - Pipe-lay
   - Pre-lay or post-lay rock placement
   - Post-lay trenching
   - Fuel supply, crew change, other materials
2. Operation (inspection, maintenance and repair).

Emissions are calculated on the basis of the operating time of the specific type of equipment used during the individual phases of construction and operation. The energy consumption of equipment, e.g. vessels, is needed in order to calculate the energy consumption, as emission factors for compounds are often given in mass/kWh.

The CO_2 emissions from vessels working in the Baltic Sea are for this purpose set at 3.1 tonnes CO_2/tonnes fuel /304/.

The NO_X emissions from vessels working in the Baltic Sea are for this purpose set at 12 g NOX/kWh (medium speed 4-stroke diesel ship engines 2000-2010) /305/. For evaluation purposes, NOX has been treated as NO2.

The SO2 emissions from vessels working in the Baltic Sea, which has SECA status, are for evaluation purposes set at 0.001 tonnes SO2/tonnes fuel, according to limit values on sulphur content in marine fuels /306/.

The particle emissions from vessels working in the Baltic Sea are for evaluation purposes set at 0.0018 tonnes TSP/tonnes fuel (emission factors for diesel ship engines in international seas after 2010) /305/.

The workload (in kWh) of the equipment may then be calculated using the following formula:

$$Energy\ consumption\ (kWh) = Effect\ (kW) x\ working\ time\ (hours) \qquad \text{Eqn. 1}$$

The emissions are in general calculated using the following formula:

$$Emission\ (tonnes) = Energy\ consumption\ (kWh)\ x\ time\ slice\ (\%)\ x\ emission\ factor\ (\frac{ton}{kWh}) \qquad \text{Eqn. 2}$$

The time slice takes into account that the engine may not be in operation during the entire period the equipment is available for the project. For example, a pipe-lay vessel is expected to be in operation (nearly) 100% of the time available during construction, whereas a support vessel may only be in operation part (e.g. 25%) of the time available during pre-commissioning.

The expected time slice for each type of equipment is defined on the basis of the time slice for similar operations in NSP, together with information on the days of operation/availability for each kind of machinery. Whenever possible, the operation time has been deduced from the current project description and the reasons for assumptions, etc., are stated in the respective sections for the different activities.

The individual equipment, machinery, etc., may use different fuel types, including:

- Heavy fuel oil (HFO);
- Medium fuel oil (MFO);
- Intermediate fuel oil (IFO);
- Light marine distillates (further divided into MDO and MGO).

However, it is assessed that the variation in emission factors between the various fuels is negligible. Therefore the same emission factors are applied in all cases.

Fuel consumption for machinery depends on the type and age of the engine, e.g. 155 g/kWh for an effective 2-stroke diesel engine up to 220 g/kWh for a 4-stroke engine /307/. For evaluation purposes, a fuel consumption rate of 195 g/kWh has been assumed for all engines /304/.

In cases where a sailing distance (or flying distance in the case of helicopter support) is needed to calculate emissions, a maximum distance of 100 nm has been used, which is equivalent to the targeted maximum sailing distance at all times from weight-coating plants/interim stockyards to pipe-lay vessel.

A large share of the emissions to air within Danish waters will be due to the operation of the pipe-lay vessel. It remains yet to be decided what kind of lay vessel will be used (anchored lay vessel and/or dynamically positioned lay vessel (DP lay vessel)). The emissions from the operation of the lay-vessel are to a large extent relying on the actual use. The anchored lay vessel is assumed to operate with 40% engine power as worst case and 15% during normal conditions (stable weather etc.). The DP vessel is assumed to operate with 70% engine power as worst case and 45% during normal conditions.

Emission calculations results for both lay vessel solutions and operating scenarios are presented below.

It should be noted that the air emissions calculated based on the above-mentioned assumptions are associated with uncertainties, e.g. related to engine type, number of engines, working load of the engines and the exact fuel type. Despite the data limitations and uncertainties, however, it is assumed that the estimated range of emissions presented in section 9.5 will be in the order of magnitude of the emissions that will effectively arise.

8.4.5.2 Total emission loads

Table 8-18 and Table 8-19 summarises the estimated emission loads associated with each activity planned within Danish waters during construction and operation of NSP2, for the anchored lay vessel scenario and for the DP vessel scenario respectively. Detailed descriptions of the calculations can be found in /303/ and the total air emissions load from NSP2 is presented in the Espoo report.

Table 8-18 Estimated emissions loads from Danish offshore activities during construction and operation of NSP2, with use of anchored vessel for pipe-lay (worst case engine power use)

Activity	Estimated emissions loads [tonnes]			
	CO_2	NO_X	SO_2	Particulate matter
Crossing installations	1,538	31	1.0	0.9
Pipe supply including thrusters	25,309	502	16.3	14.7
Pipe-lay using anchored vessel including anchor handling tugs	56,170	1,115	36.2	32.6
Survey vessel during pipe-lay	23,190	460	14.9	13.5
Rock placement	578	12	0.4	0.3
Trenching	1,950	39	1.3	1.1
Fuel supply, crew exchange, etc.	338	2	0.7	0.1
Operation (50 years)	33,667	668	21.7	19.5
Total Denmark (rounded)	168,000	3,330	110	100

The emissions from anchored lay vessel in Table 8-18 are the worst case estimations relating to high engine power. During normal conditions when power outtake is reduced, emissions from the lay vessel activity will be reduced to 37,168 tonnes CO_2, 738 tonnes NO_X, 24.0 tonnes SO_2 and 21.6 tonnes PM.

Table 8-19 Estimated emissions loads from Danish offshore activities during construction and operation of NSP2, scenario with use DP vessel for pipe-lay (worst case engine power use)

Activity	Estimated emissions loads [tonnes]			
	CO_2	NO_X	SO_2	Particulate matter
Crossing installations	1,538	31	1.0	0.9
Pipe supply including thrusters	25,309	502	16.3	14.7
Pipe-lay using DP vessels	116,109	2,305	74.8	67.4
Survey vessel during pipe-lay	23,190	460	14.9	13.5
Rock placement	578	12	0.4	0.3
Trenching	1,950	39	1.3	1.1
Fuel supply, crew exchange, etc.	338	2	0.7	0.1
Operation (50 years)	33,667	668	21.7	19.5
Total Denmark (rounded)	228,000	4,520	150	130

The emissions from DP lay vessel in Table 8-19 are the worst case estimations relating to high engine power. During normal conditions when power outtake is reduced, emissions from the lay vessel activity will be reduced to 74,641 tonnes CO_2, 1,482 tonnes NO_X, 48.1 tonnes SO_2 and 43.3 tonnes PM.

8.4.6 Remobilization and release of contaminants and nutrients into the water column

Suspension and dispersion of sediment during the construction phase will result in release of contaminants and nutrients (N and P) into the water. In this section, the quantities of contaminants and nutrients that may be remobilized together with seabed sediments and potentially released during NSP2 construction are evaluated. This is done based on the modelling results presented in section 8.4.1 and the results from the sediment survey performed along the NSP2 route. It is noted that the increased concentrations discussed below are caused by the release of contaminants and nutrients which are already present in the environment (in the seabed), and not by a net addition into the system.

The resuspended N and P can contribute to the growth of planktonic algae, whereas the contaminants that are mainly present in the particulate phase can enter the food web through uptake by filter feeders.

The release of N and P to the deep bottom waters in the Bornholm Basin is of only limited consequence, as the pelagic halocline limits vertical transport of the nutrients to the overlying photic zone. Therefore, the N and P does not become available to photosynthetic algae.

In the shallower sections of the proposed NSP2 route, e.g. the areas where trenching is carried out above the halocline, the nutrients may be assimilated by algae and contribute to the primary production. The amount of nutrients that can be made accessible to photic growth due to trenching and rock placement can be estimated based the concentrations of N and P in the sediment presented in Table 7-8 and the observed spill rates discussed in section 8.4.1. Thus, the highest measured concentrations of N and P in sediment along the proposed NSP2 route were 3,110 mg/kg dry sediment and 1,220 mg per kg dry sediment, respectively /65/. The typical rate of sediment spill is 7 kg/s during trenching /313/ and the total duration of trenching activity in Danish waters will be 62 hours for each of the two pipelines, i.e. 124 hours in total. Using these figures, and conservatively assuming that the dry weight of the sediment is 77% of the wet weight (corresponding to the highest value measured along the NSP2 route /65/), the total release of N and P along the NSP2 route caused by trenching will be approximately 7.4 tonnes N and 3.0 tonnes P. For rock placement, the spill rate in Danish waters has been modelled to be 0.22 kg/s, and the duration is estimated to be 177 hours /287/. This corresponds to a total release of 0.68 tonnes N and 0.26 tonnes P.

The amount of contaminants that will be suspended into the water column during post-lay trenching can be estimated in a similar manner to the N and P release by multiplying the spill rate with the time and the highest measured concentration of contaminants measured in the sediment along the NSP2 route. The results of such a calculation are given in Table 8-20.

Table 8-20 Amount of contaminants expected to be remobilized during post-lay trenching of both pipe-lines

Contaminant	Highest value measured in NSP2 survey	Total amount of contaminant suspended during trenching
As	19.1 mg/kg DW	46.0 kg
Pb	80.8 mg/kg DW	194.4 kg
Cd	0.48 mg/kg DW	1.20 kg
Cr	50.1 mg/kg DW	120.6 kg
Cu	57.8 mg/kg DW	139.0 kg
Co	20.7 mg/kg DW	49.8 kg
Hg	0.14 mg/kg DW	0.40 kg
Ni	43.5 mg/kg DW	104.6 kg
V	77.3 mg/kg DW	186.0 kg
Zn	77.3 mg/kg DW	498.1 kg
Total PAH	2.8 mg/kg DW	6.8 kg
Total PCB	3.6 µg/kg DW	8.60 g
Total organochlorine	14.8 µg/kg DW	35.6 g
TBT, DBT, MBT	16.7 µg/kg DW	40.2 g

In regards to areas experiencing sediment dispersal, the winter scenario described in section 8.4.1 can be considered worst-case. In the winter scenario, the predicted total area that will be affected by a SSC above 2 mg/l during trenching is 139 km^2, and the duration will be less than 12 hours. A small area of 7.65 km^2 may experience concentrations above 15 mg/l for a maximum of 5.5 hours /288/. The concentrations of the different contaminants corresponding to these levels of sediment suspensions are listed in Table 8-21. Also listed in the table are EU criteria for environmental quality standards (EQS) of the water column, or, if such is not available, the predicted no effect concentration (PNEC) /333/. The calculation of contaminants in the water column is based on the conservative assumption that all contaminants containing in the seabed sediment will be released.

Table 8-21 Amount of contaminants in the water column when the SSC is 2 mg/l and 15 mg/l.

Contaminant	Concentration in water (max value at 2 mg/l SSC), µg/l	Concentration in water (max value at 15 mg/l SSC), µg/l	EQS/PNEC µg/l
As,	0.038	0.29	0.6*
Pb	0.16	1.2	1.2
Cd	0.00096	0.0072	0.2
Cr	0.10	0.75	None
Cu	0.12	0.087	2.6
Co	0.041	0.31	None
Hg	0.00028	0.0021	0.05
Ni	0.087	0.65	8.6
V	0.16	1.2	None
Zn	0.41	3.1	None
Total PAH	0.0056	0.042	0.017[1]
Total PCB	0.000006	0.000054	None
Total organochlorine	0.000027	0.00022	None
Total TBT,DBT,MBT	0.000030	0.00025	0.00025*

*PNEC value

[1]EQS is given for selected PAH compounds, here benzo(b)fluoranthene which represent between 10 and 15% of the total mass of 16 measured PAH compounds in sediment from Danish waters around Bornholm.

None of the concentrations exceed the given EQS/PNEC threshold. The concentration of Pb at 15 mg/l SSC was identical to the EQS. This level of SSC will be reached for a brief period and in a limited area as described in section 8.4.1.

HELCOM employs concentrations of TBT and a number of PAH's (fluoranthene, anthracene, naphthalene, benzo[a]pyrene, as well as the sums benzo[g,h,i]perylene+indenol[1,2,3-cd]pyrene and benzo[b]fluoranthene+benzo[k]fluoranthene) as indicators for water quality status /89/. In Table 8-22, the contaminant concentrations corresponding to SSC of 2 and 15 mg/l are compared to applicable threshold concentrations corresponding to GES. The calculation of contaminants in the water column is based on the conservative assumption that all contaminants containing in the seabed sediment will be released.

Table 8-22 Concentrations of chemical contaminants corresponding to SSC of 2 and 15 mg/l, and the threshold values corresponding to GES. All concentrations are in µg/l.

	Fluor-an-thene	An-thra-cene	Naph-talene	Ben-zo[g,h,i]perylene + indenol[1,2,3-cd]pyrene	Ben-zo[a]-pyrene	Ben-zo[b]fluoranthene + ben-zo[k]fluoranthene	TBT
Concentra-tion at SSC of 15 mg/l	0.0042	0.0004 3	0.0005 7	0.015	0.00285	0.0078	0.0000 12
Concentra-tion at SSC of 2 mg/l	0.0005 6	0.0000 58	0.0000 76	0.0020	0.00038	0.0010	0.0000 87
GES boundary	0.1	0.1	1.2	0.002	0.05	0.03	0.0002

With one exception, the contaminant concentrations potentially released in the water due to sediment dispersion during trenching are far below the GES boundaries. The sum of benzo[g,h,i]perylene and indenol[1,2,3-cd]pyrene was the same as the GES threshold for an SSC of 2 mg/l. Thus, the level of these PAH's may exceed GES values for a period of up to 12 hours in a total area of 139 km^2.

No addition of contaminants is expected to be associated with the introduction of the rocks themselves. Clean rock will be used offshore and will be free of clay, silt and lime, and contaminants such as heavy metals that can be dissolved in the water.

8.4.7 Release of metals from anodes into the water column

Sacrificial anodes of aluminium alloy will be used on the NSP2 pipelines in Danish waters to protect the pipelines from corrosion. The aluminium alloy will contain up to approximately 5 % zinc and 0.002% cadmium (see section 6.2.3.4). The release rate of ions from the anodes depends on the total amount of anode material to be installed, the current induced in the anodes (current demand) and whether there is any damage to the pipeline coating resulting in exposure of bare pipeline steel. In this section, the significance of the metal release from anodes is discussed based on current knowledge regarding the toxicity of each metal.

8.4.7.1 Release of aluminium

Aluminium is the most abundant metal in the biosphere, and usually present in high background concentrations in marine sediments without causing problems for benthic or pelagic life. In sediments from the southern part of the Baltic Sea, the concentration is typically about 4% by dry weight /309/.

Aluminium ions are generally not considered to cause ecotoxicological impacts in the marine environment at pH values between 6 and 8, since they are mainly present as non-toxic and poorly soluble Al(OH)3 that precipitates and deposits on the sediment. Aluminium ions also precipitate in seawater by formation of complexes with e.g. fluoride, phosphate, or humic/fulvic acids /310/. At pH values less than 6, dissolved and toxic Al3+ will be present in the water, but such acidic conditions are not present in normal marine environments, including the Baltic Sea water.

An example of sediment enriched in Al from anodic corrosion protection is given in /311/. Is is reported that elevated amounts of aluminium were found in sediments from the inner parts of the harbour in Le Havre, where anodes are widely used to protect steel structures. The level of Al in the water above the sediment was not above the background level observed at a reference station outside the harbour. This fact illustrats efficient precipitation of Al released into the water from the anodes.

The low toxicity of Al in aquatic environments is illustrated by the fact that bulk addition of aluminum sulfate to eutrophied lakes and estuaries has been employed as a convenient method for preventing release of excess amounts of phosphate from the sediment, thereby limiting the growth of phytoplankton in the water /312/. Based on the above, it can be speculated that the presence of the aluminium anodes along the NSP2 pipelines may facilitate the removal of small amounts of phosphorus from the water.

Based on the low solubility and low toxicity of aluminum ions at normal marine pH and the high background of naturally occurring aluminum in the sediment, it is concluded that the release of aluminum from the anodes will not be environmentally problematic.

Aluminium sacrificial anodes are also used to protect the existing NSP pipelines from corrosion. In the area where NSP2 is crossing NSP it must be anticipated that the release of aluminium will be slightly higher since the density of anodes in this area is slightly higher compared to the rest of the NSP2 route. However, as discussed above, the release of aluminium will not be harmfull to biota in the area.

8.4.7.2 Release of zinc

Zinc ions are potentially toxic to aquatic life, as reflected by the ERL value listed in Table 7-1 (150 mg/kg in marine sediment). The NSP2 pipelines will use a total of 1054 tonnes anode material in the Danish part of the pipeline route, of which maximum 5.75%, or 60.6 tonnes, will consist of Zn. Assuming that the entire anode mass will be consumed during the 50 years of pipeline operation (a very conservative assumption), the yearly Zn release along the pipeline in Danish waters will be 1.2 tonnes. For comparison, the annual inflow of Zn in 2006 was estimated to be 15 tonnes in the Western Baltic Sea and 446 tonnes in the Baltic proper /295/.

The potential release of zinc from anodes was modelled and evaluated during the EIA phase for NSP /308/, and it was concluded that release of zinc from the anodes during the operational lifetime of NSP would not result in a general increase of the concentration of zinc in the water column, except for a zone of a few meters around the pipelines. It was also concluded that bioaccumulation, where zinc is concentrated at higher trophic levels in the food chain, would not occur. The anodes that will be used for NSP2 are similar to the anodes that were used for NSP, and the environmental impact on water quality is therefore analogous.

As mentioned above sacrificial anodes of aluminium alloy are also installed at the NSP pipelines and it must be anticipated that the release of zinc from the aluminium alloy will be slightly higher in the area of the NSP crossing compared to the rest of the NSP2 route. Based on the conclusions above it is however assessed that the higher number of anodes in the area of the NSP/NSP2 crossing will not changes the assessment, and the release of zinc will have no impact on the water quality.

8.4.7.3 Release of Cadmium

Cadmium ions are potentially toxic to aquatic life, as reflected by the low ERL value listed in Table 7-1 (1.2 mg/kg in marine sediment). The NSP2 pipelines will use a total of 1000 tonnes anode material in the Danish part of the pipeline route, of which 0.002%, or 21 kg, will consist of Cd. Assuming that the entire anode mass will be consumed during the 50 years of pipeline operation, the yearly Cd release along the pipeline in Danish waters will be 0.4 kg. For comparison, the annual inflow of Cd in 2006 was estimated to be 50 kg the Western Baltic Sea and 10,420 kg in the Baltic proper /295/.

Cadmium constitutes about 0.002% of the anode material whereas Zn constitutes about 5%. Therefore, as was the case for Zinc, it is not expected that the release of Cd to the water will have any implications for the water quality or bioaccumulation except for in a zone of a few meters around the pipeline.

As discussed above, there may be an accumulative effect with the existing NSP pipeline at the area where the pipelines cross. However, it is assessed that the higher number of anodes in the area of the NSP/NSP2 crossing will not changes the assessment, that the release of Cd will have no impact on the water quality.

8.4.8 Ecological effects of release of CWA into the water column

As described in section 7.3, quantitative chemical analysis of target CWA and their degradation products in sediment samples was undertaken to estimate their presence along the NSP2 route. An in-depth evaluation of the potential toxicological effects of any CWA present along the NSP2 route has been performed based on these measurements /387/; the findings of this evaluation are summarized below.

8.4.8.1 Calculation of predicted environmental concentrations (PEC)

In order for chemicals to be incorporated into organisms, such as fish, and exert toxicity, they generally need to be in solution. Therefore, the measured CWA concentrations in the sediments were used to calculate pore water CWA concentrations based on adapted equilibrium partitioning as described in /387/. The pore water concentration of each compound can then be considered a conservative estimate of the concentration of the compound in the bottom water above the seabed. The calculated pore water concentrations of the detected CWA and degradation products (PEC) are presented in the second column of Table 8-23.

In addition to the inherent bottom water concentration of CWA and degradation products, there will be a contribution of CWA-related chemicals from suspended sediment due to trenching, anchor handing, and other activities undertaken in relation to the NSP2 construction. The volume of sediment that may be dispersed from the pipeline due to trenching and rock placement, which are considered to be the activities which contribute the most to the disturbance of sediment, were modelled for NSP2 as described in /287/. The concentration of CWA brought into suspension as a result of these construction activities, was estimated based on sediment dispersion modelling (section 8.4.1) and measurements of CWA concentrations in sediment along the proposed NSP2 route (section 7.3), and the highest predicted concentration of suspended sediment at a distance of 200 m from the pipeline during trenching and rock placement was considered. The results of this calculation are listed in the third column of Table 8-23.

Table 8-23 Predicted environmental concentrations (PEC) in pore water/bottom water and potential added bottom water concentrations caused by sediment dispersion at the distance of 200 m from the pipeline during intervention works.

CWA	Calculated mean inherent pore water (bulk water) concentration (PEC)	Calculated mean added bulk water concentration
	µg/l	µg/l
Sulphur mustard	0.031	0.000094
1,4-dithiane	0.566	0.000029
1,4,5-oxadithiepane	0.098	0.000030
1,2,5-trithiepane	0.044	0.000089
Adamsite	0.360	0.0169
5,10-dihydroxyphenarsazin-10-ol 10-oxide	0.0023	0.0080
Diphenylarsinic acid	0.0021	0.0122
Diphenylpropylthioarsine	0.0005	0.0015
Triphenylarsine	0.0002	0.0006
Triphenylarsine oxide	0.006	0.0022
Phenylarsonic acid	0.307	0.0033
Dipropyl phenylarsonodithionite	0.073	0.0015
α-chloroacetophenone	0.283	0.00022
Tributyl arsenotrithionite	0.0094	0.00055

8.4.8.2 Calculation of predicted no effect concentration (PNEC)

The toxicologically acceptable exposure concentrations associated with fish communities was used as a measure for predicted no effect concentration (PNEC). As a measure of these exposure concentrations, the fish community extrapolated HC5 value was used. HC5 (hazard concentration 5%) represents the concentration where the acute LC50 (lethal concentration causing death of 50% of population) is not exceeded for 95% of the fish species in the community.

For simplicity, the various intact CWA and the degradation compounds that were detected in the sediment were distributed into 5 classes (sulphur mustard, organoarsenic CWA, thiodiglycol, cyclic sulphur mustard products, and α-chloroacetophenone) and HC5 was derived for each class as described below /387/.

Sulphur mustard. Based on the available literature, the chronic EC50 (i.e. the concentration that induces a response halfway between the baseline and maximum) for sulphur mustard is identified to be 2 mg/l. This value was used to derive a species sensitivity distribution for 14 different fish species using the USEPA extrapolation tool WEB ICE[46] with the most sensitive species, Bluegill sunfish, as the surrogate species. This resulted in a fish community HC5 of 0.69 mg/l.

Organoarsenic CWA. In the absence of high quality environmental toxicity data for the multitude of arsenic compounds, the known most toxic compound is used (inorganic AsIII). The toxicity of AsIII was derived from the US National Library of Medicine Hazardous Substances Data Base (HSDB). The data were used to derive a species sensitivity distribution for 12 fish species (adult and juvenile). This resulted in a fish community HC5 of 0.29 mg/l.

Thiodiglycol. The HC5 for thiodiglycol was set to 1,000 mg/l based on experimental results using bluegill sunfish /383/.

Cyclic sulphur mustard products. For the detected cyclic products of mustard gas (1,4-dithiane, 1,4-oxathiane, 1,4,5-oxadithiepane, 1,2,5-trithiepane), the new OECD standardized GLP tests with algae (*Raphidocelis subcapitata*), crustacean *(Daphnia magna)*, and marine bacteria (*Allivibiro fischerei*) were conducted in Microtox™. During initial screening, 1,4,5-oxadithiepane was shown to be one of the most toxic of the compounds, and it was chosen as a representative for the cyclic mustard gas dissipation products in subsequent tests. An assessment factor of 500 was applied to the derived no observed effect concentrations (NOECs, i.e. the concentration at which

[46] https://www3.epa.gov/ceampubl/fchain/webice/index.html

no effects are observed on the test species) from the tests in accordance with EU guidelines. At a concentration of 0.825 mg/l no effect was observed with *Daphnia magna.* In the case of *Raphidocelis subcapitata* , the test results showed no effect at concentrations at or below 8.41 mg/l. The corresponding PNECs for the two groups were thus 0.825/500 mg/l = 0.00165 mg/l and 8.41/500 = 0,0168 mg/l.

α-chloroacetophenone. The acute fish community HC5 value for α-chloroacetophenone was set to 0.5 mg/l based on available literature.

The PNEC results are summarized in Table 8-24.

Table 8-24 PNEC values for detected CWA (mg/l)

	PNEC
Sulphur mustard	0.69
Organoarsenic CWA's	0.29
Thiodiglycol	1,000
Cyclic mustard gas products	0.0168[1]/0.00165[2]
α-chloroacetophenone	0.5

[1]*Raphidocelis subcapitata*; [2]*Daphnia Magna*

8.4.8.3 Predicted fish community and environmental risk (RQ)

The risk quotient (RQ) for a hazardous compound can be calculated as the PEC divided by the PNEC. A value above 1 indicates that the compound will be present in a concentration that is high enough to affect the environment negatively whereas a value below 1 indicates that no negative effects are anticipated.

In Table 8-25 the average RQs (calculated for all stations along the route) corresponding to an undisturbed scenario are listed in column 2, and the average added RQs caused by sediment dispersion at a distance of 200 m from the NSP2 route (see section 8.4.1) are presented in column 3. The RQ during construction is the sum of the RQs in the undisturbed scenario (average RQ during undisturbed scenario) and the added CWA resulting from sediment dispersion due to intervention works (average added RQ).

Table 8-25 Calculated mean RQ during undisturbed scenario and the mean added RQ during worst-case scenario.

CWA	Average RQ during undisturbed scenario	Average added RQ
Sulphur mustard	0.00005	<0.00001
1,4-dithiane	0.34	0.00002
1,4,5-oxadithiepane	0.059	0.00002
1,2,5-trithiepane	0.027	0.00005
Adamsite	0.0012	0.00006
5,10-dihydrophenarsazin-10-ol 10-oxide	<0.00001	0.00003
Diphenylarsinic acid	<0.00001	0.00004
Diphenylpropylthioarsine	0.00002	<0.00001
Triphenylarsine	<0.00001	<0.00001
Triphenylarsine oxide	<0.00001	<0.00001
Phenylarsonic acid	0.0011	0.00001
Dipropyl-phenylarsonodithionite	0.0003	<0.00001
α-Chloroacetophenone	0.0006	<0.00001
Tripropyl arsenotrithionite	0.00003	<0.00001

Table 8-26 shows the maximum RQ calculated among the stations along the pipeline route for the same 2 scenarios.

Table 8-26 Calculated maximum RQ during undisturbed scenario and the maximum added RQ.

	Maximum RQ during undisturbed scenario	Maximum Added RQ
Sulphur mustard	0.00005	<0.00001
1,4-dithiane	0.39	0.00002
1,4,5-oxadithiepane	0.083	0.00003
1,2,5-trithiepane	0.046	0.00009
Adamsite	0.020	0.0011
5,10-dihydrophenarsazin-10-ol 10-oxide	0.00008	0.0003
Diphenylarsinic acid	0.0002	0.0010
Diphenylpropylthioarsine	0.00009	0.00003
Triphenylarsine	<0.00001	<0.00001
Triphenylarsine oxide	0.00002	0.00008
Phenylarsonic acid	0.0066	0.00008
Dipropyl-phenylarsonodithionite	0.0022	0.00005
α-Chloroacetophenone	0.0006	<0.00001
Tripropyl arsenotrithionite	0.00003	<0.00001

Based on the maximum added RQ for single compounds the sum of the maximum added RQ values for all compounds is 0.00278. This value represents maximum RQ during NSP2 construction.

In general, the RQs listed in Table 8-26 are much lower than 1, i.e. the concentrations of the different CWAs and their degradation products are far below the level at which a negative impact on the environment would be expected. This is the case both in the undisturbed scenario and during seabed intervention. In conclusion, no negative impacts related to CWA in the seabed are expected during NSP2.

9 ASSESSMENT OF POTENTIAL IMPACTS

The environmental and socio-economic resources or receptors susceptible to impacts associated with the project activities are assessed in this section. All impacts are assessed for the construction phase and operational phase in sections 9.1 to 9.22 and summarised in section 9.23. The decommissioning phase is described in section 11.

The potential impacts are assessed on the basis of information and conclusions from section 6 (project description) and the existing conditions in the project area (section 7). Cumulative impacts are assessed in section 12, whilst potential transboundary impacts are summarised in section 14. All assessments were performed following the methodology described in section 8.

9.1 Bathymetry

The sources of potential impacts on the seabed bathymetry during construction and operation of NSP2 are listed in Table 9-1.

Table 9-1 Potential source of impacts on bathymetry during construction and operation of NSP2

Source of potential of impact	Construction phase	Operational phase
Physical disturbance on seabed	X	
Sedimentation on seabed	X	
Physical presence of pipelines and structures on the seabed		X

9.1.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.1.1.1 Physical disturbance on seabed

Construction activities, mainly post-lay trenching and rock placement, will result in the physical disturbance of the seabed. Furthermore, seabed erosion may be caused by the use of thrusters on pipe-lay vessels. Bathymetry is considered to be a receptor of high importance which is not resilient to the changes caused by physical disturbances. Therefore, the sensitivity is assessed to be high.

The location and extent of seabed intervention work (post-lay trenching and rock placement) to be carried out along the proposed NSP2 route in the Danish waters are described in section 6. Post-lay trenching will displace the sediment from the trench and deposit sediment to the sides of the trench. No mechanical backfilling of removed sediments is proposed, resulting in an open trench with the pipeline at the bottom and deposits of sediment on either side of the trench. However, natural partial backfilling of the trench will occur along some sections of the trenched pipelines due to the action of waves and currents.

Post-lay trenching is expected to be carried out in three sections within Danish waters, spanning up to maximum 20.5 km, and is conservatively estimated to take maximum 2.6 days (62 hours), not including time for relocation. The volume of the trench is expected to be approximately 6.9 m^3/m.

Rock placement will be used as a support the structure at the intersection between the NSP and NSP2 pipelines south of Bornholm, and it may also be used in other sections of the proposed NSP2 route within Danish waters. Rock placement on the seabed will, depending on the amount of rocks to be used, cause a minor local reduction of the water depth. This is further described in the section relating to the operational phase (section 9.1.2.1).

Calculations and mathematical modelling of erosion of the seabed caused by the thruster of a DP vessel indicate that erosion of the seabed will not take place at water depths greater than 50 m and that only very loose sediments with dry weight of <200 kg/m^3 can be affected at water depths between 40 and 50 m, see section 8.4.2.3. Thus, given the dry-weights measured along the proposed NSP2 route, no erosion is expected at water depths above 40 m /65/. The depth is less than 40 m for the last 5 km before the border with the German EEZ. The sediment type in this area is characterized as sand/silty sand with very low silt/clay fraction and a dry weight of >500 kg/m^3, which will limit the amount of erosion that can be expected /65/.

On the basis of the above, the changes in bathymetry will not cause any depth-related changes in the local benthic communities or in the basic physical and chemical conditions for life. Furthermore, the area affected by the construction works is very small compared to the surrounding region which is characterised by a similar environment.

In summary, impacts on bathymetry from physical disturbance on the seabed during construction will be local, long-term and of medium intensity. Based on the above, the impact magnitude is judged to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact on bathymetry from physical disturbance on the seabed is assessed to be negligible.

9.1.1.2 Sedimentation on the seabed

Sedimentation of suspended sediment released by intervention works, pipe-lay, anchor handling and/or thrusters from vessels has the potential to create layer on the seabed which may affect seabed profile. With a yearly sedimentation rate of a few mm, and in the absence of regular strong bottom currents, it may take many years to cover traces of locally increased sedimentation. Therefore, bathymetry cannot be considered resilient to the impact from sedimentation, and in combination with the high importance, the sensitivity is assessed to be high.

Based on the modelling results presented in section 8.4.1, the areas and amounts of increased sedimentation caused by seabed interventions are summarized in Table 9-2 /287/.

Table 9-2 Summary of the modelling results for sedimentation in the winter scenario, which is considered worst case.

		Sedimentation layer				
Seabed intervention	**Parameter**	**>0.06 mm**	**>0.3 mm**	**>0.6 mm**	**>0.8 mm**	**>1 mm**
Post-lay trenching (three locations)	Total area (km^2)	22.0	5.4	3.1	1.2	0.54
Rock placement (crossing)	Total area (km^2)	0,74	0.1	0.1	0.1	0.1

As seen from Table 8-14 and Table 9-2, the increase in sedimentation of suspended material in the vicinity of the pipeline resulting from post-lay trenching (worst case) will exceed 200 g/m^3, corresponding to a layer of approximately 1 mm, in a total area of 0.54 km^2 /287//288/. Similarly, the deposition of suspended material caused by rock placement was modelled, indicating that sedimentation would exceed 200 g/m^2 in a total area of 0.1 km^2 around the location for the crossing of NSP The sedimentation which is predicted is therefore within the natural background sedimentation (0.5-1.5 mm/year) /318/.

The changes in bathymetry caused by the sedimentation of suspended material on the seabed are not of a magnitude that will cause any bathymetry-related changes in the local benthic communities or in the basic physical and chemical conditions for life. In addition, the area affected by the construction works is very small compared to the surrounding region.

In summary, impacts on bathymetry from sedimentation will be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact on bathymetry from sedimentation on seabed is assessed to be negligible.

9.1.2 Operational phase

In the following, potential impacts during the operational phase are assessed.

9.1.2.1 Physical presence of pipelines and structures on the seabed

The bathymetry will be permanently affected by structures such as pipelines on the seabed and areas of rock placement, and is therefore not considered resilient. Taking into account that bathymetry is an important receptor, the sensitivity is assessed to be high.

The presence of the pipelines and support structures (rock placement, mattresses) will result in a localised reduction of water depth. However, given that the diameter of the pipeline is approximately 1.4 m, the overall reduction in water depth should not exceed a few metres. It will be largest in areas of rock placement, e.g. at the point where the NSP and NSP2 pipelines cross. Water depth at the planned crossing location is approximately 47 m. It can be estimated that water depth at the crossing location will be reduced by approximately 4-5 m (see section 6.4.4) /319/.

The shape of the trench and pipeline on the seabed may affect the water column currents and alter local sediment erosion and deposition patterns, e.g. due to scour. The scour effects on the seabed accretion and erosion processes were modelled to assess the impact of NSP. The results indicated that there would be a scour effect at current speeds above 0.31 m/s perpendicular to the pipeline, and that the extent of the affected area on the leeward side of the pipeline (i.e. the side facing away from the water flow) will be up to 10-12 times the pipeline diameter, corresponding to 12-14 m. It was concluded that the scour will not cause release of significant amounts of sediment that will cause environmental impacts /320/. The maximum speed of the inflowing bottom current is achieved during large bottom water inflows, and is around 0.3 m/s. A scour effect can thus be expected only during events of major bottom water inflows /97/.

The changes in bathymetry caused by the presence of pipelines and structures are not of a magnitude that will cause any bathymetry-related changes in the local benthic communities or in the basic physical and chemical conditions for life in the area (see sections 9.2.2.1, 9.3.2.1, 9.7.2.1, 9.8.2.1, and 9.9.2.1).

In summary, the impact on bathymetry from pipelines on seabed is assessed to be local, long-term, low intensity, and magnitude is therefore assessed to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact of the presence of pipelines and structures on bathymetry is assessed to be negligible.

9.1.3 Summary of impacts

The potential impacts on bathymetry during the construction and operational phases of NSP2 are summarised Table 9-3.

Table 9-3 Assessment of the overall f impacts during construction and operation of NSP2

Sources of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance on seabed	High	Negligible	Negligible	No
Sedimentation on the seabed	High	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines and structures on the seabed	High	Negligible	Negligible	No

Based on Table 9-3 potential impacts on bathymetry from construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.2 Sediment quality

The sources of potential impacts on the sediment quality during construction and operation of NSP2 are listed in Table 9-4.

Table 9-4 Potential sources of impacts on sediment quality during construction and operation of NSP2

Potential source of impact	Construction phase	Operational phase
Physical disturbance on seabed	X	
Sedimentation on the seabed	X	
Physical presence of pipelines and structures on the seabed		X

Factors contributing to sediment quality include physical factors such as grain size, dry weight and TOC/LOI, as well as levels of heavy metals and other contaminants with potential impacts on the microorganisms and benthos in contact with the sediment.

9.2.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.2.1.1 Physical disturbance on seabed

Construction activities, mainly post-lay trenching and rock placement, will result in the physical disturbance on seabed which may affect seabed sediment quality. A conservative assumption is that physical disturbance of the seabed may cause long-term changes, which do not revert naturally over time, therefore the sensitivity towards physical disturbance is thus assessed to be high.

The locations and areas of seabed interventions to be carried out along the proposed NSP2 route in the Danish waters are described in section 6. Post-lay trenching temporarily suspends and redistributes sediment material. Within the trench, anoxic sulfidic sediment layers will be exposed and the redox potential and biogeochemical processes at the water/seabed interface will be temporarily affected. However, the geophysical survey and the measurements of contaminants, including metals, organic pollutants and CWA, from depths down to 1 m below the sediment/water interface do not indicate that sediment of a fundamentally different quality than the current surface sediment will be exposed. Furthermore, physical factors such as grain size, dry weight, TOC/LOI will not be changed by physical disturbance of the sediment because similar properties are present in all the affected layers. The surface layer of the sediment is thus expected to revert to pre-intervention condition.

CWA bound to sediment particles as well as larger intact lumps may also be remobilized and redistributed together with the sediments during intervention works or anchor handling. Larger lumps of CWA (e.g. viscous mustard gas) can be broken into smaller pieces, thus increasing the mobility with respect to current/wave action. To evaluate whether the fragmented lumps would be moved by current and waves, a desktop analysis has been performed /383//385/. This concluded that the relocation of chemical munitions would primarily be due to fishing activities and that relocation by currents is only a minor factor. This is in line with the conclusion of the HELCOM Working Group on Dumped Chemical Munitions regarding the mobility of the chemical munitions and CWA /89/. Furthermore, it was concluded that the weathering and natural degradation of viscous mustard gas is more rapid for very small lumps than for large lumps /385/. Therefore, it must be expected that the fragments with a diameter of 10 mm or less would not be preserved on the seabed as long as the larger lumps that are found in the Baltic Sea. Nevertheless, degradation of CWA is a slow process, and the impact of relocated CWA may be long-term. However, surveys performed in 2015 showed that CWA are found in the sediment at the deeper sections along the NSP2 route, i.e. below the halocline, and redistribution of CWA due to physical disturbance is unlikely to affect areas where conditions allow the existence of higher life. Monitoring of seabed sediments during NSP construction in 2010-2012 showed that intervention works did not lead to changes in concentrations of CWA in the seabed sediments, and it was concluded that the CWA-associated risks for the marine environment were insignificant /388/. It is therefore assessed that construction activities associated with NSP2 will have a local and long-term impact on CWA spreading in the close vicinity of the disturbed area, though it is not considered sufficient to alter the contamination levels of the surrounding seabed environment.

In summary, the impacts in sediments quality caused by physical disturbance in relation to the seabed intervention works is local, temporary, and of low intensity. As a result, the impact magnitude is judged to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact of physical disturbance of the seabed on sediment quality is assessed to be negligible.

9.2.1.2 Sedimentation on the seabed

Sedimentation of suspended sediment resulting from intervention works and pipe-lay may affect seabed sediment quality. A conservative assumption is that sedimentation may cause long-term changes in sediment quality, which do not revert naturally over time. The sensitivity towards sedimentation is therefore assessed to be high.

As shown in Table 8-14 and Table 9-2, modelling indicates that as a result of trenching, an area of approximately 0.54 km^2 will experience sedimentation that exceeds 200 g/m^3, corresponding to a sediment layer of approximately 1 mm. This will be distributed over the three trenched sections. This lies within the range of natural sedimentation rate within the Bornholm Basin (0.5-1.5 mm/year) /318/. The deposition of suspended material on the seabed in the area around the rock placement is even less than during post-lay trenching /287/, and the effect on sediment quality is therefore smaller.

Sediment dispersion and sedimentation can also be caused by the physical impact of laying the pipeline on the seabed and anchor handling during pipe-lay. Based on the results presented in section 8.4.2, the amount of sedimentation caused by pipe-lay (including anchor handling) are expected to be less than that caused by seabed interventions.

Levels of metals and organic contaminants in sediment along the proposed NSP2 route were generally below threshold levels (see section 7.3.3). Furthermore, the sedimentation is temporary, within natural variation and highly localized. Therefore predicted levels of sedimentation are not considered sufficient to alter the sediment quality in terms of chemistry, content of contaminants or the biogeochemical processes taking place in the sediment due to microbial processes.

In summary, impacts on sediment quality from sedimentation on seabed during construction is local, short-term and of low intensity. As a result, the impact magnitude is judged to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact of sedimentation on sediment quality is assessed to be negligible.

9.2.2 Operational phase

In the following sections, potential impacts during the operational phase are assessed.

9.2.2.1 Physical presence of pipelines and structures on the seabed

Local sediment quality may be impacted by changes in bottom water dynamics caused by the presence of pipelines and piles of rocks from rock placement. These changes can affect the re-suspension rate in the immediate vicinity of the pipelines (scour) as well as local sedimentation rate. Taking into account that seabed sediments are an important receptor, the sensitivity is assessed to be high.

However, as discussed in 9.1.2.1, the spatial scale and intensity of scouring and the associated sedimentation is highly localized and insignificant in comparison to the vast area of soft bottom habitat surrounding the proposed NSP2 route.

In summary, the impacts caused by physical presence of pipelines and structures on the seabed in regards to sediment quality are considered local, long-term and of low intensity. The impact magnitude is judged to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact of physical presence of pipelines and structures on sediment quality is assessed to be negligible.

9.2.3 Summary of impacts

The assessments of the potential impacts on seabed sediment during construction and operational phase of the pipelines are summarised Table 9-5.

Table 9-5 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance on seabed	High	Negligible	Negligible	No
Sedimentation on the seabed	High	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines and structures on the seabed	High	Negligible	Negligible	No

Based on Table 9-5 potential impacts on sediment quality from construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.3 Hydrography

The sources of potential impacts on hydrography during construction and operation of NSP2 are listed in Table 9-6.

Table 9-6 Potential sources of impacts on hydrography during construction and operation of NSP2

Source of potential impact	Construction phase	Operational phase
Sedimentation on the seabed	X	
Physical presence of pipelines and structures on the seabed		X

9.3.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.3.1.1 Sedimentation on the seabed

Sedimentation of suspended sediments will result from intervention works and pipe-lay. The potential impacts on hydrography are related to changes in seabed features that may alter the direction and/or magnitude of bottom currents, or the vertical mixing of water. Sedimentation is one of the factors that may irreversibly impact bathymetry and therefore have long-term impacts on hydrography. Taking into account the importance of hydrography, the sensitivity of this receptor is assessed to be high.

The areas and amounts of increased sedimentation caused by seabed intervention and pipe-lay operations during NSP2 construction are discussed in section 8.4.1, 8.4.2 and 9.1.1.2. Sedimentation will generally be less than 1 mm, which is within the range of natural yearly sedimentation in the Bornholm Basin /318/. The changes are therefore not of a magnitude that will cause any hydrography-related changes in the marine environment.

In summary, the impact of sedimentation on seabed is therefore assessed to be temporary, local and of a low intensity. The impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact of sedimentation on seabed towards hydrography is assessed to be negligible.

9.3.2 Operational phase

In the following sections, potential impacts during the operational phase are assessed.

9.3.2.1 Physical presence of pipelines and structures on the seabed

The physical presence of the pipelines and structures on the seabed may irreversibly impact flow patterns along the seabed and therefore have long-term impacts on hydrography. Taking into account the importance of hydrography, the sensitivity of this receptor is assessed to be high.

Potential impacts on hydrography from NSP2 include changes in seabed topography, and therefore deep water current patterns, throughout the operational lifetime of NSP2.

The possible hydrographical effects upon inflowing deep water were modelled during NSP and concluded that, since the NSP pipelines did not pass through the Bornholm Strait or the Stolpe Channel (the main gateways for inflowing seawater to the Baltic Proper), impacts would be negligible with no hydraulic effect on bulk flow /320/ /322/. In addition, the study concluded the following:

- Mixing of the new deep water might increase by 0-1.0%;
- Salinity of the new deep water may decrease by 0-0.02 psu;
- Natural variability in and below the halocline in the East Gotland Basin is around 0.5 psu;
- Flows of volume, salt and oxygen may increase by 0-1.0%;
- If topographic steering takes place it can affect at most 1.7% of the inflow;
- Dams (closed depth contours) created by the pipelines have no significant influence on the phosphorus dynamics;
- Pipelines will have no effect on or possibly slightly counteract eutrophication in the Baltic Proper.

A hydrographic monitoring programme was subsequently carried out in the Bornholm Basin in 2010/2011 in order to verify the assumptions for the theoretical analysis of the possible blocking and mixing effects of the water inflow to the Baltic Sea caused by the presence of the NSP pipelines /324/. The results amended a number of the assumptions (i.e. mean height of the pipelines above the seabed was observed to be 0.7 m as opposed to the assumed 1.0 m) and concluded that the mixing caused by the NSP pipelines in the Bornholm Basin would, at most, be 1/5 of the worst-case estimations presented above.

A review of the hydrographic effects of NSP2 on the Baltic Proper was performed and it has been concluded that theoretical analysis undertaken for NSP was also valid for NSP2 and therefore there would be no impacts on bulk flow /319/. Furthermore, analysis of the embedment of NSP pipelines in Danish waters shows that five years after installation, the pipelines are embedded at least 50% in most locations. Embedment of the pipelines reduces the potential effects on hydrography.

In summary, the impacts caused by physical presence of pipelines and structures on the seabed in regards to hydrography are considered local, long-term and of low intensity. Therefore, the impact magnitude is judged to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact of the physical presence of the pipelines and structures on the seabed on hydrography is assessed to be negligible.

9.3.3 Summary of impacts

The potential impacts on hydrography are summarised in Table 9-7. Where potential trans-boundary impacts area identified, these are further assessed in section 14.

Table 9-7 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor Sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Sedimentation on the seabed	High	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines and structures on the seabed	High	Negligible	Negligible	Yes

Based on Table 9-7 potential impacts on hydrography from construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.4 Water quality

The sources of potential impacts on the water quality during construction and operation of NSP2 are listed in Table 9-8.

Table 9-8 Sources of potential impacts on water quality during construction and operation of NSP2

Sources of potential impact	Construction phase	Operational phase
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Generation of heat from gas flow through the pipelines		X
Release of metals from anodes		X

9.4.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.4.1.1 Release of suspended sediment into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediments into the water column. Although water quality will be affected by increased suspended sediment, re-sedimentation will occur over a short time period such that the water quality will revert back to pre-impact status. Therefore, although water quality is an important receptor, it can be considered resilient to the impacts of released sediment to the water column and its sensitivity is assessed to be low.

Post-lay trenching and rock placement have the potential to cause resuspension and dispersion of seabed sediments into the overlying water column. Modelling results indicate that during post-lay trenching (worst case), an area of 139 km^2 may be affected by an SSC of >2 mg/l for a period of up to 12 hours, and an area of 7.65 km^2 may be affected by an SSC of >15 mg/l for up to 5 hours. This demonstrates that the system will rapidly revert to its pre-impact state once the activity ceases.

Monitoring of the sediment plume caused by post-lay trenching during NSP construction was undertaken in Danish and Swedish waters in 2011 and 2012. The results indicated that the plough created a plume of suspended sediment which was densest near the plough, where concentrations up to 20 mg/l were observed. The observed concentrations 500 m behind the plough were less than 4 mg/l. In respect to rock placement activities, highest SSC measured during NSP construction was 20 mg/l at a distance of 100 m from the pipeline; this increased turbidity was limited to the lowermost 10 m of the water column. In general, an area of less than 1 km was impacted by SSC levels >10 mg/l. However, some turbidity peaks above 10 mg/l were found sporadically, with a total duration of 6.5 hours /294/.

Other activities, including rock placement, anchor handling, pipe-lay, and the use of DP vessels may also cause resuspension of sediment, but to a lesser degree than post-lay trenching. Monitoring of water quality during NSP pipe-lay activities (Russia and Finland) indicated that no significant impacts associated with sediment release were observed when using either anchored or DP vessel /294/ /321/. For example, monitoring undertaken in Finland (2010) during NSP pipe-lay activities (anchored vessel) showed that at the nearest measuring point, 50 m from the pipeline, there was a slight increase in turbidity for a period of no more than 2 hours /328/.

In summary, the impact on water quality from suspended sediment will be temporary, local, and of medium intensity. Therefore, the overall impact magnitude is assessed to be low.

Based on the low impact magnitude and the low sensitivity, the overall impacts on water quality associated with the release of suspended sediment into the water column is assessed to be minor.

9.4.1.2 Release of contaminants into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of contaminants currently associated with the sediment into the water column, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide. Discharges from vessels may also contribute to water pollution. The concentration of metals, organic contaminants and nutrients in the water column are all essential characteristics that affect the water quality. However, since the water quality will rapidly revert to its pre-impact state, it is assessed to be resilient to release of contaminants. Although water quality is considered an important receptor, its sensitivity towards contaminants is assessed to be low.

The following sections deal with each of the potential contaminants in turn. The potential for release of CWA is covered in 9.4.1.2.

Heavy Metals

Based on the modelling of sediment spreading during NSP2 construction as well as field survey results, section 8.4.6 provides a conservative estimation of the total amount of heavy metals that may be remobilized and released into the water during post-lay trenching. Table 9-9 compares these estimates with the annual waterborne influx of heavy metals to the Baltic Proper (the basin crossed by the NSP2 route), corresponding to the area between the Aaland Sea and the Danish sounds /295/.

Table 9-9 Comparison of heavy metals (tonnes) potentially released during NSP2 post-lay trenching of both pipelines and annual inflow from waterborne sources /295/.

	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Suspended during NSP2 post-lay trenching	0.0012	0.121	0.139	0.0004	0.105	0.194	0.498
Annual waterborne influx to the Baltic Proper	10.42	12.60	200.62	0.11	62.38	47.59	445.90
NSP2 contribution in % of annual influx from waterborne sources	0.012	0.96	0.068	0.36	0.17	0.41	0.11

Table 9-9 demonstrates that the total remobilisation of metals caused by NSP2 during post-lay trenching is considerably below 1% of the annual inflow of all metals from waterborne sources.

The concentrations of different contaminants associated with an SSC of 2 and 15 mg/l have also been estimated (see Table 8-21) and show that contaminant concentrations in the water column are not expected to exceed thresholds for EQS or PNEC (where applicable). The impact from metals in the water column are therefore considered to be temporary, of low intensity, and localized.

Organic Contaminants

As noted in section 7.3.3, a number of organic contaminants are used by HELCOM as indicators for water quality status /89/ and the concentrations of these contaminants associated with an SSC of 2 and 15 mg/l have been estimated (see Table 8-22).

With the exceptions of benzo[g,h,i]perylene and indenol[1,2,3-cd]pyrene, the ERL threshold levels established by HELCOM are not exceeded. Both exceptions exceed ERL values only in deep parts of the route where benthic and pelagic life is scarce or absent due to low oxygen concentrations. Hence, it is considered unlikely that activities during the construction phase will expose pelagic or bottom dwelling organisms to contaminants of critical levels which would cause increased mortality or reduced growth rates. The impact from contaminants in the water column are therefore considered to be temporary, of low intensity, and localized.

Nutrients

As discussed in section 8.4.6, the total re-suspension of N and P along the NSP2 route is conservatively estimated to amount to 8.1 tonnes N and 3.2 tonnes P. In comparison, the yearly waterborne N/P loads to the Baltic Proper (the basin crossed by the NSP2 route) are approximately 370,012 tonnes N and 14,651 tonnes P /80/. These levels are considerably below the annual inputs, such that they would not cause a measurable change in nutrient availability or levels of eutrophication. In addition, it is noted that resuspension levels are likely to be lower than those caused by natural sediment disturbance due to wave impact. The impacts associated with nutrients being released into the water column are therefore considered to be temporary, of low intensity, and localized.

Hydrogen Sulphide
Hydrogen sulphide is a common end product of microbial degradation of organic material, and is normally present in most marine sediments. In the deep parts of the proposed NSP2 route, where bottom waters are anoxic or low in oxygen and benthic and pelagic life is absent, this release of sulphide is unlikely to result in a noticeable change. However, where the hydrogen sulphide is released into oxygenated bottom water (areas where the bottom 10 metres of the water column is in, or above, the halocline) there will be an immediate, chemical consumption of oxygen. Due to natural mixing of the water column, oxygen levels are expected to return to pre-impact status within days.

At the sediment dispersion rates predicted by the modelling (see section 8.4.1), the reduction in oxygen concentration will therefore be temporary, of low-medium intensity and localised to areas of sediment disturbance.

A calculation of the amounts of released nutrients and contaminants was also undertaken as part of NSP /127/, based on the measured concentrations of the contaminants in sediment and the amount of released sediment during construction. Estimates were prepared for nutrients, metals and organic contaminants. The amounts were assessed to be small and insignificant compared with the annual amounts that enter the Baltic Sea and Baltic Proper, and the contribution of nutrients as well as inorganic and organic contaminants was assessed to have negligible impact to water quality.

Discharge from Vessels
During construction of NSP2, construction and support vessels will be operating along the proposed route. On this basis, there is the potential for discharges from vessels to impact water quality; However, all project vessels will be compliant with the requirements of the Helsinki Convention (Convention on the Protection of the Marine Environment of the Baltic Sea Area) and the prescriptions for the Baltic Sea Area as a MARPOL 73/78 Special Area, these are summarised below.

- Oily Water. In accordance with MARPOL 73/78, there will be no discharges of oil or oil mixtures into the Baltic Sea area from project vessels. The oil content of discharges from machinery spaces (bilge water) will not exceed 15 parts per million.
  - For ships of 400 gross tonnage and above, oil filtration equipment will be provided with arrangements to ensure that any discharge of oily water is automatically detected and stopped when the oil content in the effluent exceeds 15 parts per million.
  - Ships lacking bilge water filtration equipment will be provided with sludge and oily water holding tanks of sufficient capacity for the time spent way from port. Oily water will be retained on-board for disposal at an on-shore reception facility.
  - Oil Record Books will record all oil or sludge transfers and discharges from vessels. Records will also be maintained for ballasting or cleaning of oil tanks and the discharge of dirty ballast or cleaning waster from fuel oil tanks.
- Sewage. In the Baltic Sea area, there will be no discharge of sewage from ships within 12 nautical miles of the nearest land unless sewage has been comminuted and disinfected using an IMO approved system and the distance to the nearest land is greater than 3 nautical miles. No discharge of sewage will take place from stationery ships or ships moving at a speed of less than 4 knots.
- Garbage. There will be no discharge of garbage from vessels. Food waste will not be discharged within 12 nautical miles of the nearest land.
- Dumping at sea. There will be no dumping of any project waste at sea, including cement dust, packaging materials and swarf generated from the milling of the pipe ends. All project generated waste (i.e. waste not deriving from the normal operation of the ship) will be retained for disposal at licensed waste facilities ashore.

In light of the above, no impacts on water quality as a result of discharges from vessels are anticipated.

In summary, the impacts on water quality caused by contaminants (metals, organic contaminants, N and P, hydrogen sulphide and/or discharges from vessels) during the construction of NSP2 are local, temporary and of low to medium intensity. The impact magnitude is therefore assessed to be low.

Based on the low impact magnitude and the low sensitivity, the overall impact on water quality from the release of contaminants into the water column is assessed to be minor.

9.4.1.3 Release of chemical warfare agents (CWA) into the water column

As noted in section 8.4.1.1, seabed interventions, pipe-lay, anchoring operations and use of DP vessels have the potential to cause resuspension and dispersion of seabed sediments into the overlying water column. This can result in the release of chemical warfare agents (CWA) currently associated with the sediment into the water column. However, the types of CWA present in the Baltic Sea are poorly dissolvable in water, and will mainly be present as particular material that will rapidly settle on the seabed after getting suspended. Therefore water quality can be considered resilient. Although water quality is considered an important receptor, the sensitivity of the water quality towards CWA is judged to be low.

The potential increase in concentrations of CWA in the water column as a result of NSP2 has been predicted based on the concentrations of CWA in seabed sediments along the NSP2 route and modelling results of sediment redistribution due to intervention works (see section 8.4.8). Risk Quotients (RQ), representing the expected CWA concentration in the water column (predicted environmental concentrations, PEC) divided by the toxicity threshold value (predicted no effect concentrations, PNEC) were calculated and shown not to exceed 0.0024 at a distance of 200 m from the pipeline (see 8.4.8.3). Thus, at a distance of 200 metres from the pipeline route, the concentration of CWA in the water column is expected to remain more than 400 times lower than the level at which a negative impact on biota may occur. Additionally, as noted above, CWA are poorly dissolvable in water and will settle out within a short time span after suspension.

In summary, it is evaluated that remobilisation of CWA into the water column as a result of NSP2 construction activities will be local, temporary and of low intensity. The impact magnitude is therefore assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on water quality from the release of CWA into the water column is assessed to be negligible.

9.4.2 Operational phase

In the following sections, potential impacts during the operational phase are assessed.

9.4.2.1 Generation of heat from gas flow through the pipelines

Water that gets in contact with unburied pipeline sections may experience a small increase in temperature as it passes over the surface. This temperature effect is short-term and the water will quickly regain its original temperature, with no lasting effects on the water quality. Therefore, the water quality can be considered resilient to the heat that may be generated from gas flow in the NSP2 pipelines. Although water quality is considered an important receptor, and the sensitivity is assessed to be low.

Gas flowing through the NSP2 pipelines during operation has the potential to increase the surface temperature of an unburied pipeline section, creating a temperature difference between the pipeline and the surrounding seawater.

Modelling of NSP showed that the temperature of the water at the surface of an unburied section of pipeline could be up to 0.5 ºC higher than the temperature of the surrounding water due to heat transfer from the pipeline. Given the similarity in design specifications, it is considered likely that NSP2 will experience a similar increase in water temperature in the immediate vicinity of unburied pipeline sections. The heat transfer will occur throughout the lifetime of the pipeline and is therefore considered long-term. Natural mixing of the water will ensure that the temperature reach equilibrium with the surrounding water body within 0.5 to 1 m after crossing the pipeline, and the impact is therefore highly local. In areas along the proposed NSP2 route where the seabed is below the halocline, the water is generally devoid of higher life because of its low oxygen content. In shallower areas, where the bottom water is within or above the halocline, natural mixing with surface waters will have a far larger impact on water temperature than heat transfer from the pipeline. For the buried part of the pipelines, NSP modelling has shown that the transfer of heat from the pipelines to the sediment and the surrounding seawater is insignificant.

In summary, it is assessed that impacts on water quality associated with the temperature difference between the pipelines and the surrounding seawater during the operational phase are local, long-term and of low intensity. The impact magnitude is therefore assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on water quality from the generation of heat by the pipelines is assessed to be negligible.

9.4.2.2 Release of metals from anodes

Sacrificial anodes of aluminium alloy will be used in the Danish NSP2 section to protect the pipelines from corrosion and will result in the release of Al, Zn and Cd. As discussed in section 8.4.7, Al release from anodes is usually not considered problematic in the marine environment. Cd and Zn may be taken up by phytoplankton and thus enter the food chain, and at high concentrations, Cd and Zn may be acutely toxic to organisms. Both Zn and Cd form insoluble salts in seawater and will ultimately settle on the seabed and get buried in the sediment. Given the high importance of the receptor, the sensitivity is assessed to be medium.

The impacts from metal release from anodes will last for the lifetime of the pipelines, and is thus considered long-term. Elevated levels of anode metal ions in the water column are expected only in the very vicinity of the anodes (few metres), and the amounts released from the anodes are insignificant compared with the existing levels of water-borne inflow of metals to the area. Furthermore, only the part of the pipelines present in shallow sections where the seabed is within or above the halocline is relevant in regards to such effects.

Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity. However, elevated concentrations of metals will be localized to the area around the crossing, and it is assessed that the combined impact from the two pipelines will be negligible.

In summary, it is assessed that impacts on water quality associated with the release of metals from anodes during the operational phase are local, long-term and of low intensity. The impact magnitude is therefore assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on water quality from release of metals from anodes is assessed to be negligible.

9.4.3 Summary of impacts

The assessment of the potential impacts on water quality is summarised in Table 9-10. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-10 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Release of sediments into the water column	Low	Low	Minor	Yes
Release of contaminants into the water column	Low	Low	Minor	Yes
Release of chemical warfare agents (CWA) from the seabed	Low	Negligible	Negligible	Yes
Operational phase				
Generation of heat from gas flow through the pipelines	Low	Negligible	Negligible	No
Release of metals from anodes	Medium	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-10) the potential impacts on water quality from construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.5 Climate and air quality

The sources of potential impacts on climate and local air quality during construction and operation of NSP2 are listed in Table 9-11.

Table 9-11 Sources of potential impacts on climate and air pollution during construction and operation of NSP2

Source of potential impact	Construction phase	Operational phase
Emissions of air pollutants and GHGs - impacts on climate	X	X
Emissions of air pollutants and GHGs - impacts on local air quality	X	X

Within this section, the phrase "air emissions" is used to collectively refer to CO_2 (an important greenhouse gas (GHG), which is considered the main driver of climate change), as well as NO_X, SO_2 and PM (gases which affect local air quality).

9.5.1 Construction and operational phase

Construction and operational activities will generate air emissions which have the potential to impact climate (through emission of GHG) and/or air quality (through emissions of NO_X, SO_2 and PM).

Air quality is generally better offshore than onshore because of the larger distance to emitters such as roads, industries and combustion plants. Air quality can be considered resilient to the emission of NO_X, SO_2 and PM, because these pollutants will precipitate within a relatively short time span. Emitted CO_2 however will remain in the atmosphere contributing to global warming. Taking into account that climate and air quality is an important receptor, it is assessed that the sensitivity of the receptor towards NO_X, SO_2 and PM emissions is low while sensitivity towards CO_2 emissions is assessed to be medium.

The total air emissions load during construction and operation of the NSP2 pipelines within Danish waters has been calculated, see section 8.4.5. The total load is predicted to comprise approximately 168,000 tonnes of CO_2, 3,330 tonnes of NO_X, 110 tonnes of SO_2 and 100 tonnes of PM, assuming use of an anchored pipe-lay vessel (under worst case conditions i.e. most intensive use of engine power). If a DP vessel is to be used, the emissions will be approximately 35% higher (also under worst case conditions i.e. most intensive use of engine power). No other GHG (e.g. methane) is expected to be emitted during NSP2 construction or operation phases.

The majority of emissions (approximately 80-85%) will occur during the construction phase and will therefore be temporary, while the remainder will be emitted during the operational phase, which has an estimated duration of 50 years.

In 2013, the total annual Danish emissions of CO_2, NO_X and SO_X were approximately 41,622,000 tonnes, 122,971 tonnes and 13,012 tonnes respectively, whilst the emissions of PM in 2014 were 91,300 tonnes /132/. NSP2 contributions would therefore represent less than 1 % of the total annual Danish emissions of CO_2, SOx and PM_{10}; whilst NO_X emissions would represent approximately 3% of the total annual Danish emissions.

In 2014, the total emissions from vessels sailing in the Baltic Sea comprised 15,000,000 tonnes of CO_2, 320,000 tonnes of NO_X, 81,000 tonnes of SO_X and 16,000 tonnes of PM /133/. NSP2 contributions would therefore represent approximately 1% of the yearly total emission loads in the Baltic Sea.

In summary, impacts on climate during the construction and operational phase are national, temporary to long-term (dependant on project phase) but of low intensity. In respect to air quality, impacts during the construction and operational phase are local, temporary to long-term (dependant on the project phase) but of low intensity. Therefore, the magnitude of the impact is assessed to be negligible.

Based on the negligible impact magnitude and the low to medium sensitivity, the overall impact on climate and air quality associated with emissions from NSP2 vessels during construction and operation is assessed to be negligible.

9.5.2 Summary of impacts

The assessment of the potential impacts on air emissions is summarised in Table 9-12. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-12 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Emissions of air pollutants and GHGs - impacts on climate	Medium	Negligible	Negligible	Yes
Emissions of air pollutants and GHGs - impacts on air quality	Low	Negligible	Negligible	Yes
Operational phase				
Emissions of air pollutants and GHGs - impacts on climate	Medium	Negligible	Negligible	Yes
Emissions of air pollutants and GHGs - impacts on air quality	Low	Negligible	Negligible	Yes

Based on the conclusions in the sections above (see Table 9-12) the potential impacts on climate and air quality from construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.6 Plankton

The sources of potential impacts on the plankton during the construction and operation phase are listed in Table 9-13.

Table 9-13 Sources of potential impacts on the plankton during construction and operation of NSP2

Source of potential impacts	Construction phase	Operational phase
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Release of metals from anodes		X

Potential impacts on plankton are predominantly correlated with impacts on water quality, which are presented in section 9.4.

9.6.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.6.1.1 Release of sediments into water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This has the potential to smother phyto- and zoo-plankton, and increase turbidity, which will in turn reduce light availability for phytoplankton. These impacts have the potential to result in reduced growth rate and photosynthesis.

Although plankton is an important receptor, it is high mobile (due to water currents) and has a short turnover time, which enables it to rapidly recover to its pre-impact status once an environment impact ceases. Furthermore, suspended sediment is a natural component of the marine environment, and the species present are therefore expected to be adapted to elevated concentrations. Thus plankton is assessed to be resilient to suspended sediment and the sensitivity is assessed to be low.

As discussed in section 9.4.1.1, modelling has shown that the maximum predicted concentration of suspended sediment is 62.3 mg/l which may occur in the immediate vicinity (200 m) of the proposed NSP2 route. However, the majority of suspended sediment will redeposit locally such that suspended concentrations above 2 mg/l will be limited to an area of approximately 139 km^2 associated with proposed post-lay trenching and rock placement locations (see section 8.4.1). The increase in suspended sediment concentration within the water column will also be temporary, as the suspended sediment concentration will decrease to below 2 mg/l within less than a day.

Furthermore, it is noted that where intervention works are planned on sections of the route which are beneath the halocline, the natural stratification will reduce the upwards transport of suspended sediments. Therefore, any increases in the concentration of suspended sediment will be contained within the lower section of the water column where phytoplankton are not present.

There is a potential for smothering of plankton, as increased concentrations of suspended sediment within the sediment plume may e.g. inhibit filter-feeding zooplankton. Most studies regarding invertebrates and suspended sediment have involved organisms of the order *Cladocera.* Cladocerans are filter-feeders, and particles of sediment that are ingested may subsequently become lodged in the gut tract /325/. Cladocerans are nonselective filter-feeders and are expected to be more sensitive than selective feeders (e.g. the order rotifer) with regard to suspended sediment.

High levels of suspended sediment (>50 mg/l) have been shown to cause significant damage to a zooplankton community in the form of decreased growth and reproduction /325/. As discussed above, such levels of suspended sediments will only be confined to the close proximity of the pipeline where post-lay trenching takes place.

In summary, the impact on plankton from increased suspended sediment in the water column is assessed to be local, temporary, of low intensity. The impact magnitude is therefore assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the impact on plankton from release of sediment to the water column is assessed to be negligible.

9.6.1.2 Release of contaminants into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of contaminants currently associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide, as discussed in section 9.4.1.2. Discharges from vessels may also contribute to water pollution. Changes in the concentrations of contaminants within the water column have the potential to affect plankton survival, reproductive success and photosynthetic rate. Contaminants released into the water column may be assimilated by plankton and impact survival rates as well as enter the food chain. It is important to note that the release of contaminants into the water column does not constitute a net increase of contaminants into the marine environment, but rather a redistribution of the substances already present in the seabed.

Although plankton is an important receptor, it is highly mobile (due to water currents) and has a short turnover time, which enables it to rapidly recover to its pre-impact status once an environment impact ceases. Thus plankton is assessed to be resilient to contaminants in the water column and the sensitivity is assessed to be low.

Modelling has shown that the release of contaminants into the water column as a result of post-lay and rock placement activities are not expected to result in concentrations which exceed thresholds for EQS or PNEC (in areas with a SSC of 2 and 15 mg/l), see section 8.4.6. The exception is in relation to benzo[g,h,i]perylene and indenol[1,2,3-cd]pyrene, where concentrations in the water may be equal to or higher than threshold levels for GES for a duration of approximately 12 hours in a total area of 139 km^2 (section 9.4.1.2 and Table 8-22). However, the majority of the affected area would be within deep parts of the route (habitat type 1) and limited to the lower 10 m of the water column where plankton is not present. Furthermore, most of the released contaminants (metals and organic contaminants) will remain bound to the sediment particles, and will therefore not be bioavailable /110/. The majority of contaminants will re-deposit on the seabed (associated with the sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route.

Dissolved nutrients currently trapped within the sediment may be released into the water column as a result of intervention works and assimilated by phyto- and zooplankton. Based on calculations of contaminants and nutrients release performed during NSP2 (section 9.4.1.2), the amounts will be considerably below the annual inputs, such that they would not cause a measurable change in nutrient availability within the Baltic Sea ecosystem. Any localised increase in nutrients in the water column would last for up to a couple of days, as the released substances will dilute or be assimilated. It has previously been described how the structure of the phytoplankton community in an upwelling zone (a place where nutrient-rich water is circulated to the photic zone) changed due to upwelling but was re-established within five days after the relaxation of upwelling /327/. In this regard, nutrients released during NSP2 construction are likely to reach the photic zone only where intervention works are planned on sections of the route which are within or above the halocline, and therefore vertical mixing is not inhibited. On this basis, no discernible impact on plankton populations is anticipated.

As assessed in section 9.4.1.2, no impacts on water quality as a result of discharges from vessels are anticipated. For this reason it is concluded that discharges from vessels will not impact plankton communities.

In summary, impacts on plankton associated with the release of contaminants into the water column will be local, temporary, and of low intensity. Therefore, the impact magnitude is considered to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on plankton from release of contaminants into the water column is assessed to be negligible.

9.6.1.3 Release of chemical warfare agents (CWA) into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of CWA currently associated with the sediment, as discussed in section 9.4.1.3. CWA released into the water column has the potential to affect plankton survival as well as enter the food chain.

Although plankton is an important receptor, it is highly mobile (due to water currents) and has a short turnover time, which enables it to rapidly recover to its pre-impact status once an environment impact ceases. Thus plankton is assessed to be resilient to CWA in the water column and the sensitivity is assessed to be low.

As discussed in section 9.4.1.3, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed along the deeper sections of the NSP2 route (where most CWA is found); the impact has been assessed to be negligible, and below applicable PNEC thresholds (section 8.4.8). The CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipelines. Furthermore, it is noted that where intervention works are planned on sections of the route which are beneath the halocline, the natural stratification will reduce the upwards transport of CWA. Therefore, any increases in the concentration of CWA will be contained within the lower section of the water column where plankton are not abundant due to low oxygen levels.

In summary, impacts on plankton associated with the release of CWA into the water column will be local, temporary and of a low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on plankton from the release of CWA into the water column is assessed to be negligible.

9.6.2 Operational phase

In the following sections, potential impacts during the operational phase are assessed.

9.6.2.1 Release of metals from anodes

As described in section 7.3.6 and 9.4.2.2, sacrificial anodes of aluminium alloy will be used in Danish waters to protect the pipelines from corrosion and will result in the release of metal ions (Al, Zn, Cd) into the water column. Release of Al from the anodes will not cause ecotoxicological impacts, however, Cd and Zn in the water column may be assimilated by plankton and impact survival rates as well as enter the food chain.

Although plankton is an important receptor, it is highly mobile (due to water currents) and has a short turnover time, which enables it to rapidly recover to its pre-impact status once an environment impact ceases. Thus plankton is assessed to be resilient to release of metals into the water column and the sensitivity is assessed to be low.

As discussed in sections 8.4.7 and 9.4.2.2, the release of Al, Zn and Cd ions from the aluminium anodes will have a negligible impact on water quality. Elevated levels of anode metals in the water column (above PNEC values) are expected only in the very vicinity of the anodes (few metres), therefore only zooplankton will be exposed (given that phytoplankton are present only within the top 20 m of the water column). More generally, the total amounts released from the anodes over the lifetime of the project are insignificant compared with the existing levels of water-borne inflow of metals to the area and no discernible impacts on plankton populations are expected.

Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity which may have a combined impact on the concentration of metals in the water column. However, these elevated concentrations of metals will be confined to a highly localised area (a few metres) around the crossing. Although some individuals may be impacted, the concentration levels are not expected to be elevated to such a level which would cause a discernable impact on plankton populations.

In summary, the impact on plankton associated with release of metals from anodes will be local, long-term and of a low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on plankton from the release of metals from anodes is assessed to be negligible.

9.6.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 9-14. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-14 Assessment of the overall impact during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Release of sediments into the water column	Low	Negligible	Negligible	Yes
Release of contaminants into the water column	Low	Negligible	Negligible	Yes
Release of chemical warfare agents (CWA) from the seabed	Low	Negligible	Negligible	Yes
Operational phase				
Release of metals from anodes	Low	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-14) the potential impacts on plankton during the construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.7 Benthic flora and fauna

The sources of potential impacts on benthic fauna during the construction and operation phase are listed in Table 9-15.

Table 9-15 Sources of potential impacts on benthos related to the construction and operation of NSP2

Source of potential impacts	Construction phase	Operational phase
Physical disturbance on seabed	X	
Sedimentation on the seabed	X	
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Changes of habitat		X
Release of metals from anodes		X

Potential impacts on benthic flora and fauna are predominantly correlated with impacts on physical/chemical receptors discussed in sections 9.1 - 9.4. As no benthic flora is present in the Danish section of the NSP2 project (see section 7.8), this section focuses solely on benthic fauna.

9.7.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.7.1.1 Physical disturbance on seabed

Construction activities, mainly post-lay trenching and rock placement, will result in the physical disturbance of the seabed. This has the potential to impact benthic faunal survival. Benthic fauna will generally not be able to avoid physical disturbance by any form of evasive behavior, and the resilience towards physical disturbance is therefore considered to be low. However, the population is expected to recover over time after an environmental disturbance. Taking into account that benthic fauna is an important receptor, the sensitivity is considered to be medium.

A substantial part of the proposed NSP2 route will be placed at depths where bottom water has a low oxygen content, preventing higher life forms to establish on the seabed (habitat type 1, see section 7.8). However, physical disturbance associated with pipe-lay, post-lay trenching and/or rock placement in areas where oxygen levels allow higher life forms to exist (habitat type 2 and type 3, see section 7.8), may result in the mortality or temporary exposure of buried or bottom-dwelling organisms (infauna). The impact would be limited to the footprint of the physical disturbance, which covers a negligible area in comparison with the surrounding habitats which are physically uniform and support similar benthic communities. Thus, whilst individual benthic organisms may be directly affected (i.e. mortality), physical disturbance from construction activities will not impact benthic populations as a whole. Furthermore, the benthic species which are impacted are not threatened and are abundant throughout the Baltic Sea. No further impacts associated with physical disturbance on the benthic community will occur outside the immediate footprint.

In summary, the impact on benthic fauna associated with the physical disturbance of the seabed will be local, temporary and of low intensity. Therefore the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on benthic fauna from physical disturbance is assessed to be negligible.

9.7.1.2 Sedimentation on seabed

Sedimentation of suspended sediment resulting from intervention works and pipe-lay may affect sediment quality and/or deposit an additional sediment layer. The local benthic fauna can be buried by sediments and in a worst case scenario be killed. Species specific resilience will depend on their ability to dig up through the additional sediment layer, though benthic organisms present are likely to have a high tolerance to temporary increases in sedimentation shown by their ability to withstand natural sedimentation rates within the Baltic Sea. Although benthic fauna is considered an important receptor, the sensitivity towards sedimentation on seabed is assessed to be low.

Studies of benthic invertebrate tolerance for sedimentation have shown that rates about 1 mm/d, equivalent to a deposition of 1-2 kg sandy sediment per square metre per day (wet weight), may have a detrimental effect /331/. As described in section 8.4.1, a total area of 0.65 km^2 will experience >200 g/m^2 of deposited sediment due to post-lay trenching and rock placement /287/. For the sandy habitat type 2 and type 3 (where oxygen conditions allow benthic life forms), 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm which is within the range of natural sedimentation rate in the Bornholm Basin of 0.5-1.5 mm/year /318/. The impact is thus highly localised and of low intensity. The system, including the benthic fauna, will quickly revert to its natural state after the termination of the project activities.

In summary, the impact on benthic fauna associated with the sedimentation on seabed will be local, temporary and of low intensity. Therefore the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on benthic fauna from sedimentation on seabed is assessed to be negligible.

9.7.1.3 Release of sediments into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This has the potential to impact benthic fauna as sediment particles brought into suspension may have direct mechanical effects on suspension feeders by clogging their feeding or respiratory apparatuses.

Benthic fauna will generally not be able to avoid areas of increased suspended sediment by any form of evasive behavior. However, benthic organisms in Danish waters are likely to have developed a high tolerance to temporary increases in suspended sediment shown by their ability to withstand natural peaks in turbidity during storm events. The sensitivity towards physical disturbance is therefore considered to be low.

As discussed in section 8.4.1, maximum predicted concentration of suspended sediment from post-lay trenching is 62.3 mg/l which may occur in the immediate vicinity (200 m) of the proposed NSP2 route. However, the majority of suspended sediment will re-deposit locally such that suspended concentrations above 15 mg/l will be limited to an area of approximately 7.6 km^2 associated with proposed post-lay trenching and rock placement locations (see section 8.4.1). The maximum duration of such an exposure is estimated to be 5.5 hours. Given that negative effects on benthic communities are unlikely at SSC below 100 mg/l /329//330/, the impact is considered to be of low intensity.

In summary, the impact on benthic fauna associated with suspended sediments in the water column will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on benthic fauna from suspended sediment in the water column is assessed to be negligible.

9.7.1.4 Release of contaminants into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of contaminants currently associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide, as discussed in section 8.4.1.2. Contaminants have a high potential for bioaccumulation, and may be acutely toxic at elevated concentrations. Benthic fauna will generally not avoid exposure by any form of evasive behavior, and the resilience towards contaminants is therefore considered to be low. However, the population is expected to recover over time after an environmental disturbance. Taking into consideration that benthic fauna is considered an important receptor, the sensitivity is considered to be medium.

Modelling has shown that the release of contaminants into the water column as a result of post-lay trenching and rock placement activities are not expected to result in concentrations which exceed relevant thresholds (EQS or PNEC in areas with a SSC of 2 and 15 mg/l), see section 8.4.6. The exception is in relation to benzo[g,h,i]perylene and indenol[1,2,3-cd]pyrene, where concentrations in the water may be equal to or higher than threshold levels for GES for a duration of approximately 12 hours in a total area of 139 km^2 (section 9.4.1.2 and Table 8-22). However, given that there are no, or only slightly elevated, contamination levels of heavy metals or organic contaminants in the surface sediments within habitat types 2 and 3, the majority of the affected area would be within deep parts of the route (habitat 1) where benthic life is scarce or absent due to low oxygen concentrations. Hence, it is considered unlikely that activities during the construction phase will directly expose benthic organisms to contaminants of critical levels which would cause increased mortality or reduced growth rates. Based on the above, as well as the conclusions of section 9.6.1.2, no added bioaccumulation of contaminants in suspension feeders is foreseen.

Moreover, it is noted that most of the released contaminants (metals and organic contaminants) will remain bound to the sediment particles, and will therefore not be bioavailable /110/. The majority of contaminants will re-deposit on the seabed (associated with the sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route.

In summary, the impact on benthic fauna associated with release of contaminants into the water column will be local, temporary and of low intensity. Therefore the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on benthic fauna from the release of contaminants into the water column is assessed to be negligible.

9.7.1.5 Release of chemical warfare agents (CWA) to the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of CWA currently associated with the sediment, as discussed in section 8.4.1.3. The release of CWA into the water column has the potential to exert toxic effect on the biological environment, including benthic fauna. Benthic fauna will generally not avoid exposure to CWA by any form of evasive behaviour, and the resilience is therefore considered to be low. However, the population is expected to recover over time after an environmental disturbance. Taking into consideration that benthic fauna is considered an important receptor, the sensitivity is considered to be medium.

CWA will settle within a few kilometres of the areas where intervention works are carried out (section 8.4.1), and the impact may thus be considered temporal and local. Furthermore, as discussed in section 9.4.1.3, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed along the deeper sections of the NSP2 route (where most CWA is found); the impact has been assessed to be negligible, and below applicable PNEC thresholds (section 8.4.8). The deeper sections of the route (defined as habitat type 1) is characterised by low oxygen levels which result in benthic life being scarce or absent. Hence, it is considered unlikely that activities during the construction phase will directly expose benthic organisms to CWA concentrations of critical levels which would cause increased mortality or reduced growth rates. The intensity of the impact is therefore considered low.

In summary, the impact on benthic fauna associated with the release of CWA from the seabed will be local, temporary and of low intensity. Therefore the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on benthic fauna from the release of CWA into the water column is assessed to be negligible.

9.7.2 Operational phase

In the following, potential impacts from change of habitat and releases from anodes are assessed for the operational phase.

9.7.2.1 Change of habitat

In the area where the pipelines will be placed directly on top of the seabed, the pipelines will appear as solid structures emerging from a quite homogenous looking seabed consisting of sand or mud. This can potentially create a new hard-bottom substrate (a reef effect from pipelines and rocks), where benthic fauna can settle and cause secondary impacts on surrounding benthos. However, none of the species present are endangered or vulnerable, and they can thus be expected to be abundant in the surrounding area. Taking into consideration that benthic fauna is an important receptor, the sensitivity is assessed to be low.

The appearance of a solid construction emerging from the seabed in a vast soft bottom area mainly consisting of mud and sand may attract sessile organisms that are otherwise uncommon in the region. This is a general observation obtained in studies of artificial marine installations /336//337/, including NSP /338/. The colonisation success (the settlement of epiphytes and larvae) will depend on the water depth and the available light and oxygen. A substantial part of the proposed NSP2 route will be placed at depths with a predominant occurrence of hypoxia, preventing higher life forms to establish. Therefore, from a biological point of view, the change of habitat caused by the presence of pipelines and supporting structures is only interesting in the shallow southern half of the route occupied by habitat 2 and 3 (section 7.8).

The colonisation of benthic fauna (when the light conditions allow) will attract other organisms such as mobile crustaceans and gastropods looking for food and/or shelter /339/. Apart from providing a substrate for colonisation and/or attracting other benthic fauna, the pipelines may impact the surrounding natural environments by modifying the pre-existing ecosystem. The benthic communities inhabiting the adjacent soft bottom may be impacted by increased oxygen consumption (as a function of the accumulation of detritus and its decomposition along the pipelines), or by predation by reef-associated organisms. Notwithstanding this, the impact of the NSP2 construction on the ecological conditions in the region must not be overestimated. Its contribution to the overall productivity in the region is very limited and will therefore have limited impacts on the overall abundance of marine life. This is because the pipelines only occupy a negligible part of the total productive volume dominating the region which sustains the ecosystem in this part of the Baltic Sea. Impacts on the food chain (including predation and competition) are assessed in section 9.8 and 9.13.

As discussed in sections 9.1 - 9.4, the significances of most potential impact on the basic ecological settings and/or on the quality elements defining the living conditions prevailing in the area have been assessed to be negligible. The impacts related to release of suspended sediments and contaminants to the water column were assessed to have a minor significance for the water quality (see section 9.4). On this basis, no discernible change in the prevailing habitat conditions is expected.

In summary, the impact on benthic fauna associated with the change of habitat will be local, long-term, and of low intensity. The impact magnitude is assessed to be low.

Based on the low magnitude and the low sensitivity, the overall impact on the benthic environment from change of habitat is assessed to be minor.

9.7.2.2 Release of metals from anodes

Release of Al from the anodes will not cause ecotoxicological impacts, Cd and Zn adhering to suspended particles may be taken up by filter- and bottom feeders and thus enter the food chain. Both metals have a high potential for bioaccumulation, and may be acutely toxic at elevated concentrations. Benthic fauna will generally not avoid exposure by any form of evasive behavior, and the resilience towards metals released from the anodes is therefore considered to be low. However, the population is expected to recover over time after an environmental disturbance. Taking into consideration that benthic fauna is considered an important receptor, the sensitivity is considered to be medium.

The release of Al, Zn and Cd ions from the aluminium anodes was described in section 8.4.7, and the impact on water quality was assessed to be negligible (section 9.4.2.2). The amounts of metals released from the anodes are insignificant compared with the existing levels of water-borne inflow of metals to the area, despite release will take place for the lifetime of the project. Elevated levels of anode metals (above PNEC values) in the water column are expected only within a few metres of the anodes. Impacts on benthos would only occur in the immediate vicinity of anodes in sections of the proposed NSP2 route that are within habitat types 2 and 3 (section 7.8). Therefore the intensity is low and no discernible impacts on benthic populations, either directly or by bioaccumulation, are expected.

Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity. However, elevated concentrations of metals will be localized to the area around the crossing. Although some individuals may be impacted, the concentration levels are not expected to be elevated to such a level which would cause a discernable impact on benthic communities.

In summary, the impact on benthos associated with release of metals from anodes will be long-term, local, and of a low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on benthic fauna from the release of metals from anodes is assessed to be negligible.

9.7.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 8-16. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-16 Assessment of the overall impact during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance on seabed	Medium	Negligible	Negligible	No
Sedimentation on the seabed	Low	Negligible	Negligible	No
Release of sediment into the water column	Low	Negligible	Negligible	Yes
Release of contaminants into the water column	Medium	Negligible	Negligible	Yes
Release of chemical warfare agents (CWA) from the seabed	Medium	Negligible	Negligible	Yes
Operational Phase				
Changes of habitat	Low	Low	Minor	No
Release of metals from anodes	Medium	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-16) the potential impacts on the benthic environment during the construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.8 Fish

The sources of potential impacts on fish during the construction and operation are listed in Table 9-17.

Table 9-17 Sources of potential impacts on fish during construction and operation of NSP2

Source of potential impact	Construction phase	Operational phase
Physical disturbance on seabed	X	
Sedimentation on the seabed	X	
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Generation of underwater noise	X	
Changes of habitat		X
Release of metals from anodes		X

Potential impacts on fish are predominantly correlated with impacts on physical/chemical receptors discussed in sections 9.1 - 9.4.

In this assessment, particular consideration has been given to the section of the proposed NSP2 route that goes through areas used as feeding and spawning ground for different fish. This comprises spawning areas/nursery areas of cod, sprat and flounder and feeding areas of herring and salmon (see Figure 9-1). In addition, consideration is given to species on the HELCOM Red List of Endangered Species and Annex II of the Habitats Directive as applicable (section 7.9.4).

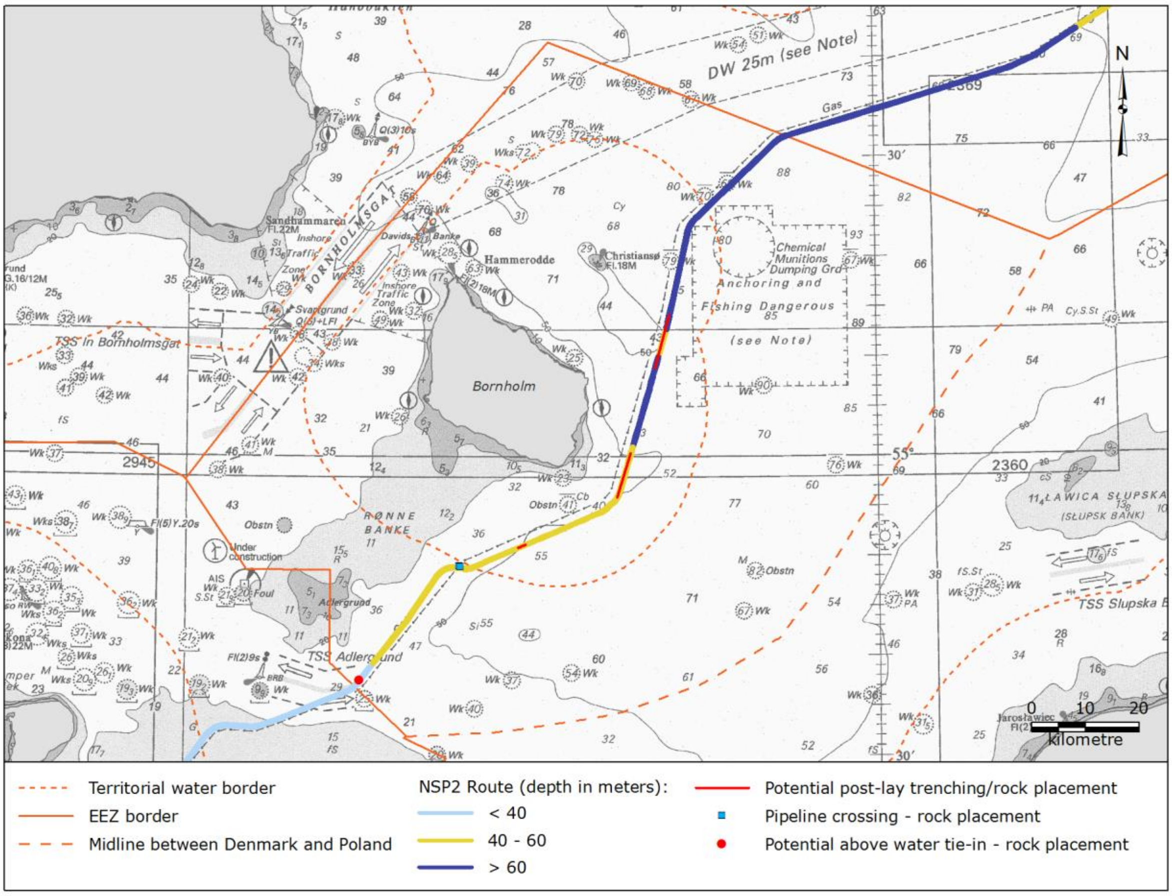

Figure 9-1. The seabed intervention of the pipelines in the Danish sector, showing where the pipelines will be placed on the seabed and where it will be trenched (red lines). The route is coloured according to the three depth intervals it will cross, reflecting habitat 3, 2 and 1, respectively.

9.8.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.8.1.1 Physical disturbance on seabed

Construction activities, mainly post-lay trenching and rock placement, will result in the physical disturbance of the seabed. This has the potential to impact fish species which are demersal or rely upon the seabed for spawning. No impacts are anticipated on fish species that spawns in the water column.

A number of demersal fish species and/or bottom spawners were identified as important, either due to their conservation status or importance for commercial and/or recreational fishery (section 7.9.3 and 7.9.4). Whereas adult demersal fish species are resilient to potential impact because of their mobility which allows escape behaviour, demersal eggs and larvae have a lower resilience due to their inability to escape. Therefore, sensitivity of demersal fish towards physical disturbance of the seabed is considered to be medium.

A part of the proposed NSP2 route in Danish waters is below the halocline (habitat 1), where conditions at the seabed are not suitable to support demersal fish, eggs or larvae. Impacts on demersal fish from physical disturbance will therefore be limited to the remainder of the route which has ambient physical and chemical conditions which allow higher life forms at the seabed (habitat 2 and 3). Impacts to demersal fish would be limited to the footprint of the physical disturbance, which occupies a negligible area compared to the surrounding habitats which are physically uniform and support similar fish communities. Thus, whilst some individuals may exhibit avoidance behavior and/or demersal larvae or eggs (i.e. turbot and herring) may be killed, physical disturbance from construction activities will not impact fish populations as a whole and the system will naturally revert to its pre-impact state within a short time span, possibly even within the same spawning season. Furthermore, no lasting effects on the ecological conditions prevailing in the region are expected.

In summary, the impact on demersal fish associated with disturbance of the seabed will be local, temporary and of low intensity. Therefore the magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity of the receptor, the overall impact on fish from physical disturbance of the seabed is assessed to be negligible.

9.8.1.2 Sedimentation on the seabed

Sedimentation of suspended sediment resulting from intervention works and pipe-lay may affect sediment quality and/or deposit an additional sediment layer. This has the potential to bury fish species which are demersal or rely upon the seabed for spawning. No impacts on pelagic fish species or spawners from sedimentation are anticipated.

Whereas demersal fish species are resilient to the impact caused by sedimentation because their mobility allows escape behaviour, demersal eggs and larvae have a lower resilience due to their inability to escape. Thus, eggs and larvae of bottom-spawning species, including the important herring and turbot, may be impacted by a rapid pulse of sediment deposition (smothering). Additionally, increased sedimentation may bury benthic fauna thus limiting fish food sources. Taking into consideration the presence of several important bottom spawning fish species along the proposed NSP2 route, the sensitivity of demersal fish to sedimentation on the seabed is assessed to be medium.

As described in section 8.4.1 a total area of 0.65 km^2 will experience >200 g/m^2 of deposited sediment due to post-lay trenching and rock placement /287/. This corresponds to a fine sand sediment layer of less than 1 mm which is within the range of natural sedimentation rate in the Bornholm Basin of 0.5-1.5 mm/year /318/. It is assessed that such degree of sedimentation will not impact demersal fish and no smothering of fish eggs and larvae is envisaged. The system will quickly revert to its natural state after the termination of the project activities.

As assessed in 9.7.1.2, no impacts on local benthic fauna due sedimentation are envisaged. Therefore, fish populations will not be impacted by the reduction in food sources.

In summary, the impact on fish associated with sedimentation will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity of the receptor, the overall impact on fish from sedimentation on seabed is assessed to be negligible.

9.8.1.3 Release of sediments into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediments into the water column. This has the potential to impact adult fish (both pelagic and demersal) by causing avoidance behaviour and injury/mortality, as well as reduce viability of larvae or eggs. Resilience of fish towards suspended sediments varies between species and development stage. Pelagic fish are less resilient to suspended sediment than demersal fish /343/, and they will probably avoid suspended material to a greater extent /344/. This may be because the gills of pelagic fish are more exposed to irritation and injury on account of the faster swimming speed and larger gill area. Furthermore, fish eggs and fish fry are less resilient than juvenile and adult fish species /298//299//300/. Taking into consideration the importance of several fish species and the presence of important areas (e.g. cod spawning area), the sensitivity of fish to sediments in the water column is assessed to be high.

As discussed in section 8.4.1 maximum predicted concentration of suspended sediment from post-lay trenching is confined to the immediate vicinity of the proposed NSP2 route and will be less than 62.3 mg/l at the distance more than 200 m from the pipelines. However, the majority of suspended sediment will re-deposit locally such that suspended concentrations exceeding 15 mg/l will be limited to a total area of 7.6 km^2 for maximum duration of 5.5 hours associated with proposed post-lay trenching and rock placement locations (see section 8.4.1). Suspended sediment concentrations of >2 mg/l will be limited to a total area of 139 km^2 for up to 12 hours (for post-lay trenching) and less than 1 km^2 for up to 19.5 hours (for rock placement). Furthermore, it is noted that suspended sediments will be limited to the lower 10 m of the water column and the impact from suspended sediments will be reversible because the system will revert to its natural state as the sediment settles back on the seabed within a short timespan. The impacts from release of sediments are therefore both temporal and local.

Laboratory and field investigations have shown that herring and smelt begin to flee areas with fine-grained suspended sediment when the concentration reaches approximately 10 mg/l and 20 mg/l, respectively /341/. Therefore, some individuals may exhibit avoidance reactions within the lower 10 m of the water column. However, this is not considered to impact fish populations as a whole.

Coarse suspended sediments may lead to skin injuries and fine sediments may clog gills and cause suffocation. Generally, high concentrations of suspended material are required in the water column in order to harm adult fish. In respect to demersal flatfish (e.g. plaice), which are especially resilient suspended sediment, concentrations of 3,000 mg/l showed no increased lethality during a 14-day period /345/. Based on the modelling results, suspended sediments caused by intervention works will therefore not lead to fish injury and subsequent mortality.

Suspended sediments may result in reduced egg respiration, affected embryonic development, or cause eggs to sink to depths where there is a risk of oxygen depletion /340//342/. Laboratory studies in which fish eggs and fish larvae were exposed to different concentrations of suspended fine-grained sediment showed no effects below 100 mg/l /301/. One study concluded that cod eggs exposed to 5 mg/l of suspended sediment was still able to float but started to sink after 96 hours in stagnant water /303/. In turbulent water however this effect has been shown to be significantly decreased /304/.

Several fish species including the commercially important cod and sprat are spawning in the water column within Danish waters, and an area northeast of Bornholm is recognised as a main spawning ground of cod. The NSP2 route crosses this area for approximately 21 km, at a water depth of 85-90 m (see Figure 9-1). Only pipe-lay is expected in this area and no intervention works are envisaged. Laying the pipelines directly on the seabed will only cause an insignificant increase of suspended concentration, which will be limited to the lower 10 m of the water column. Therefore, suspended sediments will not come in to contact with the water mass where cod spawning may take place, i.e. the reproductive layer /177/, which in the Bornholm Deep is confined to 40-60 m depths. In addition, the area that will be directly affected by pipe-lay (assuming anchor-handling) will be less than 0.05% of the cod spawning area in the Danish sector. Using a DP vessel for pipe-laying will have an even lesser impact on sediment resuspension. Based on the above, it is assessed that cod reproduction in the spawning area will not be impacted by NSP2. Similar arguments apply to the other species spawning in the area (i.e. sprat which spawns at a depth of approximately 45-55 m).

In summary, the impacts on fish associated with release of sediments to the water column will be temporary, local and of medium intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the high sensitivity of the receptor, the overall impact on fish from the release of sediment into the water column is assessed to be negligible.

9.8.1.4 Release of contaminants into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of contaminants currently associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide, as discussed in section 9.4.1.2. As assessed in section 9.4.1.2, no impacts on water quality as a result of discharges from vessels are anticipated. For this reason it is concluded that discharges from vessels will not impact fish communities.

Release of contaminants to the water column have the potential to impact both pelagic and demersal fish at all development stages causing toxic effects through direct exposure or bioaccumulation. Salmonid species, such as Atlantic salmon (protected by the EU Habitat Directive Annex II) and sea trout (vulnerable species under HELCOM Red List) are particularly susceptible. Given their high mobility, fish are not likely to spend long periods of time in the affected areas. However, they are susceptible to bioaccumulation of contaminants through the food chain. Taking into consideration the importance of fish, the sensitivity of fish towards contaminants released into the water is judged to be medium.

Modelling has shown that the release of contaminants into the water column as a result of post-lay trenching and rock placement activities are not expected to result in concentrations which exceed relevant thresholds (EQS or PNEC in areas with a SSC of 2 and 15 mg/l), see section 8.4.6. The exception is in relation to benzo[g,h,i]perylene and indenol[1,2,3-cd]pyrene, where concentrations in the water may be equal to or higher than threshold levels for GES for a duration of approximately 12 hours in a total area of 139 km^2 (section 9.4.1.2 and Table 8-22). However, the majority of the affected area would be within deep parts of the route (habitat 1) and limited to the lower 10 m of the water column where fish, fish prey (plankton and benthos), and fish eggs/larvae are not present. Furthermore, most of the released contaminants (metals and organic contaminants) will remain bound to the sediment particles, and will therefore not be bioavailable /110/. The majority of contaminants will re-deposit on the seabed (associated with the sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route. Therefore no acute toxic effect on fish is expected.

In deeper areas east of Bornholm, including the major cod spawning area, there is an increased content of organic and inorganic contaminants in the sediment. However, given that suspended sediment will impact primarily the bottom 10 m of the water column, impacts will be limited to the deep, oxygen-depleted bottom water where fish, fish prey (plankton and benthos), and fish eggs/larvae are not present. Similar arguments apply to the other spawning areas and as such, it is assessed that spawning areas will not be impacted by release of contaminants to the water column caused by NSP2.

The major source of contaminants in fish is related to their biota and not their immediate physical surroundings. For bottom-dwelling fish this goes primarily on their infaunal prey living in more close physical contact with the contaminants. As discussed in sections 9.6 and 9.7 no significant impacts on plankton and benthos are anticipated to occur as a result of NSP2. Therefore, it is assessed that no significant bioaccumulation of contaminants in fish through the food chain will occur.

In summary, the impacts on fish associated with release of contaminants to the water column will be temporary, local and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity of the receptor, the overall impact on fish from the release of contaminants into the water column is assessed to be negligible.

9.8.1.5 Release of chemical warfare agents (CWA) into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of CWA to the water column as discussed in section 8.4.1.3. This may impact both pelagic and demersal fish at all development stages causing toxic effects through direct exposure or bioaccumulation. Given their high mobility, fish are not likely to spend long periods of times in the affected areas. However, they are susceptible to bioaccumulation of contaminants through the food chain. Taking into consideration the importance of fish, the sensitivity of fish towards CWA released into the water is judged to be medium.

As discussed in section 8.4.1.3, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed, and even here, the concentration will be far below applicable PNEC thresholds, and the impact on water quality is assessed to be negligible (section 7.3.8.2). The CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipelines. Furthermore, it is noted that where intervention works are planned on sections of the route which are beneath the halocline, the natural stratification will reduce the upwards transport of CWA. Therefore, any increases in the concentration of CWA will be contained within the lower section of the water column. On this basis, no toxic effects on fish are expected.

As discussed in Section 9.6 and 9.7 negligible impacts on plankton and benthos as a result of CWA release are anticipated to occur as a result of NSP2. Taking into considering their roles within the food chain, it is assessed that no significant bioaccumulation of CWA in fish will occur.

In summary, the impact on fish associated with release of CWA to the water column will be temporary, local and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity of the receptor, the overall impact on fish from the release of CWA into the water column is assessed to be negligible.

9.8.1.6 Generation of underwater noise

Construction activities, mainly rock placement, and pipe-lay vessels will generate underwater noise. Fish can detect and utilize sounds and therefore may be susceptible to changing regime of noise. Underwater noise has a potential to cause in fish flight/avoidance reactions, injury to sensory organs and in the worst case cause mortality. Given their high mobility, fish are not likely to spend long periods of time in the affected areas. Eggs and larvae have a low resilience due to their inability to escape. Taking into consideration the importance of fish and presence of important areas (e.g. cod spawning area), the sensitivity of fish to underwater noiseis assessed to be medium.

Fish behaviour in response to noise is only poorly understood. Physical damage to the hearing apparatuses of fish do not normally imply permanent changes in the detection threshold (permanent threshold shift, PTS), as the damaged sensory epithelium will usually regenerate in time /346//347/. Temporary hearing loss (temporary threshold shift, TTS), on the other hand, may occur /348/. The temporary effect of noise is complicated to evaluate because it not only depends on the sound intensity but also the frequency, the duration of exposure and the length of the recovery time.

Diversity in hearing structures among fish results in very diverse hearing capabilities from species to species. Different species have hearing ranges from about 30 Hz to 4 kHz. Noises from shipping, seismic airguns, post-lay trenching by ploughing and pile-driving exhibit major energy below 1,000 Hz and are thus within the frequency range of hearing of most fish species. However, the perception of sound pressure is restricted to those fish species with air-filled swim bladders that respond to sound-pressure fluctuations /334//350/.

Little information is available on the hearing abilities of species of relevance for the area around Bornholm. Atlantic salmon have a swim bladder, but it is not believed to play a substantial part in its hearing. Salmon respond only to low-frequency tones (below 380 Hz), with best hearing at 160 Hz. The hearing of salmon is poor, with narrow frequency span, poor power to discriminate signals from noise and low overall sensitivity. This is in contrast to Atlantic cod and Atlantic herring, which therefore serve as more appropriate models to assess the impact of noise /331/. The criteria of these two species for PTS and TTS are presented in /301/.

Atlantic cod has a gas-filled swim bladder and is probably more sensitive to sound than Atlantic salmon. Experiments with 20 specimens in a tank found the best hearing sensitivity at 150 Hz and 160 Hz. Cod are capable of distinguishing between spatially separated sound sources and also between sources at different distances. For cod, both particle motion and sound pressure are important stimuli, especially for determining sound direction.

Atlantic herring has a swim bladder and inner ear connection, which explains its special hearing capabilities. Atlantic herring hear an extended range of frequencies between 30 Hz and 4 kHz. For NSP2, noise from the lay vessel and supporting vessels will probably lead to avoidance reactions among herring.

A study of spawning herring was carried out in Norway to investigate the effects of repeated passage of a research vessel at a distance of 7-8 km in 30-40 m water depth. At a peak value noise source level of around 145 dB re 1uPa 1Hz within the range 5-500 Hz, there was no detectable reaction amongst the spawning herring /353/.

In order to evaluate possibility of NSP2 construction activities to cause impact on fish an underwater noise propagation modelling has been carried out. Modelling has been performed at two locations in the Danish waters (RP1 and RP3) where rock placement may be performed (considered the noisiest activities arising from the project activities in Danish waters, see section 8.4.3). Threshold values for inflicting impact (mortal injury, injury, and TTS) have been determined based on an assessment on available values from the most recent scientific literature /335/.

Table 9-18 summarises the acoustic modelling results in terms of the maximum (in all directions) distances from the rock placement activity to the applicable assessment underwater noise threshold levels. As modelling results show, no permanent damage (PTS) to the sensory organs or mortality will occur.

Table 9-18 Assessment level limit distances at two positions where modelling has been undertaken in Denmark /335/

Receptor	Impact	Thresholds	RP1 - threshold distances (summer/winter)	RP3 - threshold distances (summer/winter)
		SEL(Cum*) dB re 1µPa2-s	SEL(Cum*) dB re 1µPa2-s	SEL(Cum*) dB re 1µPa2-s
Fish	Mortality (mortal injury)	207 dB	0 m	0 m
	Injury	203 dB	0 m	0
	TTS	186 dB	100 m	100 m
Eggs and larvae	Injury	210 dB	0 m	0 m
* Cumulative SEL (2 hour rock placement)				

In general, noise avoidance among fish is stimulated typically at levels above 180 dB re 1µPa. Difficulties in investigating responsiveness to noise in fish have consequences for deriving appropriate threshold values for behavioural reactions. For example, it has been proposed that fish show avoidance reactions to vessels when the radiated noise levels exceed their threshold of hearing by 30 dB re 1µPa or more. The range of reaction varies from 100-200 m for many typical vessels but is as high as 400 m for relative noisy vessels. Other factors, both physical and physiological, play a part in determining the noise level that will trigger an avoidance response from fish /354/.

Based on the modelling results and information available from the literature the conclusion is that avoidance reactions among almost all fish species will occur in close proximity to the areas of NSP2 constriction but the fish population will return within a short time after the cessation of activities.

Very few investigations on the responses of eggs and larvae to man-made sounds have been performed. But it appears that the hearing frequency range of fish larvae is similar to that of adults. Five-day-old cod larvae subjected to 250 dB suffered delaminating of the retina, while cod larvae of 2-110 days suffered no apparent injuries after exposure to 230 dB /351//352/. Since no rock placement is planned in the areas important for fish reproduction (e.g. cod and sprat spawning areas), it is assessed that fish reproduction will not be impacted by NSP2.

In summary, the impact on fish associated with underwater noise will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity of the receptor, the overall impact on fish from underwater noise is assessed to be negligible.

9.8.2 Operational phase

In the following, potential impacts on fish are assessed for the operational phase.

9.8.2.1 Changes of habitat

In the area where the pipelines will be placed directly on top of the seabed, the pipelines will appear as a solid structure emerging from a quite homogenous looking seabed consisting of sand or mud. This can potentially create a new hard-bottom substrate (a reef effect from pipelines and rocks), and introduces the possibility of increased benthic diversity and consequently fish diversity and abundance. The mobility of fish makes them highly resilient to local changes in habitats. Therefore, despite the importance of fish, the sensitivity of fish to changes of habitat is assessed to be low.

The appearance of a solid construction emerging from the seabed in a vast soft-bottom area mainly consisting of mud and sand will attract sessile organisms that otherwise are rare in the region. This is a general observation contained in studies of artificial marine installations /336//337/. Video inspections of the NSP pipelines confirm this observation /338/. The colonisation of epifauna (and epiphytes when the light conditions allow) will attract other organism such as mobile crustaceans and fish looking for food and/or shelter /339/. Therefore, the pipelines will act as an artificial reef and have a potential to increase the local biodiversity.

However, a substantial part of the proposed NSP2 route will be placed at depths with a predominant occurrence of hypoxia, preventing higher life forms to establish. Even in the areas where higher life forms can exist, its contribution to the overall productivity in the region is very limited and will therefore have low impacts on the overall abundance of marine life. This is because the pipelines only occupy a negligible part of the total productive volume dominating the region and which sustains the ecosystem in this part of the Baltic Sea. The local changes in the environment are not considered reversible, unless the pipelines become fully submerged in the seabed.

In summary, the impact on fish associated with changes of habitat will be local, long-term and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the low sensitivity of the receptor, the overall impact on fish communities from changes of habitat will be negligible.

9.8.2.2 Release of metals from anodes

Release of Al from the anodes will not cause ecotoxicological impacts, however fish are susceptible to Zn and Cd in the water and food-chain, and adult fish may experience acute toxicity or sub-lethal effects. Salmonid species, such as the important Atlantic salmon and sea trout are particularly susceptible. Given their high mobility fish are not likely to spend long periods of times in the affected areas, but they may be susceptible to bioaccumulation through the food chain. Given the presence of important fish species in the project area and the low resilience of fish towards Zn and Cd in the water, the sensitivity of fish towards metals from anodes released into the water is judged to be medium.

The release of Al, Zn and Cd ions from the aluminium anodes was described in section 8.4.7, and the impact on water quality was assessed to be negligible (section 9.4.2.2). Elevated levels of anode metals in the water column (above PNEC values) are expected only in the very vicinity of the anodes (few metres). The amounts released from the anodes are insignificant compared with the existing levels of water-borne inflow of metals to the area although the release will take place for the lifetime of the project. Therefore the intensity is low and no discernible impacts on fish, either directly or by bioaccumulation, are expected.

Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity. However, elevated concentrations of metals will be localized to the area around the crossing, and it is assessed that the combined impact from the two pipelines will be negligible.

In summary, the impact on fish will be long-term, local, and of a low intensity, and the impact magnitude is assessed to be negligible.

Based on the medium sensitivity and the negligible impact magnitude, the overall significance of the impact is assessed to be negligible.

9.8.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 9-19. Where potential transboundary impacts are identified, these are further assessed in section 14.

Given the highly localised nature of the impacts discussed above, no impacts are anticipated on species listed under Annex II of the EU Habitat Directive (see section 7.9.4).

Table 9-19 Assessment of the overall impact during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance on seabed	Medium	Negligible	Negligible	No
Sedimentation on the seabed	Medium	Negligible	Negligible	No
Release of sediment into the water column	High	Negligible	Negligible	Yes
Release of contaminants into the water column	Medium	Negligible	Negligible	Yes
Release of chemical warfare agents (CWA) from the seabed	Medium	Negligible	Negligible	Yes
Generation of underwater noise	Medium	Negligible	Negligible	Yes
Operational phase				
Changes of habitat	Low	Negligible	Negligible	No
Release of metals from anodes	Medium	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-19) the potential impacts on fish during the construction and operation of NSP2, either individually or in combination, are assessed to be negligible.

9.9 Marine mammals

The sources of potential impacts on marine mammals during construction and operation are listed in Table 9-20.

Table 9-20 Sources of potential impacts on marine mammals during construction and operation of NSP2

Source of potential impact	Construction phase	Operational phase
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Generation of underwater noise *	X	
Changes of habitat		X

* Any physical disturbance caused by NSP2 activities above water, e.g. visual presence of vessels, is considered marginal in relation to underwater noise from vessels, and is covered by the assessment for marine mammals related to underwater noise.

As described in section 7.10, the proposed NSP2 route is not in an area with regular occurrences of harbour seals. Therefore, this section focuses on the harbour porpoise and the grey seal (protected under Annex II and IV of the Habitats Directive).

9.9.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.9.1.1 Release of sediments into water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediments into the water column. Suspended sediment may have a direct impact on marine mammals by affecting their vision or causing injury to visual organs. Studies have shown that vision is not essential to seal or harbour porpoise survival, or to its ability to forage. Furthermore, marine mammals are mobile and therefore would be able to avoid areas of increased turbidity. Although marine mammals are considered an important receptor, their sensitivity is assessed to be low.

Modelling has been undertaken for sediment spill during construction of NSP2 (section 8.4.1), and impacts on water quality and turbidity were assessed to be minor. Studies have explored the effects of sediment plumes on seals and concluded that increased turbidity could affect their ability to hunt successfully; furthermore the existence of blind but well-nourished seals in the wild have been reported /363/. In addition, studies have explored the importance of vision for harbour porpoises. These have shown that harbour porpoise rely upon echolocation (rather than vision) for orientation in the environment as well as for prey localisation; as such they have been shown to hunt at night and move into depths of complete darkness with or without an accompanying calf /365//366/. Therefore, at the concentrations anticipated, suspended sediment in the water column are not expected to have a noticeable impact on marine mammal vision. Furthermore, modelled levels of suspended sediments are limited to the lowermost 10 m of the water column and are not likely to cause any further injuries to vital organs.

On this basis, the impact on marine mammals associated with the release of sediment into the water column will be local, temporary, and of low intensity. Therefore, the impact magnitude is assessed to be low.

Based on expert judgment, the overall impact on marine mammals from the release of sediment in the water column is assessed to be negligible[47].

9.9.1.2 Release of contaminants into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediments into the water column. Discharges from vessels may also contribute to water pollution. Over time, sediments accumulate toxins and pollutants such as hydrocarbons and heavy metals, as discussed in section 7.3.3. Disturbance of sediments can therefore release contaminants into the water column, which has the potential to reduce water quality. This has the potential to impact marine mammals either directly or through bioaccumulation, causing toxicity effects. Marine mammals make up the highest trophic levels and have large lipid stores, where organic contaminants and heavy metals can potentially be biomagnified, leading to an increased risk of toxicity. However, marine mammals are mobile and therefore would be able to avoid areas of increased turbidity (and thereby the areas where concentrations of contaminants will be the highest). Taking into consideration the importance of marine mammals, their sensitivity to contaminants in the water column is assessed to be medium.

Modelling has been undertaken for sediment spill during construction of NSP2 (section 8.4.1). Calculation of potential release of contaminants into the water column has shown that resulting concentrations are below PNEC thresholds (sections 8.4.6). Furthermore, most of the released contaminants (metals and organic contaminants) will remain bound to the sediment particles, and will therefore not be bioavailable /110/. The majority of contaminants will re-deposit on the seabed (associated with the sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route. Therefore no direct toxic effects on marine mammals are expected.

As assessed in section 9.4.1.2, no impacts on water quality as a result of discharges from vessels are anticipated. For this reason it is concluded that discharges from vessels will not impact marine mammals.

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[47] Assessment of the overall significance of a given impact is subject to expert judgement that deviates from the matrix presented in the section 8.3.

Released contaminants may also have an impact if the level is severe enough for the contaminants to magnify through the food chain and end in marine mammals that are top-predators. However, as discussed in sections 9.6, 9.7 and 9.8 no increased bioaccumulation is anticipated in plankton, benthos or fish as a result of NSP2. Therefore, it is assessed that no significant bioaccumulation impacts on marine mammals are expected.

On this basis, the impact on marine mammals associated with release of contaminants into the water column will be temporary, local, and of a low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the medium sensitivity and the negligible impact magnitude, the overall impact on marine mammals from the release of contaminants into the water column is assessed to be negligible.

9.9.1.3 Release of chemical warfare agents (CWA) into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of CWA currently associated with the sediment, as discussed in section 9.4.1.3. The release of CWA into the water column has the potential to impact fish causing toxic effects through direct exposure or bioaccumulation (at all development stages). For the same reasons as identified in section 9.9.1.2, the sensitivity of marine mammals to CWA in the water column is assessed to be medium.

The impact on the water quality from CWA released from the seabed during the construction phase is assessed to be negligible (section 9.4.1.3), and below applicable PNEC thresholds (section 8.4.8). The CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipelines. Furthermore, it is noted that where intervention works are planned on sections of the route which are beneath the halocline, the natural stratification will reduce the upwards transport of CWA. Therefore, any increases in the concentration of CWA will be contained within the lower section of the water column.

As discussed in sections 9.6 - 9.8, negligible impacts on plankton, benthos and fish communities as a result of CWA release are anticipated to occur as a result of NSP2. Taking into considering their roles within the food web, it is assessed that no significant bioaccumulation of CWA in marine mammals will occur.

On this basis, the impact on marine mammals associated with release of CWA into the water column will be temporary, local, and of a low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the medium sensitivity and the negligible impact magnitude, the overall impact on marine mammals from the release of contaminants into the water column is assessed to be negligible.

9.9.1.4 Generation of underwater noise

During the construction phase, underwater noise will occur as a result of rock placement, post-lay trenching, pipe-lay, anchor-handling and ship noise. Potential impacts on marine mammals from increased noise levels can occur through a number of processes, and three main issues comprise:

- Physical injury and hearing loss (including permanent threshold shift/temporary threshold shift);
- Disturbance of animal behaviour;
- Masking of other sounds.

It is widely accepted that the marine mammals have a high vulnerability to noise, with the auditory system being one of the most sensitive organs. Taking into account the importance of marine mammals, their overall sensitivity to the generation of underwater noise is assessed to be high.

Physical injury and hearing loss - permanent threshold shift and temporary threshold shift
For marine mammals it is generally accepted that the auditory system is the most sensitive organ with regard to acoustic injury, meaning that injury to the auditory system will occur at lower levels than injuries to other tissues /372/. Noise induced threshold shifts are temporary reductions in hearing sensitivity following exposure to loud noise (commonly experienced by humans as reduced hearing following rock concerts etc.). This temporary threshold shift (TTS) disappears with time, depending on the severity of the impact. Small amounts of TTS will disappear in a matter of minutes, extending to hours or even days for very large TTS.

At higher levels of noise exposure the hearing threshold does not recover fully, but leaves a smaller or larger amount of permanent threshold shift (PTS). This permanent threshold shift is a result of damage to the sensory cells in the inner ear. Two aspects of TTS and PTS are of central importance. The first aspect is the frequency spectrum of the noise causing TTS/PTS, which leads to the question of how to account for differences in spectra of different types of noise through frequency weighting. The second aspect is the cumulative nature of TTS/PTS. It is well known that the duration of exposures and the duty cycle (proportion of time during an exposure where the sound is on during intermittent exposures, such as pile driving) has a large influence on the amount of TTS/PTS induced, but no simple model is available that can predict this relationship.

In order to evaluate the output of the exposure model in terms of impact on animals, it is required to have thresholds for TTS and PTS. Based on existing scientific literature a set of threshold values have been set. The thresholds for inducing PTS or TTS are summarised in Table 9-21, and the rationale for the thresholds is described below. The sensitivity of marine mammals to hearing threshold shifts (TTS and PTS) is high, because of the comparatively low thresholds and hence high likelihood of inflicting TTS and PTS by exposure to high-intensity sounds and the permanent nature of PTS (by definition).

Table 9-21 Estimated thresholds for inducing TTS and PTS from continuous noise from rock placement. See text for justification and references to experiments underlying these thresholds.

Species	Rock placement	
	TTS	PTS
Harbour porpoise	188 dB SEL	203 dB SEL
Seals	188 dB SEL	200 dB SEL

For continuous noise, such as noise from rock placement, it is more appropriate to derive a TTS from the numerous studies using fatiguing noise of various durations /368//369//370/. These studies have been condensed into one threshold of 188 dB re. 1 $\mu Pa^2 s$ by /371/.

A threshold for inducing PTS in high-frequency cetaceans, including harbour porpoises, was proposed by /372/. However, this threshold was based solely on experimental data from mid-frequency cetaceans (bottlenose dolphins and beluga) and is no longer considered representative. Only one study is directly relevant to PTS and this was performed on a sister species to the harbour porpoise, the finless porpoise /373/. The study was able to induce very high levels of TTS (45 dB), likely close to the level required to induce PTS, by presenting octave band noise centred on 45 kHz at a received SEL of 183 dB re. 1 μPa^2 s. This signal was of much higher frequency than the main energy of rock placement noise, and it is thus questionable whether this result can be transferred to impulsive sounds or rock placement noise. In line with /372/, the PTS criterion was here instead extrapolated from TTS criterion by adding 15 dB, equal to 177 dB re. 1 $\mu Pa^2 s$ for explosions and 203 dB re. 1 $\mu Pa^2 s$ for rock placement noise.

A number of experiments have determined TTS in harbour seals for various types of noise of shorter and longer duration, summarised by /371/ and producing an average threshold estimate of 188 dB re. 1 μPa^2 s, which is considered the appropriate threshold for rock placement noise. The results from harbour seals should until actual data become available be considered valid for grey seals and ringed seals as well. A harbour seal was exposed to a 60 s tone at 4.1 kHz at a total SEL of 202 dB re. 1 μPa^2 s, which induced PTS /375/. A second experiment (in a different facility and on a different animal) produced a very strong TTS (44 dB) by exposure to 60 minutes of 4 kHz octave band noise at an SEL of 199 dB re. 1 μPa^2 s /376/. The level of TTS is considered to have been very close to inducing PTS. By combining the two experiments a threshold for PTS in harbour seals for continuous noise (rock placement) is set to 200 dB re. 1 $\mu Pa^2 s$.

A sound propagation model was run for rock placement with the NSP2 scenario and source levels, and environmental parameterisation (section 8.4.3). The criteria for PTS and TTS (as identified in Table 9-21) have been applied in the underwater noise modelling of rock placement.

Table 9-22 summarises the acoustic modelling results in terms of the maximum (in all directions) distances from the rock placement activity (considered the noisiest activities arising from the project activities in Danish waters) to the applicable assessment underwater noise threshold levels.

Table 9-22 Assessment thresholds distances at RP1 and RP3 position

Receptor	Impact Type	Thresholds	RP1 - threshold distances (summer/winter)	RP3 - threshold distances (summer/winter)
		SEL(Cum*) dB re 1μPa^2 s	SEL(Cum*) dB re 1μPa^2 s	SEL(Cum*) dB re 1μPa^2 s
Seals	PTS	200 dB	0 m	0 m
	TTS	188 dB	80 m	80 m
Harbour porpoise	PTS	203 dB	0 m	0 m
	TTS	188 dB	80 m	80 m
* Cumulative SEL (two-hour rock placement).				

As can be seen, there is no risk of PTS from NSP2 construction activities, while there is a risk of TTS very close (80 m) to specific location where rock placement is proposed.

The nearest seal haul-out site to the proposed NSP2 route is on Ertholmene, located 13 km to the west, though given the mobility of harbour porpoise and grey seals, the NPS2 route does cross areas of regular occurrence for both species (see Figure 7-30, Figure 7-31, and Figure 7-33). Notwithstanding this, individual marine mammals would need to be closer than 80m from the noise source for any potential of injury and no population level impacts are anticipated. This analysis shows that sound levels generated by the construction works are unlikely to cause mortality or injury to marine mammals.

Therefore, even with very precautionary assumptions regarding the impact of noise from rock placement the impact to marine mammals (relating to hearing loss or injury) will be local, temporary and of low intensity (PTS unlikely). Therefore, the impact magnitude is assessed to be low.

Based on expert judgement, the high sensitivity and the low impact magnitude in relation to hearing loss or injury, the overall impact on marine mammals in relation to underwater noise is assessed to be negligible.

Behavioural response and masking
Noise from rock placement was used as a proxy for construction-related noise from vessels in general, as the rock placement is considered the noisiest activities arising from the project activities in Danish waters. This is a highly precautionary approach.

Behavioural reactions to underwater noise from rock placement and other vessel-related activities around the pipelines are local and only occur while the vessels are present. It is anticipated that the marine mammals which may be present along the proposed NSP2 route will have developed a level of tolerance to noise from vessels due to the existing noise levels within the Baltic Sea (see sections 8.4.3.1). In this regard, disturbances are likely to be of a similar magnitude as the disturbance from passing merchant vessels.

In summary, the impact on marine mammals (relating to behavioural response) will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be low.

Masking is the phenomenon whereby noise can negatively affect the ability to detect and identify other sounds. The masking noise must be audible, roughly coincide with (within tens of metres), and have energy in roughly the same frequency band, as the masked sound. For sounds of longer duration, such as rock placement and ship noise the potential for masking of low frequency sounds is clearly present. However, the current level of knowledge about masking outside strictly experimental settings and the effects on short term and long term survival of marine mammals is limited. Therefore a full assessment of this topic is not considered possible. However, marine mammals may already have developed a tolerance to masking because of the widespread presence of vessel on the Baltic Sea. In this regard, disturbances are likely to be of a similar magnitude as the disturbance from passing merchant vessels.

Based on expert judgement, the high sensitivity and the low impact magnitude in relation to response and masking, the overall impact on marine mammals in relation to underwater noise is assessed to be minor.

9.9.2 Operational phase

In the following section, potential impacts during the operational phase are assessed.

9.9.2.1 Change of habitat

In the area where the pipelines will be placed directly on top of the seabed, the pipelines will appear as a solid structure emerging from a quite homogenous looking seabed consisting of sand or mud. This can potentially create a new hard-bottom substrate (a reef effect from pipelines and rocks), and introduces the possibility of increased benthic and consequently fish diversity and abundance thus increasing availability of food resources for marine mammals. The mobility of marine mammals makes them highly resilient to local changes in habitats. Although marine mammals are considered an important receptor, the overall sensitivity is judged to be low.

As assessed in sections 8.7 – 8.8 change of habitat due to presence of the pipelines will not contribute to changes in diversity and abundance of benthic and/or fish species and thus will not result in increase of food sources of marine mammals. Although the main prey of the Baltic marine mammals is fish, a substantial part of the proposed NSP2 route will be placed at depths with a predominant occurrence of hypoxia, preventing higher life forms to establish. Even those areas where higher life forms can exist, its contribution to the overall productivity in the region is very limited and will therefore have limited impacts on the overall abundance of marine life. This is because the pipelines only occupy a negligible part of the total productive volume dominating the region and which sustains the ecosystem in this part of the Baltic Sea.

On this basis, the impact on marine mammals associated with changes in habitat will be local, long-term, and of low intensity. Therefore the magnitude is assessed to be negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact on marine mammals in relation to change of ha is assessed to be negligible.

9.9.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 9-23. Where potential trans-boundary impacts are identified, these are further assessed in section 14.

Table 9-23 Assessment of the overall impact during construction and operation of NSP2

Sources of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Release of sediments into the water column*	Low	Low	Negligible	Yes
Release of contaminants into the water column	Medium	Negligible	Negligible	Yes
Release of chemical warfare agents (CWA) from the seabed	Medium	Negligible	Negligible	Yes
Generation of underwater noise*	High	Low	Negligible-Minor**	Yes
Operation phase				
Change of habitat	Low	Negligible	Negligible	No

* Assessment of the overall significance of a given impact is subject to expert judgement that deviates from the matrix presented in the section 8.3. Valid for impacts from release of suspended sediments in the water column, and generation of underwater noise and change of habitat.

** Impact on Marine mammals from underwater noise is assessed to be "Negligible" for PTS/TTS and "Minor" for behavioural response.

Based on the conclusions in the sections above (see Table 9-23) the potential impacts on marine mammals during the construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.9.4 Annex IV species

Harbour porpoise is included in Annex IV of the Habitat Directive and thus, this impact assessment has aimed to determine whether any of the pressures identified may lead to a violation of the objectives of Article 12 of the Habitats Directive, namely the deliberate capture or killing of specimens (including injury), the deliberate disturbance of marine mammals or deterioration of breeding sites. However, based on the findings summarised in Table 9-23, none of the planned impacts from NSP2 are assessed to contribute to a violation of the Annex IV conservation objectives in Denmark.

9.10 Birds

The sources of potential impacts on the birds during the construction are listed in Table 9-24. No impacts were identified for the operation phase.

Table 9-24 Sources of potential impacts on birds during the construction and operation of NSP2

Source of potential impact	Construction phase	Operational phase
Release of sediments into the water column	X	
Sedimentation on the seabed	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Physical disturbance above water	X	

In this assessment, particular consideration has been given to Important Bird and Biodiversity Areas (IBAs) DK079 Ertholmene and DK120 Rønne Banke. A separate assessment concerning birds designated for the Natura 2000 sites is presented in 9.12

9.10.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.10.1.1 Release of sediments into the water column and sedimentation on the seabed

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediments into the water column and subsequent sedimentation on the seabed. This has the potential to impact foraging efficiency of birds by decreased water transparency or reduced food availability due to prey avoidance. Birds are mobile and therefore are likely to be exposed to increased turbidity for a short duration. However, resilience of birds towards suspended sediments and sedimentation varies between bird species based on their foraging technique (e.g. pelagic or benthic feeders) and type of prey. A number of bird species and areas (IBAs) were identified as important (section 7.11). Therefore, the sensitivity of birds towards suspended sediments and sedimentation is assessed to be high.

Temporary elevated levels of turbidity may cause a decrease in the amount of light that penetrates through the water column. Generally, a concentration above 15 mg/l has the potential to impact vision of diving water birds such as common scoter, long-tailed duck, razorbill and guillemot /356/. As discussed in section 9.4.1.1, modelling has shown that the maximum predicted concentration of suspended sediment is 62.3 mg/l which may occur in the immediate vicinity (200 m) of the proposed NSP2 route. However, the majority of suspended sediment will redeposit locally such that suspended concentrations above 15 mg/l will be limited to an area of approximately 7.6 km^2 associated with proposed post-lay trenching and rock placement locations for up to 5.5 hours (see section 8.4.1). Furthermore, it is noted that suspended sediments will be limited to the lower 10 m of the water column and the impact from suspended sediments will be reversible because the system will revert to its natural state as the sediment settles back on the seabed within a short timespan.

Increased turbidity may also lead to avoidance of the areas by mobile prey species such as fish. As assessed in section 9.8, suspended sediments will not impact fish populations as a whole and no impact on bird foraging is thus expected.

Sedimentation has a potential to cause burial of food resources (infauna and epifauna species), which may affect the availability of prey species for benthic feeders (e.g. mergansers and coots). As discussed in section 8.1.1.2, the area where sedimentation (as a result of post-lay trenching and rock placement) exceeds 200 g/m^3, corresponding to a sediment layer of approximately 1 mm, is 0.65 km^2. It has been assessed that the system, including the benthic fauna, will quickly revert to its natural state after the termination of the project activities. Therefore, sedimentation on the seabed is unlikely to affect foraging of benthos-feeding birds.

The proposed NSP2 route passes approximately 13 km east of the IBA area DK079 Ertholmene. Based on modelling results (see section 8.4.1), sedimentation along the 10.2 km post-lay trenching section closest to the IBA area DK079 will be in the order of 10 g/m^2 at the distance < 1 km from the trench-site covering an area of 13.9 km^2 resulting in a sediment layer of less than 0.1 mm. The duration of concentrations above 15 mg/l in this area is modelled to be 5.5 hours for post-lay trenching. It is conservatively assessed that increased turbidity will not reach the IBA area due to the distance from the intervention works location and short duration of the impact. Thus no impacts on the IBA area DK079 Ertholmene from suspended sediments and sedimentation is expected.

The proposed NSP2 route is situated between 3 km and 17 km from the IBA area DK120 Rønne Banke until it crosses directly through the IBA just before entering German EEZ. Post-lay trenching and rock placement are planned south-east of Rønne Bank and will cause sedimentation of 10 g/m^2 in an area of 3.7 km^2 for post-lay trenching and in an area of 2 km^2 for rock placement (see section 8.4.1) resulting in a sediment layer of less than 0.1 mm. The duration of concentrations above 15 mg/l from post-lay trenching and rock placement in this area is modelled to be up to 3.5 hours. It is conservatively assessed that increased turbidity will not reach the IBA area due to the distance from the intervention works location and short duration of the impact. Thus no impacts on the IBA area DK120 Rønne Banke from suspended sediments and sedimentation is expected.

In summary, the impact on birds associated with suspended sediments in the water column and sedimentation on the seabed will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact on birds from suspended sediments in the water column and sedimentation on the seabed is assessed to be negligible.

9.10.1.2 Release of contaminants to the water column

Construction activities, mainly post-lay trenching and rock placement, will potentially result in the release of sediment into the water column. This can result in the release of contaminants currently associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide, as discussed in section 8.4.1.2. Given their high mobility, birds are not likely to spend long periods of time in the affected areas. However, they are susceptible to bioaccumulation of contaminants through the food chain. This has a potential to cause reduced viability and reproductive capacity in birds. Taking into account important bird species and areas (IBAs) (section 7.11), the sensitivity of birds towards contaminants released into the water is assessed to be medium.

Calculations have shown that release of contaminants into the water column will generally not result in concentrations with the potential to cause adverse effects in the marine environment (see section 8.4.6). Furthermore, most of the released contaminants (metals and organic contaminants) will remain bound to the sediment particles, and will therefore not be bioavailable /110/. The majority of contaminants will re-deposit on the seabed (associated with the sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route within a short time. Therefore, no acute toxic effects on birds are expected.

It is assessed that potential impact on birds due to bioaccumulation of contaminants through prey is highly unlikely since no impacts on benthos and fish from contaminants in the water column has been identified (see sections 9.7 and 9.8).

Similarly, it is conservatively assessed that potential release of contaminants into the water column will not impact the IBA areas DK079 Ertholmene and DK120 Rønne Banke due to the low intensity of the impact, distance from the intervention works locations and short duration of the impact.

In summary, the impact on birds associated with release of contaminants into the water column will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on birds from release of contaminants to the water column is assessed to be negligible.

9.10.1.3 Release of chemical warfare agents (CWA) to the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This can result in the release of CWA currently associated with the sediment, as discussed in section 8.4.1.3. The release of CWA into the water column has the potential to impact birds causing toxic effects through direct exposure or bioaccumulation. Given their high mobility, birds are not likely to spend long periods of time in the affected areas. However, they are susceptible to bioaccumulation of CWA through the food chain. Taking into account important bird species and areas (IBAs) (section 7.11), the sensitivity of birds towards contaminants released into the water is assessed to be medium.

Increased concentrations of CWA in the water column or in the sediment have the potential to exert toxic effect on the biological environment, including birds and their prey. As discussed in section 8.4.1.3, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed; the impact has been assessed to be negligible, and below applicable PNEC thresholds (section 7.3.8.2). The CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipelines. Furthermore, CWA are predominantly found at the deeper sections along the NSP2 route, i.e. below halocline and the natural stratification will reduce the upwards transport of CWA to the shallower areas where birds might be foraging or resting. Thus, no acute toxic effects from CWA on birds are expected.

The potential impact on the water and sediment quality as well as on populations of prey (benthic fauna and fish) from CWA released from the seabed during the construction phase is assessed to be negligible (sections 8.2, 9.4.1.3, 9.7.1.5, 9.8.1.5). Therefore, no bioaccumulation of CWA in birds through the food chain is expected.

Similarly, it is conservatively assessed that potential release of CWA into the water column will not impact the IBA areas DK079 Ertholmene and DK120 Rønne Banke due to the low intensity of the impact, distance from the intervention works locations and short duration of the impact.

In summary, the impact on birds associated with release of CWA into the water column will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the medium sensitivity, the overall impact on birds from release of CWA into the water column is assessed to be negligible.

9.10.1.4 Physical disturbance above water

Construction activities will result in increased presence of vessels supporting construction of NSP2. The visual presence of moving vessels as well as above-water noise may disturb seabirds and cause them to fly off and move from their resting and/or foraging area. When escaping, foraging and resting birds will use an extra energy when escaping. Taking into account important bird species and areas (IBAs) (section 7.11), the sensitivity of birds towards physical disturbance above water is assessed to be high.

Studies have shown that faster moving vessels cause a larger disturbance and a shorter flight distance than slower moving vessels /357//358/. The specific flight distance (the distance at which a species begins to react in the face of approaching danger) differs greatly between species and also depends on behavioural activity (e.g. foraging versus resting). In addition, flight distances for many bird species are unreported /357//358/.

Flight distances have been published for a number of bird species relevant to the project area. Results from these studies provide an idea of safe distances regarding disturbances associated with the moving vessels:

- Long-tailed duck: flight distance from ships up to 400 m away /357/.
- Common guillemot: flight distance from ships up to hundreds of metres away /359//360/.
- Black guillemot: flight distance from ships up to hundreds of metres away /359//360/.
- Razorbill: flight distance from ships up to hundreds of metres away /360/.
- Red- and black-throated diver: flight distance up to 1,000 m away /357//361/.
- Common goldeneye: flight distance from ships between 500-1000 m away /362/.

Based on these examples, it is concluded that impacts on birds from noise and visual disturbances from ships involved in the construction works in general will be limited to a 1-2 km radius around the working area.

As noted above, the proposed NSP2 route passes approximately 13 km from the IBA DK079 Ertholmene. Because of the distance, it is assessed that the impact from the vessel presence and associated noise disturbances on the designated area will be negligible.

The distance between the proposed NSP2 route and IBA DK120 Rønne Banke is 3 - 17 km along most of the area. However, for approximately 10 km the route, it crosses directly through the IBA DK120 Rønne Banke. The densities of monitored seabirds are considered rather low in the Danish part of the area, including the part crossed by the proposed NSP2 route, and the number of birds varies during the year with adult-chick associations of guillemots frequently observed during June and July and staging sea ducks, of which long-tailed duck is the most prevailing species, observed during February and March /230/. Foraging and resting birds within 1-2 km of construction activities may be impacted and fly off, but as construction activities have a short duration (taking into consideration speed of a pipe-lay vessel of 2.5 km a day) within a given location any disturbance of birds during construction works will be temporary.

In summary, the impact on birds associated with physical disturbance above water will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and the high sensitivity, the overall impact on birds from physical disturbance above water is assessed to be negligible.

9.10.2 Operational phase

During the operational phase, periodic inspection surveys of the pipelines will be performed. The level of ship activity connected to the survey of the pipelines is considered to be insignificant in comparison with the general level of shipping activity in the Baltic Sea, and of a smaller magnitude than during the construction phase (section 9.10.1.4).

There will also be a release of metals from the anodes mounted on the pipeline. In section 9.8.2.2, this is assessed to be of negligible significance to fish in the area or to potential bioaccumulation of metals in the food chain.

Therefore, operation of NSP2 will have a negligible impact on birds and designated bird areas.

9.10.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 9-25. Where potential trans-boundary impacts are identified, these are further assessed in section 14.

Table 9-25 Assessment of the overall impact during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Release of sediments into the water column and sedimentation on seabed	High	Negligible	Negligible	Yes
Release of contaminants into the water column	Medium	Negligible	Negligible	Yes
Release of chemical warfare agents (CWA) from the seabed	Medium	Negligible	Negligible	Yes
Physical disturbance above water	High	Negligible	Negligible	No
Operational phase				
No impacts	-	-	-	-

Based on the conclusions in the sections above (see Table 9-25) the potential impacts on the birds during the construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.11 Protected areas

Protected areas along the proposed NSP2 route comprise a number of different designations. This section focuses on Ramsar sites and HELCOM MPAs (as described in section 7). A separate impact assessment for IBAs and Natura 2000 sites are presented in section 9.10 and 9.12, respectively.

The potential sources of impacts on protected areas during construction and operation are listed in Table 9-26.

Table 9-26 Potential sources of impacts on protected areas during construction and operation of NSP2

Potential source of impacts	Construction phase	Operational phase
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Sedimentation on the seabed	X	
Introduction of non-indigineous species	X	X
Physical disturbance above water	X	X
Physical presence of pipelines and structures on the seabed		X
Release of metals from anodes		X

This section focuses on potential impacts on the species, habitats or ecosystems for which the protected area has been designated, particularly those associated with the pressures that have been identified as part of the protection, i.e. eutrophication, pollution, introduction of non-indigenous species, and physical disturbance, etc. (see section 7).

The resilience of the receptor differs for each potential source of impact, discussed below. As a conservative approach, the resilience of the protected area has been determined by reference to the least resilient feature.

9.11.1 Construction phase

In the following section, potential impacts during the construction phase are assessed.

9.11.1.1 Release of sediments into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. This has the potential to increase turbidity and impact the species, habitats or ecosystems for which the protected areas are designated (see section 7.12).

The least resilient receptor in relation to suspended sediments is considered to be seabirds, conservatively assessed to have low resilience. Therefore, taking into consideration the high importance of the protected area and the low resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be high.

Modelling of sediment dispersion and deposition (see section 8.4.1) indicates that release will be spatially and temporally distributed along the proposed NSP2 route with higher concentrations of suspended sediments only be observed in the close vicinity to the pipelines (with concentrations exceeding 15 mg/l covering a total area of approximately 8 km^2) at the locations where seabed intervention works are proposed. Concentrations of suspended sediments in the water column will exceed 2 mg/l within a distance of a few kilometres from the proposed NSP2 route, covering a total area of 139 km^2 for a period of up to 12 hours for trenching and an area of <1 km^2 for a period of up to 20 hours for rock placement. Impacts from suspended sediments are assessed to have a negligible impact on water quality, fish, marine mammals and seabirds (section 9.4, 9.8, 9.9 and 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.1.2 Release of contaminants into the water column

The release of sediment into the water column, can also result in the release of contaminants, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide, as discussed in section 9.4.1.2. However, the release of contaminants does not constitute a net increase of contaminants into the marine environment, but rather a redistribution of the substances already present in the seabed. Regardless, changes in the concentrations of these contaminants within the water column has the potential to impact the species, habitats and/or ecosystems for which the protected areas are designated (see section 7.12) or enhance existing pressures.

The least resilient receptor in relation to release of contaminants is considered to be seabirds, conservatively assessed to have low resilience (section 9.10). Therefore, taking into consideration the high importance of the protected area and the low resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be medium.

A calculation of the amounts of nutrients and contaminants released into the water column was undertaken as part of NSP /127/, based on the measured concentrations of the contaminants within the seabed and the amount of released sediment. The amounts were assessed to be small and insignificant compared with the annual amounts that entered the Baltic Sea and Baltic Proper. These results are assessed to be comparable for NSP2 (section 8.4 and 9.4).

The spatial and temporal distribution of the release, in combination with the fact that only a fraction of the released substances will be bioavailable, limits impacts on the marine environment, and the impact on water quality has been assessed to be negligible (section 9.4). Potential impacts to fish, marine mammals and seabirds from release of contaminants have also been assessed to be negligible (section 9.8, 9.9 and 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.1.3 Release of CWA into the water column

The release of sediment into the water column, can also result in the release of CWA currently associated with the sediment, as discussed in section 8.4. The release does not constitute a net increase of CWA into the marine environment, but rather a redistribution of the substances already present in the seabed. Regardless, changes in the concentrations of these CWA within the water column have the potential to impact the species, habitats and/or ecosystems for which the protected areas are designated (see section 7.12) or enhance existing pressures.

The least resilient receptor in relation to release of CWA is considered to be seabirds, conservatively assessed to have low resilience (section 9.10). Therefore, taking into consideration the high importance of the protected area and the low resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be medium.

The CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipelines. The spatial and temporal distribution of the release, in combination with the fact that only a fraction of the released substances will be bioavailable, limits impacts on the marine environment. As discussed in section 9.4, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed along the deeper sections of the NSP2 route (where most CWA is found); however, impacts have been assessed to be negligible, and below applicable PNEC thresholds (section 8.4 and 9.4). Potential impacts to fish, marine mammals and seabirds from release of CWA have also been assessed to be negligible (section 9.8, 9.9 and 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.1.4 Sedimentation on the seabed

Sedimentation of resuspended sediment and contaminants resulting from intervention works and pipe-lay may re-distribute sediments (changing local sediment characteristics and quality) and/or deposit an additional sediment layer. This has the potential to impact the species, habitats or ecosystems for which the area is designated (see sections 7.12) or enhance existing pressures.

The least resilient receptor in relation to suspended sediments is considered to be benthic habitats, conservatively assessed to have high resilience (section 9.7). Therefore, taking into consideration the high importance of the protected area and the high resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be low.

As described in section 7.3, levels of metals, CWA and organic contaminants in sediment along the proposed NSP2 route were generally below threshold levels. Furthermore, the anticipated sedimentation (section 8.4) is within natural variation and highly localized (with a majority of the suspended material expected to deposit within a few kilometres of the pipelines). Therefore predicted levels of sedimentation are not considered sufficient to alter the sediment quality in terms of chemistry, content of contaminants or the biogeochemical processes taking place in the sediment due to microbial processes.

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.1.5 Physical disturbance above water

Construction activities will result in increased presence of vessels along the proposed NSP2 route. The visual presence of moving vessels as well as above-water noise has the potential to species, habitats or ecosystems for which the area is designated (see sections 7.12), or enhance existing pressures.

The least resilient receptor in relation to physical disturbance above water is considered to be seabirds, conservatively assessed to have medium resilience, with some variation between species (section 9.10). Therefore, taking into consideration the high importance of the protected area and the medium resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be high.

Modelling of pipe-lay activities, which is considered the most noise-generating activity (airborne) during construction, shows increased noise levels within approximately 4.1 km of the proposed NSP2 route (section 8.4). Beyond this distance, noise was modelled to be comparable with ambient noise levels (approx. 33 dB). As the protected areas are located at least 13 km from the proposed NSP2 route, they will not experience any increase in noise levels as a result of propogation of airborne noise. Protected seabirds may also exibit disturbance and flight reactions within a distance of approximately 1-2 km from vessels; impacts have been assessed to be negligible (section 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.1.6 Introduction of non-indigenous species (NIS)

Vessel movements during construction have the potential to introduce NIS into Danish waters. The potential impact is highly dependant on the NIS introduced, which can be either positive or negative, and may impact the species, habitats or ecosystems for which the protected area is designated (see sections 7.12).

The most sensitive species in relation introduction of NIS is considered to be ecosystems (section 9.13). Taking into consideration the high importance protected areas and the low resilience of the most vulnerable receptor, the sensitivity of protected areas is assessed to be high.

The potential to introduce non-indigenous species is the only source of impact specific to biodiversity during the construction phase. In order to minimise the risk of introducing non-indigenous species into the Danish section of the Baltic Sea, construction vessels will conduct ballast water exchange outside of the Baltic Sea. Furthermore NSP2 will prepare Ballast Water Management Plans which will include measures to ensure adherence to OSPAR/HELCOM General Guidance on the Voluntary Interim Application of the D1 Ballast Water Exchange Standard in the North East Atlantic. Ballast tanks will also be cleaned regularly and washing water delivered to reception facilities ashore in line with IFC EHS Guidelines on shipping and the International Convention for the Control and Management of Ships Ballast Water and Sediments.

Based on these measures the risk of introducing NIS during the construction of NSP2 is considered to be very low, such that the NSP2 project will have negligible impact on biodiversity (9.13).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.2 Operational phase

In the following sections, potential impacts during the operational phase are assessed.

9.11.2.1 Physical disturbance above water

Planned maintenance activities will result in increased presence of vessels along the proposed NSP2 route. The visual presence of moving vessels as well as above-water noise has the potential to disturb protected species, habitats or ecosystems.

The least resilient receptor in relation to physical disturbance above water is considered to be seabirds, conservatively assessed to have medium resilience, with some variation between species (section 9.10). Therefore, taking into consideration the high importance of the protected area and the medium resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be high.

Modelling of pipe-lay activities, which is considered the most noise-generating activitiy (airborne) during construction, shows increased noise levels within approximately 4.1 km of the proposed NSP2 route (section 8.4). Beyond this distance, noise was modelled to be comparable with ambient noise levels (approx. 33 dB), therefore no propogation of airborne noise into the nearby protected areas is expected. It should be noted, that above-water noise from maintenance vessels is less than that originating from the pipe-lay vessels. Protected seabirds may however exibit disturbance and flight reactions within a distance of around 1-2 km from vessel activity; impacts have been assessed to be negligible (section 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.2.2 Physical presence of pipelines and structures on the seabed

The presence of the pipelines on the seabed have the potential to irreversibly impact flow patterns along the seabed and have a hydrographical blocking effect. This has the potential to impact the basic physical and chemical conditions which determine the life within the Baltic Sea, which can in turn impact the species or habitats for which the area is designated (see sections 7.12).

The most sensitive species in relation to physical presence of pipelines and structues on the seabed are considered to be benthic habitats and ecosystems (section 9.7 and 9.13). Taking into consideration the high importance protected areas and the resilience of the most vulnerable receptor, the sensitivity of protected areas is assessed to be high.

A review of the hydrographic impacts on the Baltic Proper for NSP /317//321/, which is considered to remain valid for NSP2, concluded that there would be no impacts on bulk flow or sediment accretion/erosion. Impacts on hydrography were therefore assessed to be negligible (section 9.3).

Other potential impacts on physical, chemical and biological conditions from the presence of structures and pipelines on the seabed (e.g. smothering of organisms, changes in habitat) have been assessed to be local (section 9.4, 9.8, 9.9 and 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.2.3 Introduction of NIS

In the operational phase, NIS may spread due to migration along the NSP2 pipelines. Hard-bottom species may use the NSP2 pipelines as an area of artificial reef, and therefore bridge otherwise discrete hard-bottom areas.

The most sensitive species in relation introduction of NIS is considered to be ecosystems (section 9.13). Taking into consideration the high importance protected areas and the low resilience of the most vulnerable receptor, the sensitivity of protected areas is assessed to be high.

As described in section 9.13, vessel activity during the operation phase is connected to maintenance activities where ballast water is rather taken in from the Baltic Sea than released there or to surveying activities where no release exchange of ballast water is anticipated, and no impacts are expected. During this phase, hard-bottom species may use the NSP2 pipelines as an area of artificial reef, and therefore bridge otherwise discrete hard-bottom areas. This has the potential to encourage the spread of NIS due to migration along the NSP2 pipelines. However, the abiotic conditions within the Bornholm Basin (i.e. low light and hypoxic/anoxic) will function as a barrier which will prevent migration of species along the NSP2 pipelines.

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.2.4 Release of metals from anodes

The release of metals from anodes is discussed in section 8.4. Release of Al from the anodes will not cause ecotoxicological impacts, Cd and Zn adhering to suspended particles may be taken up by marine organisms and thus enter the food chain. Both metals have a high potential for bioaccumulation, and may be acutely toxic at elevated concentrations.

The least resilient receptor in relation to suspended sediments is considered to be benthic habitats, conservatively assessed to have low resilience (section 9.7). Therefore, taking into consideration the high importance of the protected area and the low resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be high.

The release of Al, Zn and Cd ions from the aluminium anodes was described in section 8.4, and the impact on water quality was assessed to be negligible (section 9.4). The amounts released from the anodes are insignificant compared with the existing levels of water-borne inflow of metals to the area, despite release will take place for the lifetime of the project. Elevated levels of anode metals (above PNEC values) in the water column are expected only within a few metres of the anodes. Impacts on benthic habitats would only occur in the immediate vicinity of anodes in sections of the proposed NSP2 route that are within habitat types 2 and 3 (section 9.7). Therefore the intensity is low and no discernible impacts on benthic populations, either directly or by bioaccumulation, are expected (section 9.7). The impacts to seabirds from release of metals from anodes impacts have been assessed to be negligible (section 9.10).

Given the above, in combination with the fact that the protected areas are situated at least 13 km from the proposed NSP2 route, it is assessed that there will be no impacts to protected areas.

9.11.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 9-27. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-27 Assessment of the overall impacts during construction and operation of NSP2

Potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Constructional phase				
Release of sediments into the water column	High	No impact		No
Release of contaminants into the water column	Medium	No impact		No
Release of CWA to the water column	Medium	No impact		No
Sedimentation on seabed	Low	No impact		No
Introduction of non-indigineous species	High	No impact		No
Physical disturbance above water	High	No impact		No
Operation phase				
Physical disturbance above water	High	No impact		No
Physical presence of pipelines and structures on the seabed	High	No impact		No
Introduction of non-indigineous species	High	No impact		No
Release of metals from anodes	High	No impact		No

Based on the conclusions in the sections above (see Table 9-27), the potential impacts on protected areas during the construction and operation of NSP2, either individually or in combination, is assessed to be not significant.

9.12 Natura 2000 sites

An assessment of whether a project may result in significant impacts on Natura 2000 sites is required in accordance with the Habitats directive, and Danish legislation (section 4). The Natura 2000 assessment is following a designated methodology described in section 8.3. Current section serves as a first step of assessment - Natura 2000 screening, where the objective is to identify all elements of the project or plan, alone or in combination with other projects or plans, which may have significant impacts on the Natura 2000 site.

This Natura 2000 screening assesses the potential for activities within the Danish waters to have significant impacts on Danish Natura 2000 sites (as described in section 7.13). The potential for activities within the Danish sector to have significant impacts on Natura 2000 sites in the German and Swedish EEZ are described under transboundary impacts (section 14).

A Natura 2000 screening for Swedish and German Natura 2000 sites which may be affected by activities in these respective countries is presented in the relevant National EIAs.

The sources of potential impacts on Natura 2000 sites during construction and operation are listed in Table 9-28, along with reasoning for including or excluding the potential source of impact in the Natura 2000 screening. No activities associated with NSP2 in the Danish sector are planned to occur within designated Natura 2000 sites. The closest Danish Natura 2000 site is N189 Ertholmene, which is located approximately 13 km from the proposed NSP2 route.

Table 9-28 Preliminary identification of potential impacts on Natura 2000 sites during the construction and operational phase of NSP2, including reasoning for including or excluding the potential impact in the Natura 2000 screening.

Potential sources of impact	Construction phase	Operational phase	Assessed in Natura 2000 screening?
Physical disturbance on seabed	X		No. There is no disturbance of seabed in the Natura 2000 sites, as the minimum distance to a Natura 2000 site is 13 km.
Release of sediments into the water column	X		Yes, assessed for habitats and species
Release of contaminants into the water column	X		Yes, assessed for habitats and species
Release of chemical warfare agents (CWA) into the water column	X		Yes, assessed for habitats and species
Sedimentation on the seabed	X		Yes, assessed for habitats
Generation of underwater noise	X		Yes, assessed for species (marine mammals)
Physical disturbance above water (e.g. from presence of vessels, noise and light)	X	X	Yes, assessed for species
Imposition of safety zones around vessels	X	X	No. Not relevant to designated marine species and habitats.
Emissions of air pollutants and GHGs	X	X	No. Not relevant to designated marine species and habitats.
Introduction of non-indigenous species	X	X	No. Not relevant to designated marine species and habitats.
Physical presence of pipelines and structures on the seabed		X	Yes, assessed for habitats and species
Change of habitat		X	No. There is no changes to habitats in the Natura 2000 sites, as the minimum distance to a Natura 2000 site is 13 km.
Generation of heat from gas flow through the pipeline		X	No. The potential impact is local (within a few metres) near the pipeline, and the minimum distance to a Natura 2000 site is 13 km.
Release of metals from anodes		X	No. The potential impact is local (within a few metres) near the pipeline, and the minimum distance to a Natura 2000 site is 13 km.

The Natura 2000 screening presented below focuses on the species and habitats for which the Natura 2000 sites have been designated. The potential for impacts from NSP2 to combine with other planned projects are assessed in section 12.

9.12.1 Habitat types

The designated marine habitat types in the relevant Natura 2000 sites are sandbanks and reefs (section 7.13). The following sources of impact have been included within the Natura 2000 screening for these marine habitat types: release of sediments and contaminants to the water column and subsequent sedimentation (from e.g. trenching) and physical presence of pipelines and structures (i.e. altered hydrography of the Baltic Sea).

Release of sediment into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. Increased turbidity could e.g. impact the species associated with habitat types.

Modelling of sediment dispersion (see section 8.4) indicates that the concentration of suspended sediments in the water column will exceed 2 mg/l within a distance of a few kilometres from the proposed NSP2 route, covering a total area of 139 km^2 for a period of up to 12 hours for trenching and an area of <1 km^2 for a period of up to 20 hours for rock placement. The release will be spatially and temporally distributed along the proposed NSP2 route (with the highest concentrations in the vicinity of seabed intervention works), consequently making the impact at any given location very small. The release is assessed to have a negligible impact on water quality (section

8.4). Modelling demonstrates that the change in suspended sediment in the nearest Natura 2000 site, Ertholmene (13 km from the proposed NSP2 route), is within the range of ambient background concentrations (less than 2 mg/l). Furthermore increases in suspended sediment will be temporary. In other Danish Natura 2000 sites, the concentration and duration is predicted to be even smaller.

Monitoring of the sediment plume caused by post-lay trenching during NSP construction has shown that SSC was highest near the plough (up to 20 mg/l) were observed, while the observed concentrations 500 m behind the plough were less than 4 mg/l. SSC resulted from rock placement were of the same magnitude. In general, monitoring has shown that an area of less than 1 km was impacted by SSC levels >10 mg/l for several hours. No spreading of suspending sediments to the Natura 2000 sites has been observed (section 8.4, /294/).

In summary, the marine habitat types designated within the Natura 2000 sites are in a dynamic environment, where natural release of sediment into the water column is caused by natural physical disturbance (i.e. wave action), and are therefore resilient to short-term increases in turbidity. Due to the temporary nature of the increase and the low increase of suspended sediment concentration within the Natura 2000 sites, release of sediment into the water column is assessed to have no risk of significant impact on the designated habitat types.

Release of contaminants and CWA into the water column
The release of sediment into the water column (see above) as a result of construction activities, can also result in the release of contaminants currently associated with the sediment, including metals and CWA (section 8.4). It is important to note that the release of contaminants into the water column does not constitute a net increase of contaminant input into the marine environment, but rather a redistribution of the substances already present in the seabed. Increased contaminants could e.g. impact the species associated with habitat types.

A calculation of the amounts of nutrients and contaminants which may potentially be released ito the water column was undertaken as part of NSP /127/, based on the measured concentrations of the contaminants in the sediment and sediment dispersion. The amounts were assessed to be low and insignificant compared with the annual amounts that enter the Baltic Sea and Baltic Proper. The results of these calculations are considered to be comparable for NSP2 (section 9.4). The spatial and temporal distribution of the release, in combination with the fact that only a fraction of the released substances will be bioavailable, limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of negligible magnitude, therefore the overall impact has been assessed to be negligible (section 9.4).

The release of CWA currently associated with the sediment is discussed in section 8.4. As discussed in section 9.4, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed along the deeper sections of the proposed NSP2 route (where most CWA is found). The concentrations along the proposed NSP2 route in Danish waters have been assessed to be below applicable PNEC thresholds (section 7.3). In addition, the CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipeline.

In summary, levels of contaminants and CWA in sediment along the proposed NSP2 route were generally below threshold levels limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of negligible magnitude, therefore the overall impact has been assessed to be negligible (section 9.4).

Based on the temporary nature of the incease, the expectation that the contaminants will be below applicable thresholds, as well as the distance between the habitat types and the proposed

NSP2 route, release of associated contamints is assessed to have no risk of significant impact on the designated habitat types.

Sedimentation on the seabed
Sedimentation of resuspended sediment and contaminants resulting from intervention works and pipe-lay may affect sediment quality in the habitat types or smother associated species.

As described in section 7.3, levels of metals, CWA and organic contaminants in sediment along the proposed NSP2 route were generally below threshold levels. Furthermore, the sedimentation is temporary, within natural variation and highly localized. Therefore predicted levels of sedimentation are not considered sufficient to alter the sediment quality in terms of chemistry, content of contaminants or the biogeochemical processes taking place in the sediment due to microbial processes. Overall, the impacts on sediment quality are assessed to be local, temporary and negligible (section 9.2).

Sediment dispersion and sedimentation have been modelled for post-lay trenching and rock placement (section 8.4). For the Danish Natura 2000 sites, the modelling results shows sedimentation below 50 g/m^2 (corresponding to a 0.5 mm layer of sand) (see section 8.4). Based on monitoring of sediment plume during NSP construction (as discussed above) it can be concluded that no sedimentation will be observed at Natura 2000 sites as a result of NSP2 construction (section 8.4, /294/).

The marine habitat types are in a dynamic environment, with natural sedimentation caused by natural physical disturbance, and they are considered resilient to short-term, small increases in sedimentation. Due to the temporary nature of the impact, the concentrations of sedimentation in Natura 2000 sites, as well as the distance between the habitat types and the proposed NSP2 route, sedimentation is assessed to have no risk of significant impact on the designated habitat types.

Physical presence of pipelines and structures on the seabed
The presence of the pipelines and structures on the seabed have the potential to irreversibly impact flow patterns along the seabed and have a hydrographical blocking effect. This has the potential to impact the basic physical and chemical conditions which determine the marine ecosystems in the Baltic Sea, which can in turn impact the habitat types designated in the Natura 2000 sites (see sections 7.13).

A thorough review of the hydrographic impacts on the Baltic Proper for NSP and NSP2 concluded that there would be no impacts on hydrographical bulk flow or sediment accretion/erosion /317//321/, and impacts on hydrography were therefore assessed to be negligible (section 9.3).

As it has been assessed that there would be no impact to the bulk flow or sediment, the presence of the pipelines and structures on the seabed is assessed to have no risk of significant impact on the designated habitat types.

Conclusion
A screening of the potential impacts to the habitat types designated within the Danish Natura 2000 sites has been undertaken in respect to the following: release of sediments and contaminants to the water column and subsequent sedimentation (from e.g. trenching) and physical presence of pipelines and structures (altered hydrography of the Baltic Sea). In conclusion, it is assessed there there will no risk of significant impact on the designated habitat types in Danish Natura 2000 sites during construction and/or operation of NSP2.

9.12.2 Species – marine mammals

The designated marine mammals in the relevant Natura 2000 sites include the grey seal and harbour porpoise (section 7.13). The following sources of impact have been included within the Natura 2000 screening for these species: release of sediments and contaminants to the water column (from e.g. trenching), underwater noise (from vessels, rock-dumping, etc.), physical disturbance above water (presence of vessels) and physical presence of pipelines and structures.

Release of sediment into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column in connection with seabed intervention works such as post-lay trenching or rock placement. Suspended sediment may have a direct impact on marine mammals by affecting their vision and thereby their behaviour.

Modelling of sediment dispersion (see section 8.4) indicates that the concentration of suspended sediments in the water column will exceed 2 mg/l within a distance of a few kilometres from the proposed NSP2 route, covering a total area of 139 km^2 for a period of up to 12 hours for trenching and an area of <1 km^2 for a period of up to 20 hours for rock placement. The release will be spatially and temporally distributed along the proposed NSP2 route (with the highest concentrations in the vicinity of seabed intervention works), consequently making the impact at any given location very small. The release is assessed to have a negligible impact on water quality (section 9.4). Modelling demonstrates that the change in suspended sediment in the nearest Natura 2000 site, Ertholmene (13 km from the proposed NSP2 route), is within the range of ambient background concentrations (less than 2 mg/l). Furthermore increases in suspended sediment will be temporary. In other Danish Natura 2000 sites, the concentration and duration is predicted to be even smaller.

As described in section 9.9, the expected concentrations of suspended sediment in the water column are not expected to impact on marine mammal vision or cause injury to vital organs, the overall impact on marine mammals from the release of sediment in the water column is assessed to be negligible.

Due to the temporary nature of the increase and the low increase of suspended sediment in Natura 2000 sites, release of sediment is assessed to have no risk of significant impact on the designated species (marine mammals).

Release of contaminants and CWA into the water column

The release of sediment into the water column (see above) as a result of construction activities, can also result in the release of contaminants currently associated with the sediment, including metals and CWA (section 8.4). It is important to note that the release of contaminants into the water column does not constitute a net increase of contaminant input into the marine environment, but rather a redistribution of the substances already present in the seabed. The release has the potential to impact marine mammals either directly or through bioaccumulation, causing toxicity effects.

A calculation of the amounts of nutrients and contaminants which may potentially be released ito the water column was undertaken as part of NSP /127/, based on the measured concentrations of the contaminants in the sediment and sediment dispersion. The amounts were assessed to be low and insignificant compared with the annual amounts that enter the Baltic Sea and Baltic Proper. The results of these calculations are considered to be comparable for NSP2 (section 9.4). The spatial and temporal distribution of the release, in combination with the fact that only a fraction of the released substances will be bioavailable, limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of negligible magnitude, therefore the overall impact has been assessed to be negligible (section 9.4).

The release of CWA currently associated with the sediment is discussed in section 8.4. As discussed in section 9.4, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed along the deeper sections of the proposed NSP2 route (where most CWA is found). The concentrations along the proposed NSP2 route in Danish waters have been assessed to be below applicable PNEC thresholds (section 7.3). In addition, the CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipeline.

In summary, levels of metals, CWA and organic contaminants in sediment along the proposed NSP2 route were generally below threshold levels limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of negligible magnitude, therefore the overall impact has been assessed to be negligible (section 9.4).

As described in section 9.9, release of contaminants has the potential to impact marine mammals either directly or through bioaccumulation, causing toxic effects. Marine mammals make up the highest trophic levels and have large lipid stores, where e.g. metals can potentially be biomagnified in their tissues, leading to an increased risk of toxicity. Impact on marine mammals in terms of risk of contaminants and bioaccumulation is mainly connected with their feeding behavior and type of prey. Harbour porpoise and seal feed on fish and squid (see section 7.10). In section 9.8 it is concluded that there will be no significant bioaccumulation of contaminants in fish due to contamination with heavy metals or organic contaminants in the surface sediments in the Danish part of the pipeline route. Based on this it is assessed that the risk of bioaccumulation in the marine mammals through the food chain will be negligible (section 9.9).

Based on the temporary nature of the incease, the expectation that the contaminants will be below applicable thresholds, as well as the distance between the Natura 2000 and the proposed NSP2 route, release of associated contamints is assessed to have no risk of significant impact on the designated species (marine mammals).

Generation of underwater noise
During the construction phase, underwater noise will occur as a result of rock placement, trenching, pipe-lay, anchor-handling and ship noise. Noise from vessels is also expected in the operational phase during maintenance surveys.

As described in section 9.9, potential impacts on marine mammals from increased noise levels can occur through a number of processes, and three main issues comprise:

- Physical injury and hearing loss (including permanent threshold shift/temporary threshold shift);
- Disturbance of animal behaviour;
- Masking of other sounds.

Modelling of underwater noise propagation has been undertaken for rock placement (considered the noisiest activities arising from the project activities in Danish waters) as described in section 8.4. The results of the acoustic modelling were combined with the applicable scientific criteria for hearing damage (PTS, TTS) and behavioural response (as identified in section 9.9). This results in the maximum distances from the rock placement activity, where potential impacts to marine mammals may occur.

Criteria for behavioural impacts resulting from underwater noise were never exceeded, and the assessment concluded that no physical injury or permanent hearing damage (PTS) is expected to occur (section 9.9).

Criteria for TTS resulting from underwater noise were exceeded in the vicinity (<80 m) of the pipeline, and behavioural reactions to underwater noise are thus expected to occur only in the vicinity of the vessel/activity. TTS and behavioural reaction are assessed to be temporary, and to remain only for the time when the vessels are present. In addition, it is anticipated that the marine mammals which may be present along the proposed NSP2 route will have developed a level of tolerance to noise from vessels due to the existing noise levels within the Baltic Sea (see sections 9.9). The impact on marine mammals (relating to behavioural response) will be local, temporary and of low intensity, and the overall impact on marine mammals in relation to behavioural response is assessed to be minor (section 9.9).

Modelling of underwater noise propagation has also been undertaken for NSP2 and shows little noise propagation to the Danish Natura 2000 sites, corresponding to background levels. There is no exceedance of the scientific criteria for potential impacts in Danish Natura 2000 sites.

On this basis, underwater noise is not assessed to have any risk of significant impact on the designated specied (marine mammals) during construction and operation of NSP2.

Physical disturbance above water (e.g. from presence of vessels)
Construction and maintenance activities will result in increased presence of vessels along the proposed NSP2 route. The visual presence of moving vessels has the potential to disturb designated marine mammals.

As described in section 9.9, the visual presence of moving vessels has the potential to disturb species such as marine mammals. However, such impact is assessed to be negligible (section 9.9).

Vessels are not anticipated in the Natura 2000 sites, as the Danish sites are located more than 13 km from the proposed NSP2 route, and the expected ship traffic to and from marshalling yards is not expected to frequently cross the Natura 2000 sites. Based on this, it is assessed that presence of vessels will not have a significant impact on designated marine mammals.

Physical presence of pipelines and structures on the seabed
The presence of the pipelines and structures on the seabed have the potential to irreversibly impact flow patterns along the seabed and have a hydrographical blocking effect (altered hydrography of the Baltic Sea). This has the potential to impact the basic physical and chemical conditions which determine the marine ecosystems in the Baltic Sea. Changes to ecosystems could potentially impact the species designated in the Natura 2000 sites (see sections 7.13).

A thorough review of the hydrographic impacts on the Baltic Proper for NSP and NSP2 concluded that there would be no impacts on hydrographical bulk flow or sediment accretion/erosion /317//321/. It has been assessed that there would be no impact to the bulk flow or sediment, and potential impacts to ecosystems are assessed to be negligible (see section 9.13).

On this basis, the presence of the pipelines and structures on the seabed is assessed to have no risk of significant impact on the designated species (marine mammals).

Conclusion
Potential impact to designated marine mammals has been assessed for release of sediments and contaminants to the water column (from e.g. trenching), underwater noise (from vessels, rock-dumping, etc.), physical disturbance above water (presence of vessels) and physical presence of pipelines and structures. On this basis, it is assessed that there is no risk of significant impact on the designated marine mammals in Danish Natura 2000 sites during construction and operation of NSP2.

9.12.3 Species – seabirds

The designated seabirds in the Danish Natura 2000 site Ertholmene include guillemot and razorbill (section 7.13). These bird species are designated as breeding as well as migrating birds. The following sources of impact have been included within the Natura 2000 screening for these species: release of sediments and contaminants to the water column (from e.g. trenching), physical disturbance above water (presence of vessels) and physical presence of pipelines and structures.

Release of sediment into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment in the water column in connection with seabed intervention works such as post-lay trenching or rock placement. Suspended sediment may have a direct impact on seabirds by affecting their vision and thereby their behaviour.

Modelling of sediment dispersion (see section 8.4) indicates that the concentration of suspended sediments in the water column will exceed 2 mg/l within a distance of a few kilometres from the proposed NSP2 route, covering a total area of 139 km^2 for a period of up to 12 hours for trenching and an area of <1 km^2 for a period of up to 20 hours for rock placement. The release will be spatially and temporally distributed along the proposed NSP2 route (with the highest concentrations in the vicinity of seabed intervention works), consequently making the impact at any given location very small. The release is assessed to have a negligible impact on water quality (section 9.4). Modelling demonstrates that the change in suspended sediment in the nearest Natura 2000 site, Ertholmene (13 km from the proposed NSP2 route), is within the range of ambient background concentrations (less than 2 mg/l). Furthermore increases in suspended sediment will be temporary. In other Danish Natura 2000 sites, the concentration and duration is predicted to be even smaller.

As described in section 9.10, a concentration above 15 mg/l has the potential to impact vision of diving water birds such as common scoter, long-tailed duck, razorbill and guillemot. This threshold is only exceeded in the immediate vicinity (200 m) of the proposed NSP2 route and does not extend into the any of the Danish Natura 2000 sites. Therefore, the overall impact on seabirds from the release of sediment in the water column is assessed to be negligible.

Due to the temporary nature of the increase and the low increase of suspended sediment in Natura 2000 sites, release of sediment is assessed to have no risk of significant impact on the designated seabirds.

Release of contaminants and CWA into the water column

The release of sediment into the water column (see above) as a result of construction activities, can also result in the release of contaminants currently associated with the sediment, including metals and CWA (section 8.4). It is important to note that the release of contaminants into the water column does not constitute a net increase of contaminant input into the marine environment, but rather a redistribution of the substances already present in the seabed. The release has the potential to impact seabirds either directly or through bioaccumulation, causing toxicity effects.

A calculation of the amounts of nutrients and contaminants which may potentially be released ito the water column was undertaken as part of NSP /127/, based on the measured concentrations of the contaminants in the sediment and sediment dispersion. The amounts were assessed to be low and insignificant compared with the annual amounts that enter the Baltic Sea and Baltic Proper. The results of these calculations are considered to be comparable for NSP2 (section 9.4). The spatial and temporal distribution of the release, in combination with the fact that only a fraction of the released substances will be bioavailable, limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of negligible magnitude, therefore the overall significance of the impact has been assessed to be negligible (section 9.4).

The release of CWA currently associated with the sediment is discussed in section 8.4. As discussed in section 9.4, the impact on water quality from CWA is expected to be greatest in areas where post-lay trenching is proposed along the deeper sections of the proposed NSP2 route (where most CWA is found). The concentrations along the proposed NSP2 route in Danish waters have been assessed to be below applicable PNEC thresholds (section 7.3). In addition, the CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will re-settle on the seabed rapidly, and within the immediate vicinity of the pipeline.

In summary, levels of metals, CWA and organic contaminants in sediment along the proposed NSP2 route were generally below threshold levels limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of negligible magnitude, therefore the overall impact has been assessed to be negligible (section 9.4).

As described in section 9.10, seabirds are mobile and not likely to spend long periods of time in the affected areas, and no acute toxic effects on birds are expected. However, seabirds are susceptible to bioaccumulation of contaminants through the food chain. Impact on seabirds in terms of risk of contaminants and bioaccumulation is connected with their feeding behavior and type of prey. Guillemots and razorbill both feed on schooling fish and krill in the sea with main foraging areas for the two species north east of Ertholmene (see section 7.11). In section 9.8 it is concluded that there will be no significant bioaccumulation of contaminants in fish due to contamination with heavy metals or organic contaminants in the surface sediments in the Danish part of the pipeline route. Based on this it is assessed that the risk of bioaccumulation in birds through the food chain will be negligible (section 9.10).

Furthermore, the risk of bioaccumulation in the designated bird species guillemot and razorbill will be very low as the birds are mainly concentrated around Ertholmene (approximately 13 km from the proposed NSP2 route) and at sites even further from the proposed Natura 2000 sites.

Based on the temporary nature of the incease, the expectation that the contaminants will be below applicable thresholds, as well as the distance between the Natura 2000 sites and the proposed NSP2 route, release of associated contamints is assessed to have no risk of significant impact on the designated species (seabirds).

Physical disturbance above water (presence of vessels)
During the construction phase, underwater noise will occur as a result of rock placement, trenching, pipe-lay, anchorhandling and ship noise. Noise from vessels is also expected in the operational phase during maintenance surveys. Construction and maintenance activities will result in increased presence of vessels along the proposed NSP2 route. The visual presence of moving vessels has the potential to disturb designated seabirds.

As described in section 9.10, the visual presence of moving vessels as well as noise may disturb seabirds and cause them to fly off and move from their resting and/or foraging area. Based on a literature review, it is concluded that impacts on birds from noise and visual disturbances from ships involved in the construction works in general will be limited to a 1-2 km radius around the working area. Impact to birds is assessed to be temporary and negligible (section 9.10), and the designated bird species guillemot and razorbill are mainly concentrated around Ertholmene (approximately 13 km from the proposed NSP2 route) and at sites even further from the proposed Natura 2000 sites.

Vessels are not anticipated in the Natura 2000 sites, as the Danish sites are located more than 13 km from the proposed NSP2 route, and the expected ship traffic to and from marshalling yards is not expected to frequently cross the Natura 2000 sites.

On this basis, underwater noise and presence of vessels is not assessed to have any risk of significant impact on the designated seabirds during construction and operation of NSP2.

Physical presence of pipelines and structures on the seabed

This has the potential to impact the basic physical and chemical conditions which determine the marine ecosystems in the Baltic Sea. Changes to ecosystems could potentially impact the species designated in the Natura 2000 sites (see sections 7.13).

A thorough review of the hydrographic impacts on the Baltic Proper for NSP and NSP2 concluded that there would be no impacts on hydrographical bulk flow or sediment accretion/erosion /317//321/. It has been assessed that there would be no impact to the bulk flow or sediment, and potential impacts to ecosystems are assessed to be negligible (see section 9.13).

On this basis, the presence of the pipelines and structures on the seabed is assessed to have no risk of significant impact on the designated seabirds.

Conclusion

Potential impact to designated sea birds has been assessed for release of sediments and contaminants to the water column (from e.g. trenching), disturbance above water (presence of vessels) and physical presence of pipelines and structures. On this basis, it is assessed that there is no risk of significant impact on the designated seabirds in Danish Natura 2000 sites during construction and operation of NSP2.

9.12.4 Summary of impacts

Based on the Natura 2000 screening it can be objectively concluded that there are not likely to be significant effects on species/habitats designated for the Natura 2000 sites or to the integrity of the Natura 2000 sites in general. Table 9-29 provides a summary of the conculsions of the Natura 2000 screening.

Table 9-29 Summary of Natura 2000 screening

Natura 2000 site	Distance to proposed NSP2 route	Designated marine species and habitats	Conclusion
N189 Ertholmene (DK007X079)	Approximately 13 km	Grey seal Reefs Guillemot Razorbill	No risk of significant impact
N212 Bakkebrædt and Bakkegrund (DK00VA310)	Approximately 17 km	Sandbanks Reefs	No risk of significant impact
N252 Adler Grund and Rønne Banke (DK00VA261)	Approximately 16 km	Sandbanks Reefs	No risk of significant impact

9.13 Biodiversity

The sources of potential impacts on biodiversity during construction and operation of NSP2 are consistent with those identified for section 9.6-9.12, as summarised in Table 9-30.

Table 9-30 Sources of potential impacts on biodiversity during the construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on seabed	X	
Release of sediments into the water column	X	
Release of contaminants into the water column	X	
Release of chemical warfare agents (CWA) into the water column	X	
Sedimentation on the seabed	X	
Generation of underwater noise	X	
Physical disturbance above water	X	
Introduction of non-indigenous species	X	X
Emission of air pollutants and GHGs	X	X
Physical presence of pipelines and structures on the seabed		X
Changes of habitat		X
Release of metals from anodes		X

Each potential source of impacts on species and habitats has been assessed in sections 9.6 - 9.12, and are therefore not represented here. With due consideration to these assessments, this section provides an assessment of the potential for the in combination impacts (on species and habitats) to result in impacts on biodiversity and ecosystem functioning.

The impacts on biodiversity from construction and operation of the planned NSP2 pipeline within the Danish waters have been assessed with focus on the different trophic levels of the food web and on both abiotic and biotic compounds of the ecosystem, including introduction of non-indigenous species.

Given the low biodiversity within the Danish waters, the interactions within communities and the ecosystem as a whole are considered to have low resilience to change. Taking into consideration the importance of biodiversity, the sensitivity of the receptor towards sources of potential impacts associated with NSP2 is considered to be high.

9.13.1 Construction phase

As demonstrated in 9.6 - 9.12, NSP2 will not result in significant impacts on species (individual or population), habitats, nor the integrity of protected areas during the construction phase. Impacts at these levels are assessed to be negligible except for a minor impact on marine mammals due to underwater noise.

Based on a review of the potential for in combination impacts on species and habitats during construction, it is considered that NSP2 will not impact the overall integrity and functioning of the habitat, nor the trophic interactions between species. This is primarily due to the fact that NSP2 will have only temporary, negligible impacts on the bottom trophic levels (see sections 9.6 - 9.7), whose function are particularly important given that the food web in the Baltic Sea is bottom controlled. Furthermore no significant impacts on higher trophic levels are anticipated as a result of direct impacts (see section 9.8 - 9.10) or impacts on the food web. In this regard, the construction of NSP2 will not result in a significant impact on two of the main pressures on biodiversity (i.e. eutrophication or physical loss/disturbance).

The potential to introduce non-indigenous species (NIS) is the only source of impact specific to biodiversity during the construction phase. In order to minimise the risk of introducing NIS into the Danish section of the Baltic Sea, construction vessels will conduct ballast water exchange outside of the Baltic Sea. Furthermore NSP2 will prepare Ballast Water Management Plans which will include measures to ensure adherence to OSPAR/HELCOM General Guidance on the Voluntary Interim Application of the D1 Ballast Water Exchange Standard in the North East Atlantic. Ballast tanks will also be cleaned regularly and washing water delivered to reception facilities ashore in line with IFC EHS Guidelines on shipping and the International Convention for the Control and Management of Ships Ballast Water and Sediments.

With due consideration of the above, it has been assessed that impacts at species or habitats level during construction would not combine to result in impacts which would be sufficient to cause a change in biodiversity nor ecosystem functioning. However, taking into account the potential for the introduction of NIS and based on a conservative approach, it is considered that impacts on biodiversity (and ecosystem functioning) will be local, temporary and of low intensity. Therefore the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and high sensitivity of the receptor, the overall impact on biodiversity during the construction phase is assessed to be negligible.

9.13.2 Operational phase

As demonstrated in sections 9.6 - 9.12, NSP2 will not result in significant impacts on species (individual or population), habitats nor the integrity of protected areas during the operational phase. Impacts at these levels are generally assessed to be negligible except for the change of habitat which has been assessed to be minor for the benthic environment.

Based on a review of the potential for in combination impacts during operation, it is considered that NSP2 will not impact the overall integrity and/or functioning of the habitat, nor the trophic interactions between species. This is primarily due to the fact that NSP2 will only have negligible impacts on the bottom trophic levels (see sections 9.6 - 9.7), whose function are particularly important given that the food web in the Baltic Sea is bottom controlled. Furthermore no significant impacts on higher trophic levels are anticipated as a result of direct impacts (see sections 9.8 - 9.10) or impacts on the food web. In this regard, NSP2 will result in no impacts the pressures on biodiversity, including the main pressures (i.e. eutrophication or physical loss/disturbance)

The potential to introduce NIS is the only source of impact specific to biodiversity during the operational phase. However, as the only vessel activity during the operational phase is associated to planned maintenance activities, where ballast water is rather taken in from the Baltic Sea than released, no impacts related to the introduction of NIS are expected. Notwithstanding this, hard-bottom species may use the NSP2 pipelines as an area of artificial reef which bridges otherwise discrete hard-bottom areas. This has the potential to encourage the spread of NIS due to migration along the NSP2 pipelines. However, the abiotic conditions within the Bornholm Basin (i.e. low light and hypoxic/anoxic) will function as a barrier which will prevent migration of species along the NSP2 pipelines.

With due consideration of the above, it has been assessed that impacts at species or habitats level during operation would not combine to result in impacts which would be sufficient to cause a change in biodiversity or ecosystem functioning. However, taking into account the potential for the NIS spreading and based on a conservative approach, it is considered that impacts on biodiversity (and ecosystem functioning) will be local, long-term and of low intensity. Therefore the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and high sensitivity of the receptor, the overall impact on biodiversity during the construction phase is assessed to be negligible.

9.13.3 Summary of impacts

The assessments of the potential impacts are summarised in Table 9-31. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-31 Assessment of the overall impact during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Transboundary impacts
Sources of potential impact during construction	High	Negligible	Negligible	No
Sources of potential impact during operation	High	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-31) the potential impacts on biodiversity (and ecosystem functioning) during construction and operation of NSP2 either individually or in combination, are assessed to be not significant.

9.14 Shipping and shipping lanes

The potential sources of impacts on shipping and shipping lanes during construction and operation of NSP2 in Danish waters are listed in Table 9-32 and assessed below.

Table 9-32 Sources of potential impact on shipping and shipping lanes

Source of potential impact	Construction phase	Operational phase
Imposition of safety zones around vessels	X	X

For impacts during the construction phase, this assessment focuses on stationary or slow moving construction vessels which will have associated safety zones (e.g. the pipe-lay vessel or inspection vessels). The remaining construction related ship traffic, which will move with normal sailing speed and obey the same navigation rules as all other commercial ships sailing in the Baltic Sea (e.g. service vessels or pipe carrying vessels sailing from storage yards to the pipe-lay vessel), will not cause any impacts or restrictions on existing ship traffic. Therefore, no further consideration has been given to this type of construction ship traffic in this section.

9.14.1 Construction phase

In the following, potential impacts on shipping and shipping lanes during the construction phase are assessed.

9.14.1.1 Imposition of safety zones around vessels

Certain vessels used during construction will have limited ability to manouver (i.e. those involved in pipe-lay activities) such that a safety zone is imposed. The shipping lanes crossed by the proposed NSP2 route in Danish waters generally provide sufficient space and water depth for ships to plan their journey and safely navigate around possible temporary obstructions. For example, the TSS Adlergrund (which has an average of 10 ships per day on a yearly basis in each direction) has a total TSS width of 7.2 km and sufficient water depth on each side to allow ships to navigate around obstructions. A review of ship movements during the construction of NSP showed that navigators on the commercial ships made course adjustments in good time to safely pass the pipe-lay vessel and the safety zone /430/. The sensitivity of the ship traffic to the impact from the imposition of safety zones around construction vessels is therefore assessed to be low.

During construction, the contractor will implement a safety zone in the order of 3,000 m (approximately 1.5 nm) for the anchor lay barge, 2,000 m (approximately 1 nm) for the DP pipe-lay vessel, and 500 m radius for other vessels that are restricted in their manoeuvrability, to be agreed with the authorities. Contractors will be required to develop and implement monitoring (including tracking of vessels through AIS data) and communication protocols and procedures to address vessels approaching the safety zone.

Only vessels involved in the construction of NSP2 will be allowed inside the safety zone, therefore all other vessels that are not involved in the construction activities will be required to plan their journey around the safety zone. In this regard, diving, anchoring, fishery or work on the seabed will also be prohibited within the safety zone. NSP2, in conjunction with relevant construction contractors and the Danish Maritime Authority, will announce the locations of the construction vessels and the size of the requested Safety Exclusion Zones through Notices to Mariners in order to increase awareness of the vessel traffic associated with the project.

However, the imposition of the safety zone will be temporary at any given location as the construction spread is continuously moving. The pipe-lay vessel and its support vessels will move along the proposed pipeline alignment at a rate of approximately 2.5 km per day, depending on weather conditions. In total, the construction activities in Danish waters are expected to last approximately 135 days for the lay of the two pipelines.

In summary, the impact on shipping and shipping lanes associated with the imposition of a safety zone will be local, temporary, and of low intensity (because the impact does not lead to any permanent change in the structure or function of the ship traffic). Therefore, the impact magnitude is assessed to be low.

Based on the low impact magnitude and low sensitivity of the receptor, the overall impact on shipping and shipping lanes is assessed to be minor.

An above-water tie-in (see section 6.4.3) may be proposed in the TSS Adlergrund southwest of Bornholm in Danish waters due to the water depth being ideal for this type of procedure. As described in section 13.2.3 it is considered a safe operation in relation to navigational safety regardless of the position of the AWTI in the entrance to the west bound lane of the TSS Adlergrund. This is due to the traffic intensity in the TSS in combinations with the precautionary measures and the relatively short time frame of the operation.

9.14.2 Operational phase

Based on the justification provided above (section 9.14.1) the sensitivity of the ship traffic to the imposition of safety zones during operational phase is assessed to be low.

No project-related vessels will be present along the pipeline route during normal operation of the pipelines. However, external surveys of the NSP2 pipelines by project-related inspection vessels are expected to be carried out at one- or two-year intervals at the beginning of the operational phase. Later in the operational phase, there may be longer intervals between these surveys depending on the survey results. The inspection vessels will be relatively small and travel along the proposed NSP2 route at a speed of around 2 to 4 knots. Typically, a safety zone with a radius of approximately 500 m will be established around the inspection vessels. Non-project vessels will not be allowed inside the 500 m radius and will therefore be required to plan their journey around the safety zone.

This is significantly smaller than the radius of the safety zone for the pipe-lay vessel during the construction phase, and will also be temporary (moving with the inspection vessel).

In summary, the impact on shipping and shipping vessels from imposition of safety zones around survey vessels will be local, temporary, and of low intensity (because the impact does not lead to any permanent change in the ship traffic). Therefore, the impact magnitude is assessed to be negligible.

Based on the low sensitivity of receptor and the negligible impact magnitude, the overall impact on shipping and shipping lanes is assessed to negligible.

9.14.3 Summary of impacts

The potential impacts on shipping and shipping lanes during construction and operation of NSP2 within Danish waters are summarised in Table 9-33. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-33 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Imposition of safety zones around vessels	Low	Low	Minor	No
Operational phase				
Imposition of safety zones around vessels	Low	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-33) the potential impacts on shipping and shipping lanes from construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.15 Commercial fishery

The potential sources of impacts on commercial fishery during construction and operation of NSP2 are listed in Table 9-34 and assessed below.

Table 9-34 Sources of potential impacts on commercial fishery

Source of potential impacts	Construction phase	Operational phase
Imposition of safety zones around vessels	X	
Physical disturbance above water - presence of vessels	X	
Physical presence of pipelines and structures on the seabed		X

Commercial fishery in Danish waters comprises both Danish fishing boats and fishing boats of other nationalities bordering the Baltic Sea. In this section focus is on the potential impacts on Danish fishery in the area. It should however be noted that any impacts identified on Danish fishermen in Danish waters would be the same for fishermen of other nationalities fishing in Danish waters.

9.15.1 Construction phase

In the following sections, the sources of potential impacts on commercial fishery during the construction phase are assessed.

9.15.1.1 Imposition of safety zones around vessels

The fishery in Danish waters is of local or regional significance to the livelihoods of some fishermen. However, given the availability of alternative fishing grounds which can provide the same service, the sensitivity of the fishery is assessed to be medium.

The contractor will implement a safety zone in the order of 3000 m (approximately 1.5 nm) for the anchor lay barge, 2000 m (approximately 1 nm) for the DP pipe-lay vessel, and 500 m radius for other vessels that are restricted in their manoeuvrability, to be agreed with the authorities. Unauthorised ship traffic, including fishing vessels, will not be permitted to enter this safety zone. However, as the pipe-lay vessel will move forward with a speed of approximately 2.5 km per day, depending on weather conditions, the imposition of the safety zone at any given location will be temporary. The construction activities in Danish waters are expected to last approximately 135 days for the lay of the two pipelines.

NSP2, in conjunction with relevant construction contractors and the Danish Maritime Authority, will announce the locations of the construction vessels and the size of the requested Safety Exclusion Zones through Notices to Mariners in order to increase awareness of the vessel traffic associated with the project. Where appropriate for construction activities, a fisheries representative will be present on one of the construction vessels to provide direct information to the fishermen and other marine users. This was also done successfully during the construction of NSP. Construction activities, as confirmed by fishermen on several occasions, are not considered a big problem by the fishermen. They will simply avoid the lay vessel and other construction activities during the construction phase.

In summary, the impact on commercial fishery from imposition of safety zones around construction vessels will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the medium sensitivity and the negligible impact magnitude, the overall impact on commercial fisheries is assessed to be negligible.

9.15.1.2 Physical disturbance above water - presence of vessels

Based on the justification provided in section 9.15.1.1, the sensitivity of commercial fishery to physical disturbance above water is assessed to be medium.

During construction, supply vessels will bring pipes and other supplies to the pipe-lay vessel. The increased traffic in the area has the potential to damage fishing gear, particularly longlines at the surface of the water column. Longlines are in some cases up to several kilometres long (equipped with hooks every 1-3 m) and could be cut if crossed by a vessel. However, the potential impact would be local (along the supply line route) and temporary (during supply vessel movements). Approximately 20 vessels from Bornholm periodically use this type of equipment (some of which are fishing for cod close to the seabed, and therefore the lines are not disturbed by traversing vessels) and as such the intensity is assessed to be low.

In summary, the impact on commercial fishery from physical disturbance above water will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the medium sensitivity and the negligible impact magnitude, the overall impact on commercial fisheries is assessed to be negligible.

9.15.2 Operational phase

In the following sections, the sources of potential impacts on commercial fishery during the operational phase are assessed.

9.15.2.1 Physical presence of pipelines and structures on the seabed

Based on the justification provided in section 9.15.1.1, the sensitivity of commercial fishery to physical presence of pipelines and structures on the seabed is assessed to be medium.

During operation the physical presence of pipelines and structures on the seabed has the potential to impact on fishing activities through either protection zones (loss of opportunity) or through obstruction (potential damage or loss of gear). Offshore pipelines in Danish waters automatically get a 200 m wide protection zone along each side of the pipeline in which e.g. bottom trawl activities are not allowed[48]. However, the NSP2 pipelines in Danish waters have been designed to be resistant to impacts from any interaction with fishing gear and other larger objects. As such, NSP2 will apply for a dispensation to remove the fishery restriction zone around the pipelines to allow fishing activities. Therefore the following paragraphs focus on impacts through obstruction.

Obstruction impacts will essentially be limited to bottom trawling activities, as the use of gear such as gill nets, pound nets, Danish seine and longlines allows fishery in the area without the risk of incidence or obstruction. Furthermore, pelagic trawlers will be able to avoid the NSP2 pipelines by allowing a sufficient depth between the pipelines and the towed net.

The NSP2 pipelines will have an outside diameter of approximately 1.4 metres. In some parts of the proposed NSP2 route in Danish waters the pipelines may be fully exposed on the seabed. However, in many locations natural embedment (and post-lay trenching) of the pipelines will reduce the actual height above the seabed. Analysis of the embedment of the existing NSP pipelines in Danish waters show that five years after installation, the pipelines are embedded at least 50% in many locations. A similar level of embedment is expected for the NSP2 pipelines.

Where NSP2 crosses the NSP pipelines rock placement will be performed (see section 6), the height of the rock berms is assumed to be up to approximately 5 metres above the seabed at this location.

There is a potential for trawl gear to get stuck in areas where the pipelines are placed directly on the seabed, especially if the approach angle to the pipelines is small (less than 15 degrees). In areas where the pipelines does not naturally embed itself into the seabed, fishermen will therefore have to cross the pipelines at as steep an angle as possible – preferable 90 degrees – to reduce the risk of the trawl boards getting stuck. Therefore, the NSP2 pipelines will result in fishermen having to adapt their trawl patterns. Experiences from the NSP pipelines, however, show that fishermen can coexist with the pipeline system and thus far no gear has been reported lost or damaged.

The distance between the NSP pipelines and the NSP2 pipelines will be approximately 1,200 meters in Danish waters. The separation distance may vary slightly along the proposed NSP2 route, seeking to maximise the possibility for fisherman to trawl between the pipelines whilst also optimising the route and spatial planning.

The fishermen most affected by activities in Danish waters will be those from Bornholm. The harbour of Nexø on the eastern part of Bornholm has the largest number of fishing vessels (33 vessels in 2014), which are dominated by trawlers. Other important harbours in relation to the value of catches such as Tejn, Hasle and Rønne have between 7-10 fishing vessels primarily using trawls.

In summary, the impact on commercial fishery from the presence of pipelines and structures on the seabed will be local, long-term and of low intensity (as the presence of the pipelines and structures on the seabed is considered to have a limited effect on fishery patterns). Therefore, the impact magnitude is assessed to be low.

Based on the medium sensitivity and the low impact magnitude, the overall impact on commercial fisheries is assessed to be minor.

[48] Order no. 939 of 27 November 1992 - Order on Protection of Submarine Cables and Pipelines

9.15.3 Summary of impacts

The impacts on commercial fishery during construction and operation of NSP2 within Danish waters are summarised in Table 9-35. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-35 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Imposition of safety zones around vessels	Medium	Negligible	Negligible	No
Physical disturbance above water - presence of vessels	Medium	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines on the seabed	Medium	Low	Minor	Yes

Based on the conclusions in the sections above (see Table 9-35) the potential impacts on commercial fishery from construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.16 Cultural heritage

The potential sources of impacts on cultural heritage during construction and operation of NSP2 are listed in Table 9-36.

Table 9-36 Sources of potential impacts on marine cultural heritage

Sources of potential impact	Construction phase	Operational phase
Physical disturbance on seabed	X	
Physical presence of pipelines and structures on the seabed		X

To ensure the integrity of cultural heritage during the construction and operation of NSP2, detailed geophysical reconnaissance surveys of the proposed NSP2 route have been performed, see section 7.17. Objects of potential cultural importance have been identified and where required will be subjected to further visual inspection in a later stage of the project. The need for this further inspection will be agreed in consultation with the relevant Danish authorities.

9.16.1 Construction phase

In the following sections, the sources of potential impacts on cultural heritage during the construction phase are assessed.

9.16.1.1 Physical disturbance on seabed

Due to the high importance of cultural heritage objects (CHO) or sites, the protection under the Danish Museum Act (§ 29g of LBK no. 358 of 08/04/2014) as well as the low resilience to potential impacts from construction activities the sensitivity is assessed to be high.

Physical disturbance on the seabed during the construction phase has the potential to damage cultural heritage sites/objects or render these inaccessible for future research during the operational lifetime of the pipeline.

Should an anchored pipe-lay vessel be used for pipeline installation, anchor handling and the sweep of anchor wires could potentially cause damage to CHOs present in the anchor corridor. Similarly, anchoring in areas of submerged Stone Age settlements could potentially disturb the stratigraphy of the archaeological layers and possibly destroy artefacts. However, the proposed

NSP2 route will not pass through areas where submerged Stone Age settlements may be present and as such this impact has not been assessed any further.

In the event that an anchored lay vessel is used, an anchor corridor survey will be undertaken to identify, verify, and catalogue all obstructions. Plans and procedures for the placement and use of pipe-lay vessel anchors will be prepared to ensure that wires and chains are used in a manner that avoids impacts on known cultural heritage sites. The pipe-lay vessel anchoring plans shall include provisions to ensure that at no time (immediately after deployment, after dragging on the seabed and during recovery/redeployment) the anchor or the anchor wire are within a certain distance (measured on the horizontal and vertical plane) of any identified CHO. The distances will be agreed with the Danish Agency for Culture and Palaces. Anchor patterns in the proximity of CHOs will be approved prior to construction in consultation with national cultural heritage agencies as required.

Based on the geophysical surveys a total of seven potential wrecks have been identified in the proposed NSP2 route corridor. Furthermore, a recognised marine archaeology agency will screen the survey data with the aim of assessing all CHOs of potential importance in the proposed pipeline corridor. Subsequently, and based on the supplemental screening, visual inspections of objects of potential cultural value will be performed in agreement with the relevant Danish authorities (The Danish Agency for Culture and Palaces).

During NSP a number of wrecks were identified in the route corridor and as such a number of mitigation measures were implemented including a controlled lay and a suitable exclusion zone around identified wrecks and possible CHOs. Furthermore, a wooden rudder was salvaged for preservation prior to the construction phase of NSP /379/, /380/. The post-lay wreck monitoring programme for NSP consisted of visual inspection of two wrecks located closest to the pipeline route and confirmed that neither of the wrecks in Danish waters were affected by the installation of the pipeline /381/, /382/.

In the pipeline routing process for NSP2, an initial avoidance buffer of up to 200m (to be determined in consultation with individual regulations) will be placed around all CHOs within the nearshore and offshore regions of the project area to provide for sufficient separation distances between wrecks and the pipeline route. Route alternatives will be assessed to avoid impacts to wrecks and measures will be undertaken to ensure that wrecks of cultural heritage importance are protected. The final exclusion zone, will be agreed with the relevant authorities once the route has been finalised and installation vessel type has been confirmed.

In the event that a CHO is located in a position which cannot be avoided by re-routing the pipeline due to other constraints, an object-specific management plan will be prepared.

For the construction of underwater rock berms, fall pipes will be used to direct rock placement in a precise manner for all areas within a certain distance of known cultural heritage sites. The distances will be agreed with the Danish Agency for Culture and Palaces.

Even the highest standard of geophysical survey may not identify every single archaeological object of importance. Therefore, a chance finds procedure will be implemented to manage actions in the event of chance finds of objects that could potentially be cultural heritage objects, munitions, or existing installations. The chance finds procedure will prescribe notification instruction to inform the national cultural heritage agencies of the finds, contractor roles, management actions, responsibilities and lines of communication /378/.

Based on the procedures described above no impacts on cultural heritage are expected. However, conservatively, impacts on cultural heritage can be considered to be local, long-term and of low intensity. Therefore, the impact magnitude is judged to be negligible.

Therefore, based on the negligible impact magnitude and high sensitivity of the receptor, the overall impact from the disturbance of the seabed during the construction phase is assessed to be negligible.

9.16.2 Operational phase

In the following sections, the sources of potential impacts on cultural heritage in relation to the operational phase are assessed.

9.16.2.1 Physical pipelines and structures on the seabed

As mentioned above the sensitivity of cultural heritage objects or sites is assessed to be high.

The long-term presence of the pipelines on the seabed have the potential to alter sedimentation patterns and/or cause erosion around protected wrecks due to local changes in currents in the areas where the pipelines have been placed directly on the seabed.

However, as assessed in sections 9.2 and 9.3, the local currents will not change due to the presence of the NSP2 pipelines and sedimentation will be confined to the immediate vicinity of the pipeline route. Furthermore, as NSP2 has been routed to avoid potential cultural heritage objects, and where required an exclusion zone around CHOs will be established (the final radius of the zone will be determined in consultation with individual regulations), no impacts from erosion around CHOs is anticipated.

The cultural heritage monitoring programme undertaken for NSP showed that the presence of the pipeline on the seabed did not cause disturbance of any identified wrecks /380/. On the basis of the results from the NSP monitoring survey, in combination with the proposed routing for the NSP2 pipelines, no impacts on cultural heritage are expected. However, conservatively, impacts on cultural heritage can be considered to be local, long-term and of low intensity. Therefore, the impact magnitude is judged to be negligible.

Therefore, based on the negligible impact magnitude and high sensitivity of receptor, the overall impact from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.16.3 Summary of impacts

The impacts on cultural heritage during construction and operation of NSP2 within Danish waters are summarised in Table 9-37.

Table 9-37 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance of the seabed	High	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines and structures on the seabed	High	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-37) the potential impacts on cultural heritage from construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.17 People and health

The potential impacts on people and health during construction and operation of NSP2 are listed in Table 9-38.

Table 9-38 Sources of potential impacts on people and health

Source of potential impacts	Construction phase	Operational phase
Physical disturbance above water – noise	X	X
Physical disturbance above water – light	X	X

This assessment has been undertaken with reference to recommendations of the World Health Organization (WHO) as appropriate.

9.17.1 Construction phase

In the following sections, the sources of potential impacts on people and health during the construction phase of NSP2 are assessed, particularly in respect to noise and light.

9.17.1.1 Physical disturbance above water - noise

Construction activities have the potential to result in airborne noise which may have health impacts on the residents of Bornholm and Ertholmene (i.e. disturbing sleep). People are inherently considered a receptor of high sensitivity towards noise.

The municipality of Bornholm does not have specific guidelines for construction noise, but WHO recommends that in order to protect all individuals from health impacts, the night-time noise levels should not exceed 40 dB (A) /389/. The noise distribution at night is considered most critical (and conservative), as night-time noise is generally related to higher levels of annoyance and physical and mental health impacts occur at lower noise levels during the night than during the day.

As illustrated on Figure 8-13 the noise levels from the pipe-lay activities (considered worst-case for airborne noise) would range from 57 dB in close proximity to the activity, to 33 dB at a distance of 4,100 m from the activity. Pipe-lay will be conducted on a 24-hour basis, but the ship will move continuously along the route at a rate of approximately 2.5 km per day. As the proposed NSP2 route passes approximately 10 km and 15 km (shortest distance) from the coasts of Bornholm and Ertholmene respectively, the pipe-lay activities will not result in noise levels on land that exceed the recommendations from WHO (of 40 dB) /389/. In fact, it is unlikely that the noise will be heard above ambient levels on land.

In summary, the impact on people and health from disturbances above water (airborne noise) will be local, temporary and of low intensity. Therefore, the impact magnitude will be negligible.

Based on the high sensitivity and the negligible impact magnitude, the overall impact on people and health from noise is assessed to be negligible.

9.17.1.2 Physical disturbance above water - light

Construction activities have the potential to result in light pollution which may have health impacts on the residents of Bornholm and Ertholmene. People are inherently considered a receptor of high sensitivity towards light pollution.

High light intensities can disturb the sleep of people living close to the light source, and if the impact is persistent, long-term sleep disturbances can result in annoyance and negative health consequences. Pipe-lay will be conducted on a 24-hour basis, and during the dark periods at night, the pipe-lay vessel will use spotlights. The visibility of the vessel will be dependent on the metrological situation; on days with very good visibility, it is possible to see 19 km or more across the Baltic Sea /390/. Therefore, when visibility is good, the spotlight may be visible from both Bornholm and Ertholmene. However, the intensity of the impact will be low as the light source will be at least 10 km from land (where the pipeline runs closest to the Bornholm coast), and the light intensity will decrease with increasing distance. The low intensity of the spotlight is not considered sufficient to cause a nuisance by disturbing the sleep of the people living close to the southern or eastern coast of either island. Furthermore, although construction activities will occur on a 24-hour basis, the vessel will continuously be moving along the proposed NSP2 route (at a rate of 2.5 km per day) such that any potential impacts will be temporary.

In summary, the impact on people and health from disturbances above water (light) will be regional, temporary and of low intensity, such that the impact magnitude is assessed to be negligible.

Based on the high sensitivity and the negligible impact magnitude, the overall impact on people and health from light is assessed to be is negligible.

9.17.2 Operational phase

The pipeline itself will not have an impact on people and health in the operational phase. However, during the operations, internal/ external inspection activities will be required which may cause temporary airborne noise or light pollution from vessels. The frequency of inspections is expected to be every 1-2 years for the first years of operation, but this may be adjusted on the basis of experience and requirements.

During operation, potential impacts on people and health from inspection activities (resulting in noise and light) will be of the same magnitude or, more likely, lower than the magnitude predicted during the construction phase. It is therefore assessed that the overall impact on people health from inspection activities will be negligible.

9.17.3 Summary of impacts

The potential impacts on people and health during construction and operation of NSP2 within Danish waters are summarised in Table 9-39.

Table 9-39 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance above water – noise	High	Negligible	Negligible	No
Physical disturbance above water - light	High	Negligible	Negligible	No
Operational phase				
Physical disturbance above water – noise	High	Negligible	Negligible	No
Physical disturbance above water - light	High	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-39) the potential impacts on people and health from construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.18 Tourism and recreational areas

The potential impacts on tourism and recreational areas during construction and operation of NSP2 are listed in Table 9-40.

Table 9-40 Sources of potential impacts on tourism and recreational areas

Source of potential impacts	Construction phase	Operational phase
Imposition of safety zones around vessels	X	X
Physical disturbance above water - noise	X	
Release of sediments into water column	X	

This section focuses on both onshore and offshore tourism and recreation. Based on the findings of the baseline descriptions, the assessment also focuses on impacts to accommodations, attractions, activities and recreational areas on Ertholmene and on the eastern and southern part of Bornholm as well as offshore activities east and south of the islands.

9.18.1 Construction phase

In the following section, the sources of potential impacts on tourism and recreational areas during the construction phase of NSP2 are assessed.

9.18.1.1 Imposition of safety zones around vessels

As previously noted, the contractor will implement a safety zone in the order of 3000 m (approximately 1.5 nm) for the anchor lay barge, 2000 m (approximately 1 nm) for the DP pipe-lay vessel, and 500 m radius for other vessels that are restricted in their manoeuvrability, to be agreed with the authorities. The safety zones will prevent other ships from entering the waters around the construction work and any recreational activities on the water such as recreational diving or recreational fishing will be prohibited within the safety zones.

Generally, recreational divers use the waters close to the coast and only visit locations distant from the coast if the sites are of special interest, for example a shipwreck or other cultural heritage interests. Given that the proposed NSP2 route has been designed to avoid any sites with cultural heritage interests, see section 9.16, it is assessed that recreational divers will not experience any impacts from NSP2. The current section therefore focuses only on recreational fishing.

Recreational fishing in the waters around Bornholm is not constrained to any specific locations, therefore multiple areas within Danish waters are used. Furthermore, by their nature, the fishing activities serve as a recreational activity and do not sustain a household. Recreational fishing is therefore judged to have a low sensitivity to the imposition of safety zones.

Recreational fishing vessels, will not be permitted to enter the safety zone. However, as the pipe-lay vessel will move forward with a speed of approximately 2.5 km per day, depending on weather conditions, the duration of the impact from the imposition of safety zones around vessels at any given location will be temporary. Furthermore, the impact will be limited to a radius of up to a maximum of 3,000 m (approximately 1.5 nm).

In summary, the impact of the imposition of safety zones on tourism and recreational activities (fishing) will be local, temporary and of low intensity. Therefore the impact magnitude will be negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact on tourism and recreational areas from imposition of safety zones around vessels is assessed to be negligible.

9.18.1.2 Physical disturbance above water – noise

Construction activities have the potential to increase airborne noise which may impact tourism and recreation on Bornholm and Ertholmene. On both islands, there are several areas associated with recreational activities and tourism which are susceptible to impacts from increased levels of noise (due to their reliance on a quiet and relaxing environment e.g. coastal walks and bird watching). Therefore tourism and recreation is considered to be a receptor of high sensitivity.

Recreational areas are important respites for many people and contribute to ensuring physical and mental well-being /392/. In many instances, the quality of the recreational areas is influenced by the composition of ambient noise (i.e. natural or mechanical sounds). Studies have shown that noise levels above 50 dB will decrease how pleasant the soundscape of the recreational area is perceived by the people visiting /393/.

As illustrated in Figure 8-13, the noise levels on Bornholm or Ertholmene will not reach levels near or above 50 dB at any time. In fact noise levels above ambient are not expected and the intensity of the impact will therefore be low. Furthermore, given the continual movement of the pipe-lay vessel along the proposed NSP2 route, impacts will be temporary.

In summary, the impacts on tourism and recreation from physical disturbance above the water will be local, temporary and of low intensity. Therefore, the impact magnitude is judged to be negligible.

Based on the high sensitivity of receptor and the negligible impact magnitude, the overall impact on tourism and recreation from airborne noise is assessed to be negligible.

9.18.1.3 Release of suspended sediments into water column

As described in section 9.4, water turbidity may increase in close vicinity to the proposed NSP2 route during the construction phase. It can potentially have an impact on tourism and recreation related to diving. Recreational diving is usually associated with visiting interesting locations such as wrecks or other CHO. Given that the pipeline has been designed to avoid sites of cultural heritage importance, see section 9.16, it is considered unlikely that recreational diving activities will be conducted in waters impacted by increased turbidity. Given that other suitable diving sites are present within Danish waters, the sensitivity of tourism and recreation towards release of suspended sediments into water column is low.

Recreational divers will not be allowed within the safety zone (which will vary between 500 m for support vessels to 3,000 m for anchor-lay vessel) where turbidity will be at its highest. Suspended sediment beyond the safety zone will be lower (see section 8.4.1), therefore the intensity is assessed to be low. Moreover, the highest increase in suspended sediments is associated with intervention works such as trenching and rock placement (see section 8.4.1). These construction activities will be limited up to maximum 20.5 km along the proposed NSP2 route and suspended sediments are expected to settle within a few hours in the close proximity to the pipelines.

In summary, the impact on tourism and recreation from suspended sediments in the water column will be local, temporary and of low intensity. The magnitude of the impact is thus assessed to be negligible.

Based on the low sensitivity of receptor and the negligible impact magnitude, the overall impact is assessed to be negligible.

9.18.2 Operational phase

In the current section, potential sources of impact occurring during the operational phase are assessed.

9.18.2.1 Imposition of safety zones around vessels

No project-related vessels will be present along the proposed NSP2 route during normal operation of the pipelines. However, it may be necessary to create temporary safety zones around survey vessels used during inspection of the pipeline system. Inspections are expected to be carried out with a frequency of 1 - 2 years for the first years and then may be adjusted on the basis of experience and requirements. The safety zones will prevent other ships (including recreational sailing vessels) from entering the waters around the construction work and any recreational activities on the water will be prohibited within the safety zones. As noted in section 9.18.1.1, tourism and recreational is judged to have a low sensitivity to the imposition of safety zones.

During operation, potential impacts on tourism and recreation from inspection activities (resulting in safety zones around vessels) will be of a lower magnitude than those predicted during the construction phase due to a reduced safety zone radius. It is therefore assessed that the overall impact on tourism and recreation from safety zones around vessels will be negligible.

9.18.3 Summary of impacts

The potential impacts on tourism and recreation from construction and operation of NSP2 within Danish waters are summarised in Table 9-41.

Table 9-41 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Imposition of safety zones around survey vessels	Low	Negligible	Negligible	No
Physical disturbance above water – noise	High	Negligible	Negligible	No
Release of sediments into water column	Low	Negligible	Negligible	No
Operational phase				
Imposition of safety zones around vessels	Low	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-41) the potential impacts on tourism and recreation from the construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.19 Existing and planned installations

The potential impacts on existing and planned infrastructure (offshore infrastructure mainly including cables, pipelines and offshore wind farms) during construction and operation of NSP2 are listed in Table 9-42. This section focuses on the potential for conflicts between NSP2 and existing and planned installations; potential cumulative impacts are addressed in section 12.

Table 9-42 Sources of potential impacts on existing and planned installations

Source of potential impacts	Construction phase	Operational phase
Physical disturbance on the seabed	X	
Physical presence of pipelines and structures on the seabed		X

No wind farms or areas designated for development of future wind farms, or of national interest for wind farms are present along the proposed NSP2 route (see Figure 7.21), therefore no possible conflicts have been identified. Given that the construction and operation of NSP2 would not prevent future wind farm projects being realised, no further consideration is given in relation to wind farms in this impact assessment. Instead this section focuses on the four existing cables and the existing NSP pipelines which are crossed by the proposed NSP2 route within Danish waters (see section 7.21).

9.19.1 Construction phase

9.19.1.1 Physical disturbance on the seabed

Construction activities have the potential to result in impacts on localised areas of existing pipelines and cables crossing the proposed NSP2 route (e.g. damage).

However, where the pipeline crosses existing infrastructure such as cables and pipelines, Nord Stream 2 will agree designs for safe crossing with the owner of the installations and implement the agreed design. Cable crossing designs will ensure that:

- A separation is maintained between the pipeline and the cable;
- The operation of the cable will not be impaired.

Therefore, subject to the implementation of the agreed crossing method, the sensitivity of existing and planned infrastructure is assessed to be low.

Conservatively, impacts on existing and planned infrastructure from physical disturbance on the seabed can be considered to be local, long-term and of low intensity. Subject to the implementation of the above, the construction of NSP2 is not expected to cause measurable damage to the existing installations. Therefore, the impact magnitude is assessed to be negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact is assessed to be negligible.

9.19.2 Operational phase

9.19.2.1 Physical presence of pipelines and structures on the seabed

The NSP2 pipelines will occupy a corridor of approximately 139 km in the Danish section, within which the seabed will be of limited availability to existing and planned installations. At crossings, the presence of the pipelines and support structures has the potential to hinder the ability to repair the existing cables and pipelines. This may have financial implication for the operators/owners of the cable/pipeline.

However, subject to the implementation of the agreed crossing method the sensitivity of existing and planned infrastructure is assessed to be low.

During the construction of NSP, flexible concrete mattresses were used for placement over the existing cables at the crossing locations to increase the bending radius imposed on the cables and to ensure a permanent vertical separation between the NSP pipelines and the cables. In cases where the cables were buried at a lesser depth, neoprene pads were added to the lower surface of the mattresses. For some crossings, concrete berm mattresses were used for placement under the NSP pipelines at locations adjacent to the crossing points to provide additional bearing support to the pipeline, thereby reducing the load on the cables at the crossing locations. No hinder in operation or maintenance of the existing installations has been reported. A similar approach is planned for NSP2.

Subject to implementation of best practice measures, impacts on existing and planned infrastructure from physical presence of pipelines and structures on the seabed will be local, long-term and of low intensity. The impact magnitude is therefore considered to be negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact is assessed to be negligible.

9.19.3 Summary of impacts

The potential impacts on existing and planned installations during construction and operation NSP2 within Danish waters are summarised in Table 9-43.

Table 9-43 Assessment of the overall impact during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance on the seabed	Low	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines and structures on the seabed	Low	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-43) the potential impacts on existing and planned installations from the construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.20 Raw material extraction sites

The potential impacts on raw material extraction during construction and operation of NSP2 are listed in Table 9-44.
Given that there have been no permits issued in respect to the exploration or extraction of natural resources within approximately 7 km of the proposed NSP2 route within Danish waters (see section 7.22), it is assumed that there will be no impacts on existing raw material extraction during construction.

Table 9-44 Sources of potential impacts on areas for raw material extraction

Source of potential impacts	Construction	Operation
Physical presence of pipelines and structures on the seabed		X

9.20.1 Operational phase

In the following sections, the sources of potential impacts on raw material extraction sites in relation to the operational phase of NSP2 are assessed.

9.20.1.1 Physical presence of pipelines and structures on the seabed

During operation the NSP2 pipelines will occupy a corridor of approximately 139 km in Danish waters, within which the seabed will be inaccessible for future extraction of raw materials. However, given that the proposed NSP2 route does not cross any sites which are of potential importance for raw material extraction, see section 7.22, in combination with the availability of designated raw material sites in the surrounding environment, the sensitivity of raw material extraction areas is low.

The proposed NSP2 route in Danish waters is located at depths greater than 20 m, where it is not considered feasible (due to technical and mechanical constraints) to establish new raw material extraction sites. Therefore the impact magnitude is considered to be negligible.

Based on the negligible impact magnitude and the low sensitivity, the overall impact on raw material extraction from the presence of pipelines and structures on the seabed is assessed to be negligible.

9.20.2 Summary of impacts

The potential impacts on raw material extraction during construction and operation of NSP2 within Danish waters are summarised in Table 9-45.

Table 9-45 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
No impacts	-	-	-	-
Operational phase				
Physical presence of pipelines and structures on the seabed	Low	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-45) the potential impacts on raw material extraction from the construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.21 Military practice areas

The potential impacts on military practice areas during construction and operation of NSP2 are listed in Table 9-46.

Table 9-46 Sources of potential impacts on military practice areas

Source of potential impacts	Construction phase	Operational phase
Physical disturbance above water - presence of vessels	X	

9.21.1 Construction phase

In the following sections, the sources of potential impacts on military practice areas during the construction phase of NSP2 are assessed, particularly in respect to increased vessel traffic.

9.21.1.1 Physical disturbance above water - presence of vessels

During construction, supply vessels will bring pipes and other supplies to the pipe-lay vessel. The increased traffic in the area has the potential to conflict with military activities occurring within designated military practice areas. However, NSP2 will, in due time, contact and coordinate with the appropriate authorities to ensure that there will be no conflict between military activities and the construction of the NSP2 pipeline. The sensitivity of military practice areas towards disturbance from project related presence of vessels is therefore assessed to be low.

Furthermore, subject to communication and coordination with the appropriate authorities (e.g. ADF), the impact magnitude is assessed to be negligible.

Based on the negligible impact magnitude and low sensitivity, the overall impact on military practice areas from increased vessel traffic is assessed to be negligible.

9.21.2 Summary of impacts

The potential impacts on military practice areas during construction and operation of NSP2 within Danish waters are summarised in Table 9-47.

Table 9-47 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Physical disturbance above water - presence of vessels	Low	Negligible	Negligible	No
Operational phase				
No impacts	-	-	-	-

Based on the conclusions in the sections above (see Table 9-47) the potential impacts on military practice areas from construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.22 Environmental monitoring stations

The potential impacts on the monitoring stations from construction and operational activities of the pipeline are summarised in Table 9-48.

Table 9-48 Sources of potential impacts on monitoring stations

Source of potential impacts	Construction phase	Operational phase
Suspended sediments and contaminants into the water column and sedimentation on the seabed	X	

9.22.1 Construction phase

In the following sections, the potential impacts on environmental monitoring stations during the construction phase of NSP2 are assessed.

9.22.1.1 Suspended sediments and contaminants into the water column and sedimentation on the seabed

As described in section 7.3 and 8.4, construction activities may result in increased suspended sediment (and contaminants) in the water column, and subsequent sedimentation in close vicinity to the proposed NSP2 route, which has the potential to impact measurements at environmental monitoring stations. If environmental monitoring stations are impacted by suspended sediments or contaminants in the water column it would have the potential to affect data collection which covers years of sampling. The sensitivity is therefore considered high.

The closest monitoring station is located approximately 7 km from the proposed NSP2 route. As previously described, modelling indicates that the area where sedimentation as a result of post-lay trenching exceeds 200 g/m^3, corresponding to a sediment layer of approximately 1 mm, is 0.54 km^2, distributed over the three trenched sections (section 8.4.1). Furthermore, modelling indicates that during post-lay trenching, an area of 139 km^2 may be affected by an SSC of >2 mg/l for a period of up to 12 hours, and an area of 7.65 km^2 may be affected by an SSC of >15 mg/l for up to 5 hours. Modelling results of rock placement indicate that an area of less than 1 km^2 may be affected by an SSC of > 2 mg/l (see section 8.4.1). Based on this it is assessed that there will be limited potential for impacts on the environmental monitoring stations. Regardless, should construction works be scheduled to be performed in the vicinity of long term monitoring stations, at a similar time to the planned measurement/sampling programme, then Nord Stream 2 AG will consult with the authority to minimise interference. The impact magnitude is therefore assessed to be negligible.

Based on the negligible impact magnitude and high sensitivity, the overall impact on environmental monitoring stations from suspended sediments and contaminants in the water column, as well as from sedimentation is assessed to be negligible.

9.22.2 Summary of impacts

The impacts on environmental monitoring stations during construction and operation of NSP2 within Danish waters are summarised in Table 9-49.

Table 9-49 Assessment of the overall impacts during construction and operation of NSP2

Source of potential impact	Receptor Sensitivity	Impact magnitude	Overall impact	Potential trans-boundary impact
Construction phase				
Release of sediments and contaminants into the water column and sedimentation on the seabed	High	Negligible	Negligible	No
Operational phase				
No impacts	-	-	-	-

Based on the conclusions in the sections above (see Table 9-49) the potential impacts on environmental monitoring stations from construction and operation of NSP2, either individually or in combination, are assessed not to be significant.

9.23 Summary of potential impacts

As described in the previous sections 9.1 to 9.22, the construction and operation of NSP2 is assessed potentially to have different impacts on the environment. The overall impacts on all receptors assessed in this EIA is summarised in Table 9-50 and Table 9-51.

Table 9-50 Summary of the overall impacts caused by the NSP2 project on physical-chemical and biological resources or receptors

Potential impact		Physical-chemical					Biological							
		Bathymetry	Sediment quality	Hydrography	Water quality	Climate and air quality	Plankton	Benthic flora and fauna	Fish	Marine mammals	Birds	Protected areas***	Natura 2000***	Biodiversity
Construction phase	Physical disturbance on seabed	Negligible	Negligible					Negligible	Negligible					Negligible
	Release of sediments into the water column				Minor		Negligible	Negligible	Negligible	Negligible	Negligible	No impact	No significant impact	Negligible
	Release of contaminants into the water column				Minor		Negligible	Negligible	Negligible	Negligible	Negligible	No impact	No significant impact	Negligible
	Release of CWA into the water column				Negligible		Negligible	Negligible	Negligible	Negligible	Negligible	No impact	No significant impact	Negligible
	Sedimentation on the seabed	Negligible	Negligible	Negligible				Negligible	Negligible		Negligible	No impact	No significant impact	Negligible
	Generation of underwater noise								Negligible	Minor **			No significant impact	Negligible
	Physical disturbance above water*										Negligible	No impact	No significant impact	Negligible
	Emissions of air pollutants and GHGs					Negligible								Negligible
	Introduction of non-indigenous species											No impact		Negligible
Operation phase	Presence of pipelines and structures on the seabed	Negligible	Negligible	Negligible								No impact	No significant impact	Negligible
	Changes of habitat							Minor	Negligible	Negligible				Negligible
	Physical disturbance above water*											No impact	No significant impact	Negligible
	Emissions of air pollutants and GHGs					Negligible								Negligible
	Generation of heat from gas flow through the pipelines				Negligible									Negligible
	Release of metals from anodes				Negligible		Negligible	Negligible	Negligible			No impact		Negligible
	Introduction of non-indigenous species											No impact		Negligible

* E.g. from presence of vessels, airborne noise and light
** Impact on Marine mammals from underwater noise is assessed to be "Negligible" for PTS/TTS and "Minor" for behavioural response

- (grey) Negligible impact
- (yellow) Minor impact
- (light green) It has been assessed that there will be no impact on protected areas.
- (green) For Natura 2000 sites, a Natura 2000 screening has been performed and it is assessed that there will be no risk of significant impact.

Table 9-51 Summary of the overall impacts caused by the NSP2 project on socio-economic resources or receptors

Potential impact		Socio-economic: Shipping and shipping lanes	Commercial fishery	Cultural heritage	Environmental monitoring stations	People and health	Tourism and recreational areas	Existing and planned installations	Raw material extraction sites	Military practice areas
Construction phase	Physical disturbance on seabed			Negligible				Negligible		
	Release of sediments into the water column				Negligible		Negligible			
	Release of contaminants in the water column				Negligible					
	Physical disturbance above water*		Negligible			Negligible	Negligible			Negligible
	Imposition of safety zones around vessels	Minor	Negligible				Negligible			
	Sedimentation on the seabed				Negligible					
Operation phase	Presence of pipelines and structures on the seabed		Minor	Negligible				Negligible	Negligible	
	Physical disturbance above water*					Negligible				
	Imposition of safety zones around vessels	Negligible					Negligible			

* E.g. from presence of vessels, noise and light

Negligible impact (grey) Minor impact (yellow)

Selected impacts are described in general terms below. For details on the assessments please refer to the relevant sections 9.1 to 9.22.

9.23.1 Construction phase

The pipeline installation phase in Danish waters is expected to last a total of approximately 135 days for the two pipelines and the installation is assumed to be sequential, meaning that one pipeline will be installed at a time in Danish waters.

The main sources of impacts during construction are considered to be associated to the presence of vessels, including the restriction zones around the construction site, as well as the necessary intervention work, including post-lay trenching and rock placement.

Post-lay trenching will displace the sediment from the trench and deposit sediment to the sides of the trench. Post-lay trenching is expected to be carried out in three sections within Danish waters, spanning up to maximum 20.5 km for each NSP2 pipeline, and is conservatively estimated to take maximum 2.6 days (62 hours), not including time for relocation. The volume of the trench is expected to be approximately 6.9 m^3/m.

The increased sedimentation of suspended material resulting from post-lay trenching in the vicinity of the pipeline has been modelled and shown to exceed 200 g/m^3, corresponding to a layer of approximately 1 mm in a total area of 0.54 km^2, including all three trenched sections.

The post-lay trenching and the consequent sediment spreading can potentially impact different physical-chemical and biological receptors (e.g. sediment quality, water quality, benthic fauna, fish, marine mammals etc.) as well as socio-economic receptors (e.g. cultural heritage and munitions). In general the overall impacts are assessed to be negligible except for the impacts from release of sediments and contaminants into the waters column where the impacts are assessed to have a minor overall impact on water quality, (see Table 9-50). Notwithstanding that, the potential impacts on biological and socio-economic environment from post-lay trenching are assessed not to be significant.

The intervention works are expected to also include rock placement, mainly in the area where the NSP2 pipelines are crossing the existing NSP pipelines to provide support for separation between the two systems. Furthermore, rock placement can be used as an alternative measure at the three post-lay trenching sections and/or where further stabilization of the pipelines is required.

The overall impacts from rock placement (e.g. sediment dispersion and noise propagation) have generally been assessed to be negligible. The impact from rock placement related to underwater noise is however assessed to have a minor overall impact on behavioural response in mamals (see Table 9-50). Notwithstanding that, the potential impacts on biological and socio-economic environment from rock placement are assessed not to be significant.

During the construction phase presence of vessels will be increased and temporary safety zones will be established around the pipe-lay vessels where unauthorised navigation is prohibited. Physical disturnance above water from the presence of vessels during construction is assessed to have a minor impact on marine mammals. Imposition of safety zones around vessels is assessed to have a minor impact on ship traffic. Potential impacts on other receptors are assessed to be negligible (see Table 9-50). Furthermore, the potential impacts on biological and socio-economic environment from presence of vessels and safety zones are assessed not to be significant.

In summary, the potential impacts from construction of NSP2, either individually or in combination, are assessed not to be significant.

9.23.2 Operational phase

The main sources of impacts during operation are considered to be associated with planned inspection and maintenance activities. Furthermore, the presence of the pipelines and structures on the seabed will potentially also cause impacts on the surrounding environment.

In general potential impacts on biologicl and socio-economic environment during the construction phase are assessed to be negligible except for the two potential impacts (see Table 9-50 and Table 9-51).

The changes of habitat for the benthic fauna and the fish communities in the proposed pipeline route due to the presence of the pipeline on the seabed is assessed to have potentially both positive and negative impacts on benthic fauna and fish. The impact is assessed to be minor.

Finally, the presence of the pipelines on the seabed may have impacts on the fishery where the pipelines traverse areas where bottom trawling is practiced. The pipelines are however designed to withstand trawling activities and no restriction zone for fishing is expected around the pipelines. The potential impact on fishery is therefore assessed to be minor, Table 9-51.

In summary, the potential impacts from operation of NSP2, either individually or in combination, are assessed not to be significant.

10 MARINE STRATEGIC PLANNING

In addition to analysing potential impacts on specific receptors in accordance with the EU Environmental Impact Assessment (EIA) Directive, it is also important to consider the impacts of NSP2 in the context of other relevant EU legislation and recommendations designed to protect the marine environment and create a framework for the sustainable use of marine waters in the Baltic Sea.

The objectives of this section are therefore to:

- supplement the information provided in section 4.3 on key EU Directives Marine Strategic Framework Directive (MSFD) and Water Framework Directive (WFD) as well as the Baltic Sea Action Plan (BSAP; and
- assess the degree of compliance of NSP2 with the objectives of these legislative tools (as they have been transposed into National Legislation), and management plans based on the potential impacts of NSP2 during construction and operation.

10.1 Legislative Context and Implementation Status

The legislation described in this section including the Marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD) together with the Baltic Sea Action Plan (BSAP) are closely interlinked. Together, they aim to improve the quality of the European waters as set out in the Marine Spatial Planning Directive, which was adopted by the European Parliament in July 2014, creating a common framework for maritime spatial planning in Europe (see section 4.3).

In particular, there are synergies between the MSFD and WFD, which have comparable objectives for Good Environmental Status (GES) of marine waters and Good Ecological/Good Chemical Status of surface waters respectively. Significant levels of overlap include chemical quality, eutrophication and other aspects of ecological quality, and hydromorphological quality. Where geographical overlap occurs (in coastal waters up to 12 nm), see Figure 10-1, the MSFD is generally being applied to those aspects which are not already covered by WFD.

Both the MSFD and WFD are also inter-related to the Habitats and Birds Directive. However, the scope of MSFD is far broader than all three directives in that it aims to achieve and maintain GES, which includes all marine biodiversity (and therefore requires an ecosystem approach), whilst the Habitats and Birds Directive focus on the conservation of particular habitats and species, and the WFD assesses the quality of each ecosystem component separately. In this regard, the impact of NSP2 in the context of the Habitats and Birds Directive has been addressed in section 9.10 - 9.12.

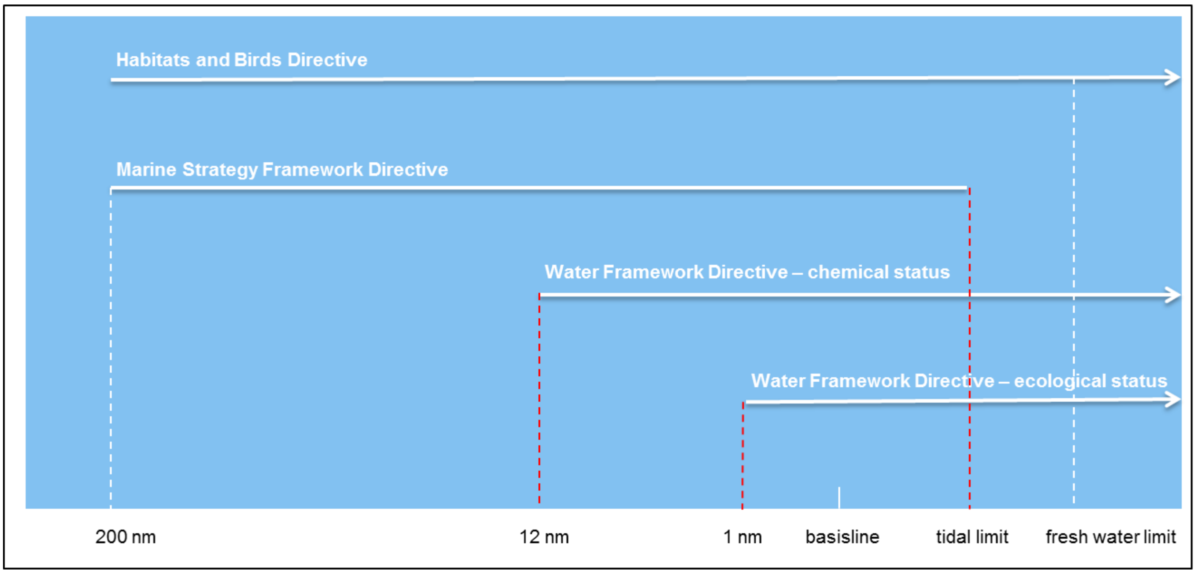


Figure 10-1 Marine Areas covered by EU Marine legislation

The MSFD requires that, in developing their marine strategies, Member States use existing regional co-operation structures to co-ordinate their actions with those of other countries in the same region or sub-region. The HELCOM Baltic Sea Action Plan is such a regional plan and thus is considered relevant to the Marine Strategies of the Baltic States and forms the basis for the countries' national strategies for reaching GES.

10.1.1 Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) is the first encompassing piece of EU legislation specifically aimed at protecting the marine environment and natural resources, encouraging the sustainable use of marine waters. It establishes a framework within which each of the Member States must take the necessary measures to achieve or maintain 'good environmental status' (GES) of the marine environment by the year 2020 at the latest (Article 1).

The MSFD outlines 11 high-level descriptors used to assess the GES of the marine environment (Annex I) and provides a list of associated anthropogenic pressures (Annex III). As these descriptors cover a broad range of topics, the EU Commission produced a set of detailed criteria and methodological standards for GES to help Member States measure progress of the status /440/.

As noted in section 4.3, the MSFD was implemented in Denmark by the Act on Marine Strategy (act 522 dated 26 May 2010, and the consolidation act dated 10 December 2015). In accordance with this legislation, the Danish Agency for Water and Nature Management has prepared a detailed assessment of the current environmental status (for each descriptor) with a definition of GES at regional levels /278/.

The Danish Agency for Water and Nature Management also issued a report including the environmental targets for the Danish sector of the Baltic Sea focusing on both environmental conditions and environmental pressures. For each target the authorities have designated specific indicators relevant to the subdivisions of the Danish waters /279/. Indicators are specific attributes of each GES criterion that can either be qualitatively described or quantitatively assessed to determine whether each criterion meets good environmental status, or to ascertain how far each criterion departs from GES. Although consideration has been given to indicators when preparing the assessments, specific reference has not been made to them.

For each indicator there is a condition criterion. Given that there are multiple targets for each descriptor in the Danish Marine Strategy it is considered appropriate to assess impacts of NSP2 on condition criteria.

Table 10-1 presents the definition of GES and the condition criteria associated with each descriptor. It also sets out the current environmental status for the descriptors within the Danish sector of the Baltic Sea (Bornholm and Arkona Basin) where available and identifies the associated anthropogenic pressures. The table also identifies where in the EIA further baseline information can be found. Current environmental statuses are not available for all descriptors, as identified in the annex to the report on the first phase of implementation of the Marine Strategy Framework Directive /433/.Where information in the Danish Marine Strategy was insufficient to determine the current environmental status reference has been made to the information from HELCOM /441/.

The classification scheme for current ecological and chemical status includes five categories: "high", "good", "moderate", "poor" and "bad". 'High' and 'good' statuses for ecological and chemical parameters result in an overall evaluation of GES for an area. In order to achieve 'GES' both ecological and chemical statuses must be at least good. If either ecological or chemical status is classified as 'moderate', 'poor' and 'bad' this result in 'impaired ecological status' or simply 'Not good status'.

Overall, the Danish Marine Strategy defines the environmental status of the Danish waters around Bornholm as 'poor' /278/, with the most significant anthropogenic pressures related to eutrophication, fishery and pollutants (e.g. metals).

Table 10-1 Description of GES with relevant criteria, statuses and pressures

Descriptor	Description of GES	Relevant Condition Criteria	Current Environmental status	Relevant pressures	EIA baseline information
D1 Biodiversity	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species reflect the prevailing physiographic, geographic and climatic relationship	• Species distribution • Population size • Population condition • Habitat distribution • Habitat extent • Habitat condition • Ecosystem structure	'Not good'[1]	All pressures	Sections 8.6-8.10
D2 Non-indigenous species*	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem	• Abundance and state characterisation of NIS in particular invasive species • Environmental impact of invasive NIS	N/A[3]	• P8	Section 8.15
D3 Commercial fish and shellfish*	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock	• Level of pressure of the fishing activity • Reproductive capacity of the stock • Population age and size distribution	'Not good'[2]	• P1 • P2 • P5 • P3 • P8	Sections 8.7, 8.8
D4 Food webs	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	• Productivity of key species or trophic groups • Proportion of selected species at the top of food webs • Abundance/distribution of key trophic groups/species	'Not good'[2]	All pressures	Sections 8.6-8.10
D5 Eutrophication*	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.	• Nutrients levels • Direct effects of nutrient enrichment • Indirect effects of nutrient enrichment	'Not good'[1]	• P7	Section 8.2, 8.4
D6 Sea-floor integrity	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic	• Physical damage having regard to substrate characteristics • Condition of benthic commu-	GES reached[2]	• P1 • P2	Section 8.1, 8.3 and 8.7

Descriptor	Description of GES	Relevant Condition Criteria	Current Environmental status	Relevant pressures	EIA baseline information
	ecosystems, in particular, are not adversely affected.	nities			
D7 Hydrographical cond.	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	• Spatial characterisation of permanent alterations • Impact of hydrographical changes	N/A[3]	• P4	Section 8.3
D8 Contaminants*	Concentrations of contaminants are at levels not giving rise to pollution effects.	• Concentration of contaminants • Effect of contaminants	'Not good'[1]	• P5	Section 8.2, 8.4
D9 Contaminants in seafood*	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.	• Levels, numbers and frequency of contaminants	'Not good'[2]	• P5	Section 8.2, 8.4 (precursors). Section 8.7
D10 Marine litter*	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	• Characteristics of litter in the marine and coastal environment • Impacts of litter on marine life	N/A[3]	• P3 • P6 •	Section 6
D11 Energy, Underwater noise*	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	• Distribution in time and place of loud, low and mid frequency impulsive sounds • Continuous low frequency sound	N/A[3]	• P3	Sections 8.7-8.10
Pressures identified in the MSFD annex III		**Impacts associated with the pressures in MSFD annex III) (NSP2 relevancy are underscored)**			
P1 Physical loss (Footprint)		Smothering, sealing			
P2 Physical damage (Physical disturbance)		Siltation, Abrasion, Extraction			
P3 Other physical disturbance		Underwater noise, Litter			
P4 Interference with hydrological processes		Significant changes to thermal or salinity regimes			
P5 Contamination by hazardous substances		Synthetic compounds, Non-synthetic compounds, radio nuclides			
P6 Release of substances		Other substances			
P7 Nutrient and organic matter enrichment		Fertilizers, Other N- or P-rich substances, Organic matter			
P8 Biological disturbance		Introduction of microbial pathogens, NIS, Extraction of species			

1: Information from Basis Analysis for Danish Marine Strategy /278/
2: Information from HELCOM /441/
3: No information available in either Danish Marine Strategy or HELCOM. Therefore it has not been possible to derive a current environmental status.
*: These descriptors are considered 'pressure descriptors', which relate to human pressures. In respect to D3, this is both a state and pressure descriptor.

A programme of measures is designed to achieve or maintain GES has been sent into public hearing in 2016. The measures are primarily of administrative and monitoring character, however, protection of six areas with restrictions on trawling, marine resource extraction and dumping sites are proposed in the Kattegat. The areas are more than 200 km away from the NSP2 route and will not be of relevance to NSP2. No further measures are been identified to date.

10.1.2 Water Framework Directive

The Water Framework Directive (WFD) is a key initiative aimed at improving water quality throughout the EU to achieve a good status of both groundwater and surface waters. In this regard, the WFD has a number of objectives, such as preventing and reducing pollution, promoting sustainable water usage, environmental protection and improving aquatic ecosystems. As noted above, whilst the main focus is fresh water, the Directive also covers transitional and coastal waters up to one nautical mile off the coast for ecological status and 12 nautical miles for chemical status. The objective of the WFD was to achieve 'good ecological and chemical status' for all EU waters by 2015. In 2016 a new management period started with the same target for 2021.

As noted in section 4.2.6, the WFD has been implemented in Denmark by the Act on Water Planning (Act 1606 dated 26 December 2013) and a number of associated orders. In accordance with this legislation, the Danish Ministry of the Environment (the authority responsible for implementing the WFD), published a management plans for each sub-region covering the period 2015 – 2021 in June 2016, including area 3.1 covering Bornholm /434/.

The Marine Strategy reports (basis analysis and target report) /278//279/ provide information on the environmental status (chemical and ecological) of Danish waters, anthropogenic pressures, monitoring programmes and the measures taken to achieve the objectives for the status of the waters, including the zone covered by the WFD. Although the plans themselves are not legally binding, an Executive Order (794/2016) was issued in connection with the plans. This set out a specific programme of measures designed to maintain or improve the environmental status of comprised bodies of water, and is legally binding.

Furthermore, the Executive Order 795/2016 sets out that all state authorities must work to prevent deterioration of the status of the water bodies and to achieve the environmental objectives set out. The environmental objective for the coastal waters of Bornholm is 'good ecological status' by 2021.

Management plan area 3.1, 'Bornholm', is the only plan of relevance to the NSP2 project; particularly the 12 nm zone from Bornholm and Christiansø (see Figure 10-2), which will be crossed by NSP2. The current chemical status within this 12 nm zone is 'good' based on measurements of benzo (a) pyrene and fluoranthene levels in mussels /281//282//283/. The proposed NSP2 route is located approximately 10 km from the 1 nm zone around Bornholm and 12 km from the 1 nm zone around Ertholmene , and has a current status of 'poor' around Bornholm and 'moderate' around Ertholmene /281//282//283/ based on phytoplankton biomass (chlorophyll-*a*), the depth of eelgrass and the Danish quality index for benthic fauna /282/.

The main pressures on the marine environment within Area 3.1 are related to eutrophication (particularly with regard to nitrogen), fishery and pollutants (e.g. metals) /280/.

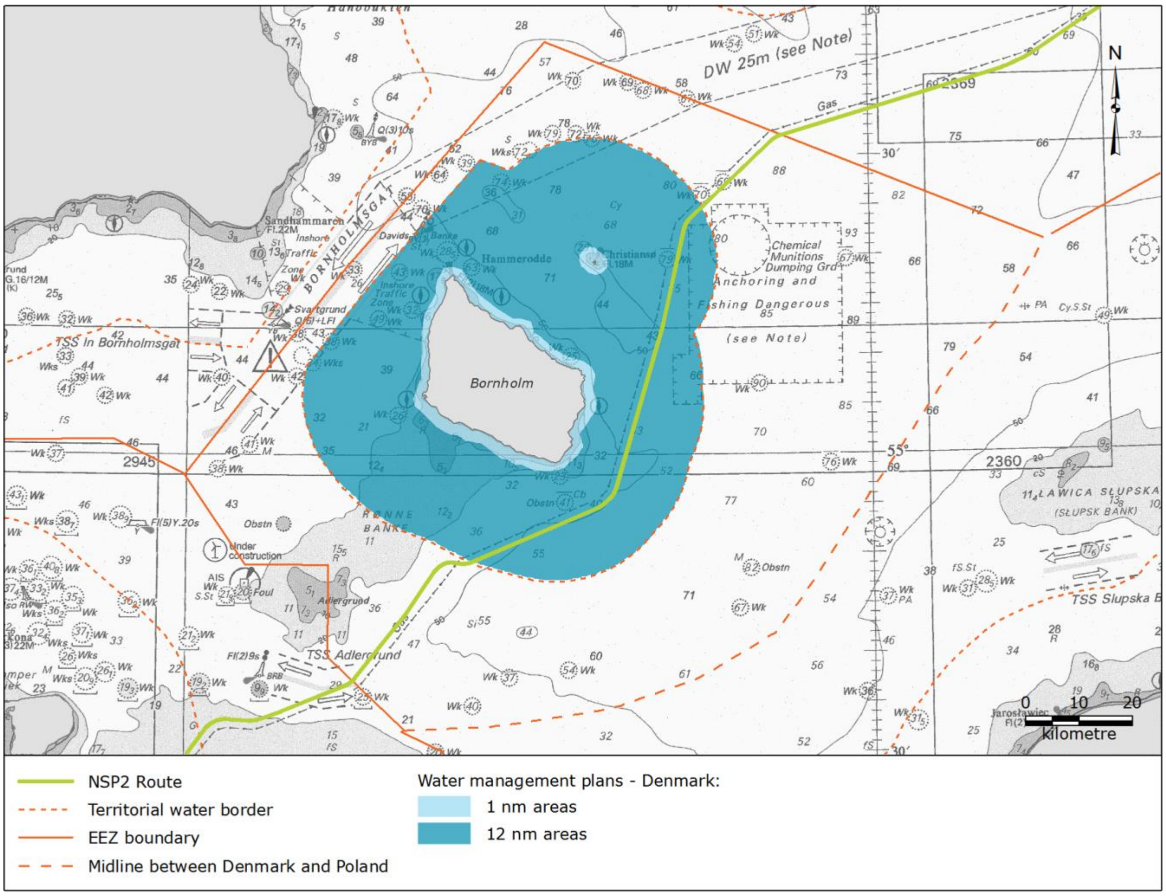


Figure 10-2 Management Area 3.1: Bornholm

According to the management plan for area 3.1 (2015-2021), the targets for the marine waters are 'good' chemical status within the 12 nm area and 'good' ecological status within the 1 nm area /281//282//283/. Area 3.1 is expected to meet the targets for 2021 through existing management measures /281//282/. The water quality along the NSP2 route is described in section 6.5.

10.1.3 HELCOM Baltic Sea Action Plan

The 1992 Helsinki Convention entered into force on 17 January 2000 and the Baltic Marine Environment Protection Commission (Helsinki Commission/HELCOM) was established. In 2007, the HELCOMs 'Baltic Sea Action Plan' (BSAP) was adopted; the contracting parties are Denmark, Estonia, Finland, Estonia, Latvia, Lithuania, Poland, Sweden, the Russian Federation and the European Union.

The BSAP is an ambitious programme to restore the good ecological status of the Baltic marine environment by 2021 /285/. Although the BSAP was originally adopted by all of the Baltic coastal states and the EU in 2007 (see above), a HELCOM ministerial meeting was held in October 2013 during which the Baltic Sea countries reconfirmed their commitment to the BSAP.

The main goals of the BSAP are to achieve a Baltic Sea which:

- is unaffected by eutrophication;
- is undisturbed by hazardous substances;
- has a favourable biodiversity conservation status; and which
- has maritime activities carried out in an environmentally friendly way.

The BSAP adopts an ecosystem approach, based on the integrated management of human activities impacting the marine environment and the marine ecosystem, thus supporting sustainable use of ecosystem goods and services. Under the BSAP, a number of recommendations are presented to support the four goals identified above. Included in the BSAP is also a document, listing indicators and target for monitoring and evaluation of the BSAP /285/.

As noted in section 4.3, Denmark is a signatory of the convention and therefore bound to implement measures relating to the BSAP.

10.2 Qualitative Compliance Assessment

In the following sections, a qualitative assessment of the compliance of NSP2 in the context of the above legislation is provided, supported by the assessments undertaken in chapter 9. The assessments have been undertaken assuming implementation of identified mitigation measures (see chapter 15) and assuming compliance with relevant legislation, as well as best practice.

10.2.1 Marine Strategy Framework Directive

The following sections discuss the potential for the construction and operation of NSP2 to prevent achievement of targets or the long-term goal for GES for each descriptor set out in the MSFD.

Below the pressure descriptors are discussed with focus on whether NSP2 activities will result in a worsening of the pressure (D2, D3, D5, D8, D9, D10 and D11). Hereafter NSP2 impacts on state descriptors are discussed based on the relevant pressures.

Pressure descriptors

10.2.1.1 Non indigenous species (D2)

Non-indigenous species (NIS) is considered a ‘pressure descriptor’ (relating to P8, Biological disturbance) which relates to human-induced pressures. The following sections discuss the potential for NSP2 to impact existing pressures, and conclude (on the basis of assessments presented in section 9.13) the potential for impact on the condition criteria for D2.

The target for D2 is to reduce introduction of NIS by vessel traffic.

NSP2 has the potential to introduce NIS through vessel movements (construction and operation) as well as colonisation along the pipelines (operation). Such introduction has the potential to threaten native species by competition for food and space. However, as discussed in section 15.3, NSP2 will prepare Ballast Water Management Plans which will include measures to ensure adherence to OSPAR/HELCOM General Guidance on the Voluntary Interim Application of the D1 Ballast Water Exchange Standard in the North East Atlantic. Implementation of these measures will reduce the risk of introducing NIS into Danish waters via vessel movements to a very low level.

In respect to operation, the NSP2 pipelines will introduce a hard substrate where there has previously been sand, creating a new habitat type. This impact would be highly localised to the proposed NSP2 route and the spread of NIS along the pipelines would be limited by changes in abiotic conditions (i.e. reduced light conditions, low oxygen conditions).

In summary, and as described in section 9.13, impacts during construction and operation (individually or in combination) will not result in significant impacts on the abundance and trends of NIS, or the overall environmental impact of NIS (criteria of D2).

It can therefore be concluded that NSP2 will not prevent or delay the achievement of targets or the long-term goal for GES for Descriptor D2.

10.2.1.2 Commercial fish and shellfish (D3)

Commercial fish and shellfish is considered both a 'state descriptor' and a 'pressure descriptor' (relating to P1 Physical loss, P2 Physical damage, P3 Other physical disturbance, P5 Contamination with hazardous substances and P8 Biological disturbance) as it relates to human-induced pressures. P5 Contamination with hazardous substances is discussed separately in 10.2.1.4 and not included below.

The target for commercially exploitable fish is to keep the spawning biomass at a safe biological limit. The following sections discuss the potential for NSP2 to impact existing pressures on D3, and conclude (on the basis of assessments presented in sections 9.7 and 9.8) the potential for impacts on the condition criteria.

Physical loss (P1) and physical damage (P2) resulting from construction activities is of particular relevance to shellfish. Physical loss will be limited to the immediate footprint of the pipeline, which in Danish waters corresponds to a total area of <0.1 km^2. The maximum level of siltation, which has the potential to cause physical damage, will be limited to an area of approximately 0.65 km^2 (see section 10.2.1.7).

Given the highly localised and temporary nature of these impacts, in combination with the fact that a proportion of the affected area is not colonised by benthic communities (due to abiotic conditions) impacts from physical loss and/or physical damage have been assessed to be negligible (see section 9.7).

Existing fishing pressures (both bottom trawling (P3) and midwater trawling (P8)) may be locally and temporarily redistributed due to the safety zone around NSP2 during the construction phase. However, no long term impacts are expected on fishing practices and extent. There are no restrictions during the operation phase.

Given the highly localised nature of these impacts, in combination with the fact that demersal fish species are present only along sections of the route where there are suitable abiotic conditions to support them (and no threatened species are affected), impacts from physical loss and damage have been assessed to be negligible (section 9.7 and 9.8).

Although some of the impacts described above occur simultaneously and hence have the potential to impact the same individuals, no significant in-combination impacts are anticipated.

In summary and on the basis of the above, impacts during construction and operation (individually or in combination) will not result in significant impacts on the level of fishing, stock fertility and/or stocks, age and size distribution (criteria of D3).

On that basis it can be concluded that NSP2 will not delay or prevent the achievement of the targets for commercial fish and shellfish in Denmark, nor prevent the achievement of the long-term goal for GES for Descriptor D3.

10.2.1.3 Eutrophication (D5)

Eutrophication is a 'pressure descriptor' (relating to P7, Nutrient and organic matter enrichment) which relate to human-induced pressures. Eutrophication has the potential to increase primary production (including also toxic algal blooms) and potentially offset the balance of the food web and ecosystem of the Baltic Sea.

The target for eutrophication is to keep the concentration of total N within the limits for chemical quality defined by the WFD for the 12 nm area. The following sections discuss the potential for NSP2 to impact existing pressures on D5, and conclude (on the basis of assessments presented in sections 9.4 and 9.6) the potential for impacts on each condition criteria.

Nutrients may be released from the sediment as a result of disturbance of the seabed by intervention works, pipe-lay and/or anchor handling during the construction phase. However, the transfer of nutrients from the sediments to the water column is assessed to have negligible impact on turbidity and based on this it is assumed that there is also negligible impact on oxygen content in Danish waters (see section 9.4). No algal blooms including those of toxic algae are expected and negligible impacts on pelagic or benthic communities (see section 9.6 and 9.7).

No release of nutrients is expected for the operational phase.

In summary and on the basis of the above, impacts during construction and operation (individually or in combination) will not result in significant impacts on the total N concentration in the water column (criteria of D5).

On that basis it can be concluded that NSP2 will not delay or prevent the achievement of the targets for eutrophication in Denmark and hence NSP2 will not prevent the achievement of the long-term goal for GES for Descriptor D5.

No impacts are expected during operation phase.

10.2.1.4 Contaminants (D8) and contaminants in seafood (D9)

Contaminants and contaminants in seafood are considered ‘pressure descriptors’. The descriptors are grouped as they are closely interlinked and targets overlap.

The target for contaminants in the marine environment is to keep the concentration in water, sediments and living organisms within limits defined by environmental standards of national legislation which includes the Environmental Protection Act and the Marine Environment Act. The target for contaminants in seafood is correlated to human health. The following sections discuss the potential for NSP2 to impact existing pressures on D8 and D9, and conclude (on the basis of assessments presented in sections 9.2 and 9.4) the potential for impacts on each condition criteria.

Hazardous substances (P5) will be released from NSP2 activities in both construction and operational phases due to release form sediments (construction phase) and anti-corrosion measures (operation phase). Management plans for all vessel activities ensure that no impacts on water quality as a result of discharges from vessels will occur.

With the exceptions of benzo[g,h,i]perylene and indenol[1,2,3-cd]pyrene, the ERL threshold levels established by HELCOM are not exceeded within the sediment along the proposed NSP2 route (see Section 9.2 and 9.4). Such exceedance occurs in deep parts of the NSP2 route where no benthos is present, preventing the compounds bioaccumulating in the food chain. CWA-associated risks were also assessed to be negligible in sections 9.2 and 9.4 and based on this it is assessed that that benthic or pelagic organisms will not be exposed to critical levels of contaminants in the water column.

Although some of the impacts described above occur simultaneously and hence have the potential to impact the same individuals, no significant in-combination impacts are anticipated (section 9.4, 9.6-9.9).

During operation phase, release of zinc from anodes will result in elevated concentrations in the water column however this is measurable only within a few meters from NSP2 and is assessed to be negligible (see section 9.4).

In summary and on the basis of the above, impacts during construction and operation (individually or in combination) will not result in significant impacts on the level of contaminants in exploited fish and shellfish and subsequently also negligible impact on human health (criteria of D8 and D9).

On this basis it is concluded that NSP2 will not prevent the achievement of the targets for contaminants in the marine environment and for contaminants in seafood in Denmark and hence NSP2 will not prevent the achievement of the long-term goal for GES for Descriptors D8 and D9.

10.2.1.5 Marine litter (D10)

Marine litter is defined as a 'pressure descriptor' which relates to human activities. Marine litter has the potential to disturb marina fauna in both movement and feeding.

The target is to prevent marine litter from impacting the marine ecosystem and the socio economic services provided by the ecosystem, as well as prevent the litter from acting as a vector for NIS. The following sections discuss the potential for NSP2 to impact existing pressures on D10, and conclude the potential for impacts on each criteria.

On the basis of section 6.7 and HSES MS management plans it is assessed that for both construction and operational phases there will be no physical disturbances of the sea, seabed or coastlines due to management plans for litter (P3 and P6) and hence, NSP2 would result in negligible impact on amount of litter in the water column, in by-catches and on beaches.

In summary and on the basis of the above, impacts during construction and operation (individually or in combination) will not result in significant impacts on the level of litter in the water column or on beaches (criteria of D10).

On this basis it is concluded that NSP2 will not delay or prevent the achievement of the targets for marine litter in Denmark and hence NSP2 will not prevent the achievement of the long-term goal for GES for Descriptor D10.

10.2.1.6 Energy, underwater noise (D11)

Underwater noise is a 'pressure descriptor' which relates to human induced activities. Elevation of underwater sound levels may mask sounds from the marine fauna or cause avoidance behaviour, whilst sound pulses have the potential to cause temporary or permanent damage to hearing apparatus.

The target for underwater noise is to prevent an increase of noise in the marine environment. The following sections discuss the potential for NSP2 to impact existing pressures on D11, and conclude (on the basis of assessments presented in section 8.4.3) the potential for impacts on criteria.

Underwater noise (P3) from seabed intervention works and vessel activity during the construction phase will temporarily elevate background noise levels. NSP2 will not result in acoustic impulses, i.e. munition clearance, in Denmark.

The underwater noise from rock placement may result in TTS for marine mammals within a zone of 80 m, and the activity. The intensity of the predicted noise levels will not cause permanent damage to the auditory organs of marine fauna and hence no long term and permanent impacts are anticipated. Behavioural and masking impacts on marine mammals and fish from underwater noise is assessed to be negligible. (See sections 9.8 and 9.9).

No underwater noise is anticipated for the operational phase.

In summary and on the basis of the above, impacts during construction and operation (individually or in combination) will not result in significant impacts on the noise level in the water column (criteria of D10).

On this basis it is concluded that NSP2 will not delay or prevent the achievement of the targets for energy and underwater noise in Denmark and hence NSP2 will not prevent the achievement of the long-term goal for GES for Descriptor D11.

State descriptors

10.2.1.7 Biodiversity (D1), food webs (D4) and Sea-floor integrity (D6)

The descriptors associated with biodiversity (D1), food webs (D4) and Sea-floor integrity (D6) are closely linked and in some instances overlap. Therefore, the following sections discuss the potential for NSP2 to impact existing pressures on all three state descriptors, and conclude (on the basis of assessments presented in sections 9.6 - 9.10 and 9.13) the potential for impacts on the condition criteria.
The targets of the three descriptors are to maintain the biodiversity for on species, population and habitats level and to ensure that structures and functions of ecosystems are are sustained.

Physical loss (P1) and physical damage (P2) resulting from construction activities (such as pipe-lay, intervention works and/or anchor handling (if required)) is of particular relevance to benthic communities which may experience burial or clogging of respiratory and filtration apparatuses. Impacts from physical disturbance of benthos, which includes physical loss and physical damage, is further discussed in section 9.7. Physical loss will be limited to the immediate footprint of the pipeline, which in Danish waters corresponds to a total area of <0.1 km^2. The maximum level of siltation (>200 g/m^2, which is equivalent to approximately 1mm), which has the potential to cause physical damage, will also be limited to an area of approximately 0.65 km^2. The resulting sedimentation (1 mm) is within the natural annual sedimentation rate of the Baltic Sea (0.5-1.5 mm/year) and the measure is therefore very conservative

Given the highly localised and temporary nature of these impacts, in combination with the fact that a proportion of the affected area is not colonised by benthic communities (due to abiotic conditions) and no threatened species are affected, impacts from physical loss and/or physical damage have been assessed to be negligible (see section 9.7). Negligible impacts are also predicted for all other species and habitats along the NSP2 route in Danish waters (section 9.6 and 9.8 - 9.10). It is assessed that the structures will not act as a barrier for the reproduction and spreading of the marine flora and fauna and therefore neither biomass nor diversity of benthos will be impacted.

Increased suspended sediment in the water column (P3) resulting from construction activities has the potential to reduce light penetration through the water column (resulting in a reduced photic zone and reduced primary production); visibility (resulting in a behavioural response in mobile species (i.e. fish, marine mammals)); and/or reduce viability of fish eggs. Concentrations of suspended sediment in the water column exceeding 15 mg/l will be limited to an area of approximately 7.6 km^2 and will persist for a maximum of 5.5 hours. Given its localised extent and temporary nature, impacts from increased suspended sediment on primary production (phytoplankton) and other species (benthos, fish, mammals and birds) are assessed to be negligible (see section 9.7-9.10).

The construction activities of NSP2 also have the potential to cause release of contaminants (P5-P6) and nutrients (P7) currently trapped in the sediment into the water column. However, concentrations of contaminants are not expected to exceed thresholds for EQS and PNEC except for two organic compounds that will be released in anoxic sections of the route, and hence not represent any impact to biodiversity and food web. Release of nutrients in oxygenated sections will result in oxygen consumption. However, that oxygen levels are assessed to return to pre-impact status within days (see section 9.4).

On this basis, the potential impacts on water quality are assessed to be negligible (see section 9.4), with negligible impacts on biological receptors (see sections 9.6-9.9). This is further discussed in sections 10.2.1.3 (D5 Eutrophication) and 10.2.1.4 (D8/D9 Contaminants).

The generation of underwater noise (P3) by construction activities has the potential to trigger a behavioural response, or cause injury to fish, marine mammals and/or birds. However, noise impacts from pipe-lay will occur in close proximity to the noise source (i.e. the lay vessel) which will be moving along the NSP2 route at a rate of approximately 2.5 km a day, therefore they can be considered to be local and temporary. Worst case impacts from rock placement, which is planned for two locations in Denmark, is modelled to result in TTS for fish and marine mammals in a zone of only 80 meters from the activity. No PTS is expected. Given the local extent and temporary nature of the impact, in combination with the low intensity, potential impacts on noise sensitive receptors (fish and marine mammals) are assessed to be negligible (see section 9.8.1.6 and 9.9.1.4).

The construction of NSP2 will result in negligible impacts on the abiotic conditions (including hydrological processes, P4), except for minor impacts on water quality, and as discussed in sections 9.6-9.12 potential impacts on species and habitats present in Danish waters are assessed not to be significant.

During construction, vessel movements have the potential to introduce non-indigenous species into the Baltic Sea (P8). However, subject to the implementation of standard mitigation measures (see section 15), the risk of introducing NIS in Danish waters is considered to be low. However, the potential impacts from NIS during construction and operation are conservatively assessed to be negligible. This is further discussed for the Non-Indigenous species descriptor in section 10.2.1.1.

In summary and as described in section 9.13, impacts at species or habitat level would not combine to result in impacts which would be sufficient to cause a change in biodiversity nor ecosystem functioning. Therefore it can be concluded that impacts during construction (individually or in combination) will not result in significant impacts at species, habitat and/or ecosystem level (the condition criteria of D1 and D6). Furthermore, no significant impacts on the productivity of key species, proportion of top predators or distribution of key notorious groups (the condition criteria of D4) are anticipated. The same conclusion can be reached for the operational phase, where impacts (if applicable) would be of a lower magnitude to those during the construction phase. Based on the above, it is assessed that none of the impacts have the potential to be transboundary.

It can therefore be concluded that the construction or operation of NSP2 will not prevent or delay the achievement of targets or the long-term goal for GES for Descriptors D1, D4 and D6.

10.2.1.8 Hydrographical conditions (D7)

Hydrographical conditions are 'state descriptors' which describes the physical parameters of seawater such as temperature, salinity, depth, currents, waves, turbulence and turbidity.

No targets are defined for D7 as impacts from construction activities are regulated by individual permits. However, through this process it is generally considered that only localised permanent changes to hydrography would be allowed.

There are no impacts on the hydrography during construction phase.

The presence of the pipelines on the seabed during the operation phase will be a limited interference with local hydrological processes (P4) by introducing a small change in bathymetry (see Section 9.1 and 9.3). However, the scale and the fact that exchange of water in the Baltic Sea primarily takes place in upper levels of the water column, the impact on the hydrographical conditions are assessed to be negligible.

In summary and on the basis of the above, though no criteria are clear for this descriptor, impacts during construction and operation (individually or in combination) will not result in significant impacts on hydrographical conditions.

On that basis it can be concluded that NSP2 will not delay or prevent the achievement of the targets for hydrographical conditions in Denmark and hence NSP2 will not prevent the achievement of the long-term goal for GES for Descriptor D7.

10.2.2 NSP2 impact on national compliance with MSFD

NSP2 will neither impact pressures, criteria nor targets (where applicable) for the descriptors.

On that basis it can be concluded that NSP2 will not prevent or delay the achievement of the long-term goal for GES.

10.2.3 The Water Framework Directive

NSP2 does not enter the 1 nautical mile area of Denmark. Given that the proposed NSP2 route crosses the 12 nautical mile area of the Bornholm Management Area (where chemical status is the defining parameter), the main pressures to the marine environment in relation to the Water Framework Directive (WFD) comprise eutrophication (particularly related to nitrogen) and pollutants (e.g. metals). The following section discusses the potential for NSP2 to impact existing pressures.

It is noted that all project vessels will be compliant with the requirements of the Helsinki Convention (Convention on the Protection of the Marine Environment of the Baltic Sea Area) and the prescriptions for the Baltic Sea Area as a MARPOL 73/78 Special Area. Therefore, impacts on water quality as a result of discharges from project vessels (e.g. sewage) are assessed to be negligible (See section 9.4). As such, no further consideration has been given to this source of impact in this section.

Construction activities associated with NSP2 such as pipe-lay, seabed intervention works and anchor-handling (if required) has the potential to disturb the seabed and cause the release of contaminants and nutrients into the water column (reducing water quality).

However, turbidity and sedimentation have been modelled for trenching and rock placement activities (see section 9.4) and indicate that the concentration of suspended sediment in the water column will exceed 2 mg/l within a distance of only a few kilometres from the proposed NSP2 route. The total area impacted would be approximately 139 km^2, for a duration of maximum 12 hours. Therefore, the impacts on water quality associated with suspended sediment release (contaminants and nutrients) will be temporary. Therefore impacts within the 12 nautical mile area designated under the WFD will be negligible.

Anodes will prevent corrosion of the pipelines during operation of the pipelines. Metals such as aluminium, zinc and cadmium will be released from the anodes. The impact from the release of metals is assessed to be low and local and will not be measurable in the water column except from a few metres around the pipelines. The release of metals is assessed to have negligible impact in Danish waters (section 9.4).

Overall it is concluded that NSP2 will not increase the pressures on water quality, nor be contrary to the objectives and initiatives set out in the WFD.

10.2.4 HELCOM Baltic Sea Action Plan

The HELCOM Sea Action Plan sets out four key focus topics in order to achieve the goal of the Baltic Sea being of good environmental status before 2021. The BSAP has formed basis for the targets of both the MSFD and WFD and consequently the focus topics of the BSAP are overlapping with the goals of both MSFD and WFD. The topics comprise:

- Eutrophication;
- Hazardous substances;
- Nature conservation and Biodiversity and
- Maritime activities.

For each focus topic, HELCOM has set indicators and targets. Where these are considered relevant to NSP2, specific reference has been made in the following sections.

10.2.4.1 Eutrophication

As noted above, disturbances of the seabed by intervention works, pipe-lay and/or anchor handling will cause resuspension of sediment and associated release of nutrients from the sediment pool. However, the impact is assessed to be negligible on the eutrophication in Danish waters (see section 9.4).

NSP2's impact regarding eutrophication is assessed in section 9.4 and though seabed interventions may cause local and temporary release of nutrients transferred from the sediments to the water column, the impact is assessed to be negligible due to the overlying halocline. In section 9.6 it is further assessed that the small release of nutrients will not result in algal bloom.

Based on these assessments it is concluded that NSP2 will not impact the clarity of the water and it is concluded that NSP2 would not prevent member states in reaching the target for eutrophication.

10.2.4.2 Hazardous substances

NSP2's handling of hazardous substances is described in section 15.13 and release of substances to the water column is assessed in section 9.4.

Hazardous substances may be released from the pool in the sediment during pipeliay and rock placement. Furthermore metals will be released from anodes on the pipeline (anti-corrosion measures) during operational phase. However, the impact on the concentration of hazardous substances in the Baltic Sea is assessed to be negligible (see section 9.4).

Based on the assessments it is concluded that NSP2 will have negligible impact on the TBT levels in sediment and biota or imposex and that NSP2 will have no impact on trends in concentrations of TBT, Nonyl Phenol or metals.

Based on this it is concluded that NSP2 will not prevent member states in reaching the targets for hazardous substances.

10.2.4.3 Nature conservation and biodiversity

NSP2's impact regarding biodiversity is assessed in section 9.13. The identified impacts are primarily connected to disturbance of the seabed with resulting resuspension of sediments and associated eutrophication, loss of habitats and underwater noise.

Siltation and abrasion may bury benthic habitats and seabed interventions will release nutrients from the pool but the resuspension of sediments will be restricted to the lower parts of the water column where photosynthesis does not occur and the impact is temporarily and spatially limited. The impacts are assessed to be negligible (see sections 9.4, 9.6 and 9.7).

Underwater noise from trenching and rock placement may cause temporary avoidance reactions by some key predators within a limited area from the activity. The impact is assessed to be negligible for fish and minor for mammals (see sections 9.8 and 9.9). As the impact on the predators is temporary and no impacts are expected regarding primary production, it is assessed that NSP2 would result in negligible impact on trends in trophic structures and diversity of species.

On the habitats level NSP2 would result in negligible impact on habitat forming species. NSP2 would result in negligible impact on abundance and distribution of rare or threatened habitats and negligible impact on trends in numbers or detection of NIS. The overall assessment for the entire project is therefore that NSP2 will not impact indicators set for biodiversity with respect to habitats.

Marine and coastal landscapes are not impacted by NSP2.

No impacts on targets regarding spatial distribution, abundance and quality of habitat forming species are anticipated and NSP2 will not impact threatened or declining habitats.

There will be no impact on conservation status of species included in the HELCOM lists of threatened/declining species/habitats and NSP2 will not impact the abundance or diversity on any element of the marine food web. The project will have no impacts on number or biomass of NIS. NSP2 will have no impact on possibilities for eel migration and no impact on possibilities of achieving viable Baltic cod populations.

Based on this it is concluded that NSP2 will not prevent member states in reaching the targets for biodiversity.

10.2.4.4 Maritime activities

Lay barge and vessels emit fossil fuels and use anti fouling agents and the presence of vessels increases risk of accidents and e.g. oil spills. Furthermore NSP2 vessel activities have the potential to introduce NIS through ballast water and hull fouling (see section 9.13).

The impact is mitigated by NSP2 management plans (see section 6.7) and the overall assessment concludes that impact is negligible.

In summary, NSP2 will have negligible impact pollution and risk of e.g. oil spills and NSP2 will have negligible impact on introduction of NIS. Based on this it is concluded that NSP2 will not impact indicators or targets set for maritime activities.

10.2.5 Compliance with objectives and initiatives in the Baltic Sea Action Plan

Based on the above it is assessed that NSP2 will have no significant impacts on relevant indicators and that NSP2 will have no significant impacts on relevant targets.

Overall, it is assessed that NSP2 will not be contrary to the objectives and initiatives set out in the HELCOM Baltic Sea Action Plan.

11 DECOMMISSIONING

As described in section 6, NSP2 is designed to operate at least 50 years. The proposed decommissioning programme will be developed during the operation phase of NSP2 to allow consideration to be given to any new or updated legislation and guidance available at the time, as well as to utilise good international industry practice and technical knowledge gained over the lifetime of NSP2. It is considered highly likely that statutory requirements, technological options and preferred methods for decommissioning will have changed in 50 years' time.

The condition of NSP2 infrastructure may also influence the preferred decommissioning method and relevant mitigation measures.

This chapter highlights the legislation and policy context related to decommissioning, the potential options for decommissioning NSP2 and the associated potential impacts.

11.1 Overview of legal requirements

The decommissioning process for offshore structures is regulated by a framework of international conventions which aim to influence national legislative requirements. The primary international conventions specifically related to decommissioning are defined in section 3 and include:

- UNCLOS (Article 60 (3) – which states that *"Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organization. Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States"*. The competent organisation for the decommissioning of offshore installations or structures is the IMO, which in 1989 adopted the IMO Guidelines and Standards setting out the minimum international standards for the removal of offshore installations. The guidelines state that "*the decision to allow an offshore installation, structure, or parts thereof, to remain on the sea-bed should be based, in particular, on a case-by-case evaluation, by the coastal State with jurisdiction over the installation or structure".*

- London (Dumping) Convention – which promotes effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea resulting from dumping of wastes and other matter; and

- International Convention for the Prevention of Pollution from Ships (MARPOL) - sets the standards and guidelines for the removal of offshore installations worldwide.

Although consideration will be given to the international conventions listed above, there is no specific Danish legislation or policies for the decommissioning of offshore installations or pipelines at this point in time. Given this limited legislative framework, a review of other guidance has been undertaken to provide additional context, see below.

11.2 Overview of decommissioning guidelines

Although there is no international guidance on the decommissioning of pipelines or specific guidance developed, Norway and the United Kingdom have enforced guidelines within this field. Those of particular relevance to NSP2 include:

- DNV recommended practice document "Marine Operations during removal of offshore installations", which provides guidance on technical feasibility and overcoming technical challenges related to the removal of offshore installations /435/.

- Norwegian Parliament white paper "Decommissioning of redundant pipelines and cables on the Norwegian continental shelf", which briefly addresses the options for the decommissioning of pipelines and cables and highlights the need for decommissioning programmes to be developed with due consideration given to potential environmental, socio-economic and marine spatial planning impacts as well as overall cost /436/.
- UK Oil and Gas guidance note "Decommissioning of offshore installations and pipelines", which provides a framework for decommissioning of offshore installations and pipelines and provides guidance for the safe decommissioning of pipelines /437/.
- Oil & Gas UK "Decommissioning of pipelines in the North Sea region", which provides an overview of pipeline infrastructure in the North Sea and achievements in decommissioning parts of that infrastructure. It also highlights the technical capabilities and limitations that impact the decommissioning options available to owners of pipeline systems /438/.

In the absence of specific guidance for the Baltic Sea, the general principles contained within these documents are considered broadly applicable to the development of the decommissioning programme for NSP2.

These general principles can be summarised as follows:

- The potential for reuse should be considered before decommissioning. If reuse is considered viable, suitable and sufficient maintenance of the pipeline should be detailed.
- All feasible decommissioning options should be considered and a comparative assessment undertaken in respect of technical, environmental and socio-economic criteria (including those relevant to marine spatial planning and other sea users). Assessment of decommissioning options should be based on scientific evidence, with consideration given to the following topic areas as a minimum:

  - Water quality;
  - Geology;
  - Hydrography;
  - Biodiversity (including threatened species and habitats);
  - Commercial fishery;
  - Contamination and pollution.

- The condition of the pipeline should be considered in respect to deterioration, exposure and/or burial (both in terms of potential implications for decommissioning method and possible future impacts on the environment).
- The decision should be undertaken in light of individual circumstances.

According to the UK Oil and Gas guidance note /437/, the following pipelines may be candidates for *in situ* decommissioning:

- Pipelines which are adequately buried or trenched and which are not subject to development of freespans and are expected to remain so;
- Pipelines which were not buried or trenched at installation but which are expected to self-bury over a sufficient length within a reasonable time and remain buried;
- Pipelines where burial or trenching of the exposed sections is undertaken to a sufficient depth and it is expected to be permanent;
- Pipelines which are not trenched or buried but which, nevertheless, are candidates for leaving in place if the comparative assessment shows that to be the preferred option (e.g. trunk lines);
- Pipelines where exceptional and unforeseen circumstances due to structural damage or deterioration or other causes mean they cannot be recovered safely and efficiently.

The guidance note also states that where rock placement has been used to protect a pipeline, the removal of the pipeline (or pipeline section) is unlikely to be practicable. It is therefore assumed that rock placement will remain in place, unless there are special circumstances that would warrant consideration of removal. Should the rock be associated with a pipeline that is removed, a minimum disturbance of the rock placement material to allow safe removal of the pipeline and any seabed obstructions would be expected.

Although the above guidelines serve as an illustration of the general principles to be applied in decision making processes concerning decommissioning, it is anticipated that additional international or national guidelines will be developed before the end of the operational life of NSP2. Should such documents become available, these will be taken into consideration when preparing the decommissioning programme for NSP2.

11.3 Decommissioning practices

The comparative assessments of the majority of decommissioning cases in the United Kingdom have demonstrated that the preferred decommissioning option for large diameter pipelines is to leave them *in situ*, either on the seabed or buried. This approach is often complemented by remedial actions to reduce risks to other sea users, for example the cutting and removal of exposed pipeline ends to minimise snagging risk /438/ and is in accordance with the guidelines highlighted in section 11.1.

11.4 Decommissioning options for NSP2 and potential impacts

11.4.1 Potential decommissioning options

As noted above, at present there is no certainty as to which decommissioning method will be applied to the offshore strucutures of NSP2. Therefore, a detailed impact assessment for the decommissioning phase has not been carried out within this report.

The decommissioning plan for the offshore structures of NSP2 will be developed during the latter years of the operation phase. The identification of the preferred option will likely be based on the following criteria:

- Technical feasibility;
- Health and safety;
- Environmental impacts;
- Socio-economic impacts.

Notwithstanding this, two decommissioning scenarios (a base case and theoretical alternative) for NSP2 have been considered during the EIA phase. The options considered (based on the guidelines outlined in section 11.1) are as follows:

- Based on precedent and industry best practice guidelines for large diameter pipelines, the base case is to leave the pipeline on the seabed (*in situ*):
  - Following the gas inventory removal and pipe cleaning operations, the pipeline will then be flooded in a controlled manner with seawater. After the pipeline is filled with water, the ends would be capped and buried. The pipeline and rock berms will then remain *in situ*, until they slowly degrade according to natural processes in the marine environment.
- Based on a review of other potential options, the theoretical alternative is pipeline removal by reverse lay recovery or by sectional recovery, followed by waste management:
  - Reverse-lay recovery would be carried out by pulling the pipelines up and cutting out the pipes using a pipe-laying barge. The pipeline, when recovered to the pipe-lay barge, would then be then cut into convenient sections (12-24 m) and taken by pipe-carrier vessels to the shore for disposal. Whilst technically feasible, such reverse lay would require a significant engineering assessment of the condition of the pipelines and of the pipeline

seabed configuration. Apart from the risks associated with the structural strength of the pipeline, the resistance during reverse pipe-lay may also be unpredictable dependant on the degree of natural embedment of the pipelines. Should there be sudden changes in resistance during break-out of the seabed, the reverse-lay operations would be difficult to control, and there would be associated risks to the vessel, equipment and personnel.
- Sectional recovery would comprise cutting the pipelines into sections (12-24 m) on the seabed and the recovery of the sections to a pipe-carrier piece-by-piece. This method can be perfomed with the use of a ROV and a diamond cutter or a high-powered water jettng system.
- When onshore the pipeline materials would either be further processed for material recovery or disposed of. Regardless, temporary storage areas (i.e. storage yards for removed pipe sections) and processing would be required. Permanent areas for disposal may also be necessary.

It should also be noted that hybrid options (comprising a combination of the above) may also be considered. However, given that the pipelines will, over their operational lifetime, become an integrated part of the seabed (due to embedding and colonisation by marine life), leaving the pipelines *in situ* (base case) is likely to remain the optimal solution.

11.4.2 Potential impacts

A qualitative review of potential sources of impact which may arise from the above decommissioning options has been undertaken based on the conclusions of the impact assessment outlined in section 9, the decommissioning report developed for NSP /439/ and professional experience. These are summarised below.

It is noted that the identification of potential impacts associated with pipeline removal is theoretical and has relied heavily upon professional experience. This is due to lack of empirical data as, based on existing knowledge, no similar large-diameter pipelines have been decomissionioned by removal. Should a hybrid option be chosen, the potential impacts would be a combination of those identified below, though the magnitude of each type of impact would likely be reduced compared to the removal option.

11.4.2.1 Leave *in situ* option

For the leave in situ option, it is anticipated that many of the potential sources of impacts will be a continuation of impacts likely to be encountered due to the presence of the pipelines during the operation phase (therefore of a lower magnitude than the pipeline removal option). Other impacts related to the operation of the pipelines (e.g. local temperature difference, impacts associated with inspections/survey) will not be relevant after decommissioning.

The potential sources of impacts from the leave *in situ* option comprise:

- Continued presence of the pipeline on the seabed which has the potential to impact commercial fisheries and further habitat creation;
- Continued release of contaminants from pipeline anodes which has the potential to reduce water quality (through increased metal concentrations).

11.4.2.2 Pipeline removal option

For the pipeline removal option, it is anticipated that the potential sources of impacts will be similar in nature, temporary and of a similar or greater order of magnitude to those encountered during the construction phase (and therefore of a higher magnitude than the leave *in situ* option). Recovery would require a significant spread of vessels, operating along the route and to and from ports, and is unlikely to be carried out with the same speed as pipe-lay (therefore requiring greater resource/energy use).

Following recovery to shore, the pipeline materials could either be further processed for material recovery or disposed of. In any case, temporary areas for storage (i.e. storage yards for removed pipe sections) and processing would be required. Permanent areas for disposal may also be necessary.

The potential sources of impacts from the pipeline removal option comprise:

- Physical changes to seabed features (natural and man-made) which has the potential to impact benthic habitats in areas where the pipelines have acted as an artificial reef;
- Release of sediments into the water column which has the potential to impact water quality due to the spreading of sediments, with secondary impacts on marine fauna and flora;
- Release of contaminants and/or nutrients into the water column (e.g. sediment-associated contaminants) which has the potential to impact water quality with secondary impacts on marine fauna;
- Sedimentation on the seabed which has the potential to impact sediment quality, benthic flora and fauna and fish;
- Generation of underwater noise and/or vibrations which has the potential to impact fish and marine mammals;
- Above water disturbance (noise, visual including light, vessel movement, etc.) which has the potential to impact marine mammals, birds and people;
- Safety zones around vessels which has the potential to impact commercial fisheries and maritime traffic (shipping);
- Release of air pollutants and GHGs from vessels which has the potential to impact the climate and local air quality with secondary impacts on people;
- Employment generation.

11.5 Concluding remarks

Based on the guidelines and conclusions for the cases of the decommissioning programmes in the United Kingdom, leaving *in situ* is likely to be the preferred option for both onshore and offshore structures of NSP2. Management and mitigation methods for decommissioning of NSP2 will be developed:

- in agreement with the relevant national authorities;
- in accordance with the legislative requirements at the time of decommissioning;
- with due consideration of the technology available at the time of decommissioning; and
- with due consideration of the knowledge gained over the lifetime of NSP2 and the condition of the infrastructure.

Therefore, for the marine areas (offshore), the potential impacts resulting from leaving the pipelines *in situ* would likely be related to the gradual dissolution of materials over time and continued obstruction on the seabed. The potential impacts from pipeline recovery would comprise seabed disturbance, vessel operations, and the use of energy and land areas for material separation, recycling and/or disposal. The potential impacts on the marine environment from pipelines left *in situ* are generally considered to be lower than the impacts from recovery.

Although this chapter has sought to provide an overview of the potential options for decommissioning of NSP2, and their associated potential impacts, a decommissioning programme will be developed during the latter years of the operation phase. This will allow regulations, technical knowledge gained over the lifetime of NSP2 and prevailing pipeline decommissioning practices at the time to be taken into account /438/.

12 CUMULATIVE IMPACTS

While the impacts of the NSP2 project have been considered in section 9, there is also a need to consider the potential for impacts to interact with impacts from other projects. These other projects may generate their own individually insignificant impacts, but when considered in combination with the impacts from NSP2, the impacts could amount to a significant cumulative impact, for example, combined sediment impacts from two or more (planned) projects within a certain timeframe and distance. Cumulative impacts can be defined as follows:

"Impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted[49]

12.1 Methodology

This section sets out the parameters within which the cumulative impact assessment has been undertaken. This section has been prepared taking into account current good practise and established practise, as well as the IFC guidance note on cumulative impact assessment[50].

The receptors considered within this cumulative impact assessment are consistent with those considered within the wider EIA. A summary of their baseline condition is provided in section 7.

Only receptors which have the potential to experience cumulative impacts are discussed for each project. Where receptors are not considered to have the potential to experience cumulative impacts, these have been screened out, based upon available knowledge, professional judgement and previous experience.

The spatial and temporal boundaries relevant to this cumulative impact assessment have been defined taking into consideration the characteristics of the NSP2 project, and the areas defined within the various technical assessments presented in section 9.

The spatial boundaries have been defined as projects within a distance, which is considered to be the maximum distance at which there is the potential for cumulative impacts to occur (based on areas defined within the technical assessments in section 9). To ensure a conservative approach, a consistent spatial boundary has been considered for the construction, pre-commissioning and operational phase.

The temporal boundaries have been defined as projects which have the potential to result in impacts during the construction (including pre-commissioning) and operation phase of the NSP2 pipeline. The potential for the cumulative impact have been considered only for the relevant project phase – construction and/or operation.

The projects which have been identified within Danish waters and scoped into the cumulative assessment, on the basis of the following criteria:

- Whether they are located within the spatial boundaries set out above;
- Whether they will result in impacts during the temporal boundaries set out above;
- Whether they are sufficiently progressed in the planning process or reasonably defined such that the project is subject to a medium/high degree of certainty of being delivered; and
- Whether they have the potential to result in impacts on the same receptors as NSP2.

[49] IFC Performance Standard 1

[50] IFC Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets.

12.2 Planned projects

Within the spatial boundaries of this cumulative assessment, several infrastructure projects are under consideration, although they are currently at different planning stages. These projects are summarized in Table 12-1, with an assessment of whether the project has the potential to interact with NSP2 (either spatially or temporally) and therefore whether it has been taken forward for further consideration of potential cumulative impacts.

Consideration has been given to possible interactions between NSP2, in combination with the relevant planned projects and susceptible receptors.

As noted in Table 12-1, the only planned projects which are considered to have the potential to result in cumulative impacts are the planned Bornholm Wind Farm and extraction areas south of Bornholm.

Table 12-1 Planned projects which in combination with the NSP2 project have the potential to result in cumulative impacts

Planned Project Name and Details	Approximate distance from the NSP2 Pipeline Corridor (Danish Sector)	Approximate timeframe for delivery/ operation	Status/ Planning Stage	Anticipated Activities	Considered further in this Assessment	Justification for scoping out of this Assessment
Bornholm Wind Farm • A proposed offshore wind farm which would occupy an area of approximately 45 km², with an estimated generation capacity of up to 50 MW.	18 km	Construction expected 2017-2018, commissioning 2019.	Planning stage, EIA has been undertaken by DEA.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm, and vessels.	Yes	-
Baltic Pipe • An EU 'project of common interest' which would comprise a proposed subsea natural gas pipeline spanning approximately 250 km between Denmark and Poland, with associated	0 km minimum (potentially crossing NSP2 south-west of Bornholm)	Unknown, anticipated completion by 2022.	Feasibility Stage initiated.	Seabed intervention, pipe-lay, presence of pipelines and vessels.	No	The project is not sufficiently progressed within the planning process to be subject to a medium/high degree of certainty of being delivered. It is considered that should this project be further developed in the future, they would be required to consider NSP2 within their subsequent cumulative impact

Planned Project Name and Details	Approximate distance from the NSP2 Pipeline Corridor (Danish Sector)	Approximate timeframe for delivery/ operation	Status/ Planning Stage	Anticipated Activities	Considered further in this Assessment	Justification for scoping out of this Assessment
landfalls.						assessment such that any potential cumulative impacts would be identified at this stage.
Krigers Flak Wind Farm • A proposed offshore wind farm with between 60 -200 turbines and an estimated generating capacity of 600 MW. • There is a possibility that this area could be divided into two projects, a 200 MW project to the west and 400 MW to the east.	>80 km	Expected commissioning in 2018.	Consent application submitted and EIA completed . Tender procedure by the DEA ongoing.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm, and vessels.	No	The construction site for these wind farms are likely to be located more than 80 km from the NSP2 route and as such there is no spatial overlap with NSP2 and no significant cumulative impacts (related to construction or operation) are expected to occur.
Offshore wind farms proposed within the Swedish EEZ • Various proposed offshore wind farms in different stages of the planning process.	>80 km	Unknown, project currently on hold.	Consented but on hold.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm, and vessels.	No	The construction site for these wind farms are likely to be located more than 80 km from the NSP2 route and as such there is no spatial overlap with NSP2 and no significant cumulative impacts (related to construction or operation) are expected to occur.
Offshore wind farms proposed within the German EEZ • Various proposed wind farms are in different	>25 km	Unknown to construction ongoing and commissioning in 2017.	Concept to Under Construction	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm, and vessels.	No	The construction site for these wind farms are likely to be located more than 25 km from the NSP2 route and as such there is no spatial overlap with NSP2 and no significant cumulative

Planned Project Name and Details	Approximate distance from the NSP2 Pipeline Corridor (Danish Sector)	Approximate timeframe for delivery/ operation	Status/ Planning Stage	Anticipated Activities	Considered further in this Assessment	Justification for scoping out of this Assessment
stages of the planning process.						impacts (related to construction or operation) are expected to occur.
Offshore wind farms proposed within the Polish EEZ • Licence application areas for offshore wind projects.	11 km	Unknown	Concept	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm, and vessels.	No	The projects are not sufficiently progressed within the planning process to be subject to a medium/high degree of certainty of being delivered. Given that the project is in the early stages of planning, there is also a low risk of temporal overlap of construction activities. It is considered that should this project be further developed in the future, they would be required to consider NSP2 within their subsequent cumulative impact assessment such that any potential cumulative impacts would be identified at this stage.
DK Reserved area for offshore wind farms – Rønne Banke	3 km	Unknown	Area reserved.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm, and vessels.	No	The project is not sufficiently progressed within the planning process to be subject to a medium/high degree of certainty of being delivered. Given that the project is in the early stages of planning, there is also a low risk of temporal overlap of construction activities.

Planned Project Name and Details	Approximate distance from the NSP2 Pipeline Corridor (Danish Sector)	Approximate timeframe for delivery/ operation	Status/ Planning Stage	Anticipated Activities	Considered further in this Assessment	Justification for scoping out of this Assessment
Extraction Areas South of Bornholm • Extraction areas have been designated as resource extraction areas. The nearest extraction areas are along the southeast part of Rønne Banke.	>6 km	Unknown.	Reservation. No valid permits issued for resource extraction.	Extraction and transport of sediment	Yes	-

Although there are currently no valid permits for the extraction area south of Bornholm, its designated status provides sufficient confidence that extraction activities are likely to come forward in the future. It is noted however, that given the lack of information and uncertainty on timeframes, it has only been possible to consider potential cumulative impacts qualitatively.

12.2.1 Cumulative impact assessment - Bornholm Wind Farm

Bornholm Wind Farm occupies an area of approximately 45 km^2, with an estimated generation capacity of up to 50 MW. Within this area, only an area measuring up to 11 km^2 will be used to erect the offshore wind farm. The power which is produced by the offshore wind turbines will be delivered by export cables to shore on the coast southeast of Rønne.

The wind farm is currently in the planning stage, and an EIA has been undertaken /397/. An open tender process was initiated in 2015 by DEA. It is noted that the project is reportedly on hold, pending political decision.

Activities associated with the wind farm include construction of wind turbines, inter-array and landfall cables, as well as presence of wind farm and cables in the operation phase. In construction and operation phase, vessels are expected in the area.

Potential cumulative impacts

Potential impacts from the activities associated with the construction and operation of the proposed offshore farm and NSP2 have been evaluated. Table 12-2 provides an assessment of the potential cumulative impacts between NSP2 and Bornholm Wind Farm.

Based on the nature of the projects, the spatial extent of the impacts (as assessed in Sections 9 and /397/, as well as professional judgement and previous experience, cumulative impacts in relation to the following have been screened out of further consideration:

- Contaminants in the water column (construction);
- Conventional/chemical munitions and CWA (construction);
- Change of habitat (operation);

- Temperature difference (operation); and
- Release of metals from anodes (operation).

Table 12-2 Assessment of potential cumulative impacts from NSP2 and Bornholm Wind farm

Potential impact	NSP2	Bornholm Wind Farm	Potential cumulative impacts
Physical disturbance/ sediment disturbance, dispersion and sedimentation (construction)	During construction of the NSP2 project, seabed disturbance and spill of seabed sediments are expected in connection with seabed intervention works. The modelling and monitoring of impacts during NSP, and subsequent modelling for NSP2 has shown that post-lay trenching is expected to give rise to more sediment spill than rock dumping and pipe-lay activities. However, even for the worst case, the impacts are local and short term and expected to be of negligible significance. Monitoring during NSP revealed that no measurable physical effects on the seabed could be detected more than 25 m from the pipelines in Denmark.	The sediment dispersion during construction of the Bornholm Wind Farm has been modelled /397/. The results show that the seabed sediments are coarse, and that re-suspended sediment and increased sedimentation will occur within a distance of 500 m from the construction activity, and with a short duration (days).	Due to the local extent of sediment spill and sedimentation for both projects, in combination with the short duration, negligible potential cumulative impacts are expected.
Underwater noise (construction)	During construction of the NSP2 project, underwater noise is expected in association with seabed intervention (trenching and/or rock placement) and pipe-lay activities. The underwater noise during NSP2 will be short-term, localised and only in the construction phase, expected to be of no/negligible/minor significance.	During construction of the wind farm project, underwater noise is expected in association with seabed intervention and piling activities. The underwater noise will be short-term, only in the construction phase and localised.	Although impacts from both projects are anticipated to be localised, given the likely temporal overall of the construction activities, the potential for cumulative impacts have been assessed further below.
Emissions (construction and operation)	Emissions will arise from construction and operation activities of NSP2. Emissions have been calculated in section 8.4.5 and predict impacts of no or negligible significance.	Emissions have been calculated in the EIA /397/. Although during construction there is an increase in emissions, this will have a short duration, and during operation the wind farm is expected to lead to an overall decrease in emissions.	Due to the short duration of emissions during the construction and operation period, negligible cumulative impacts are expected.

Potential impact	NSP2	Bornholm Wind Farm	Potential cumulative impacts
Airborne noise (construction)	Airborne noise has been calculated in section 8. Impacts will be of a short duration and localised, and expected to be of no or negligible significance.	Airborne noise have been calculated in the EIA /397/. Although during construction there is likely to be an increase in airborne noise, these will be of a short duration and localised.	Due to the local extent of impacts in combination with the short duration of emissions during the construction period, negligible cumulative impacts are expected.
Presence of vessels and restriction zones around vessels (construction and operation)	During construction of the NSP2 project, various vessels will be present for construction activities. During operation, vessels are limited to maintenance activities, which are expected to consist of surveys every 1-2 year. Impacts will be of a short duration and localised, and expected to be of no or negligible significance.	Vessel traffic associated with the construction will increase during the construction phase, and maintenance vessels will be present in the operation phase. Impacts from the presence of the vessels will be of a short duration and localised.	Due to the local extent of impacts associated with the presence of vessels, no potential cumulative impacts are expected.

As discussed in Table 12-2, only underwater noise generated during the construction of the two projects has the potential to lead to cumulative impacts. The potential receptors which may be impacted by underwater noise have been identified in section 8 and comprise fish, marine mammals and protected areas (including Natura 2000 sites). These are further assessed below.

Fish

The impacts from underwater noise to fish during the construction of NSP2 are assessed applying underwater modelling (see section 8 and 9). Potential impacts from underwater noise on fish are assessed to be local, within 100 m from the proposed NSP2 pipeline route.

In respect to the Bornholm Wind Farm, pile driving in connection with the foundation work is expected to generate significant underwater noise. According to the EIA, the potential impacts to fish related to underwater noise are assessed to be local, within 1 km of the monopole locations /397/.

Given that the distance between NSP2 and the Bornholm wind farm is more than 18 km, there is no potential for the impacts of increased noise associated with construction activities of the two projects to overlap. Based on the above, it assessed that there will negligible cumulative impacts on fish. Furthermore, given that the potential behavioural response of fish to underwater noise is highly localised, there is no overlap between the potential disturbance area for both projects.

Marine mammals

In section 9, the impacts from underwater noise to marine mammals during NSP2 are assessed applying underwater modelling. Potential impacts from underwater noise on marine mammals are assessed to be local, with the potential for TTS onlye within 80 m from the proposed NSP2 pipeline route.

As noted above, the EIA for Bornholm wind farm presents results from the modelling of underwater noise generated from pile driving, which is considered to be the most significant noise source during the construction phase. Figure 12-1 show the spatial extent where harbour porpoise and seals may be exposed to sound levels which can cause permanent or temporary threshold shift (PTS and TTS, respectively).

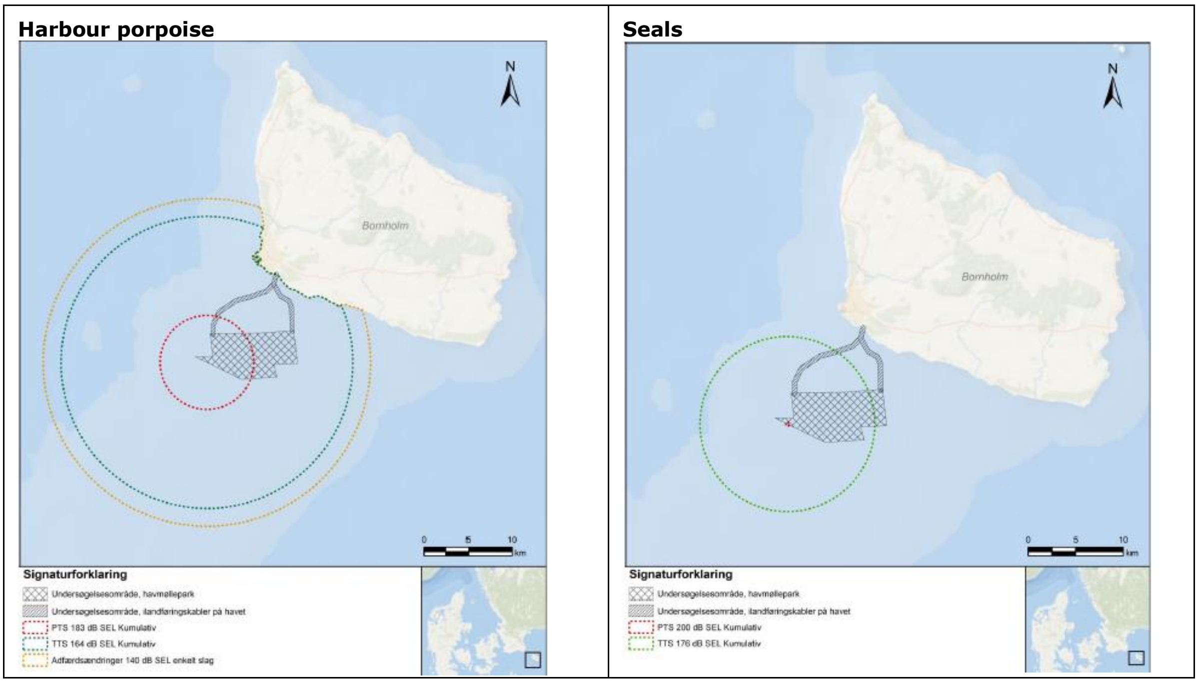


Figure 12-1 Modelling results for underwater noise from pile driving during construction of Bornholm wind farm.

The area where noise generated by the pile driving may result in impacts on marine mammals is located less than 100 m from the proposed NSP2 pipeline route and as such, there is no overlap between the potential PTS and TTS impact areas for the two projects. Furthermore, given that the potential behavioural response of marine mammals to the presence of vessels is highly localised, there is no overlap between the potential disturbance area for both projects.

Based on the above, it assessed that there will negligible cumulative impacts on marine mammals.

Protected areas

A number of protected areas are designated to protect the marine environment. As described above, no cumulative impacts are expected to occur to the marine receptors (plankton, benthic fauna, fish, marine mammals, seabirds), and as such no significant cumulative impacts are foreseen to the protected areas and/or Natura 2000 sites.

12.2.2 Cumulative impact assessment - Extraction Areas South of Bornholm

Areas located 6 km south of the NSP2 pipeline corridor are reserved for resource extraction on Rønne Bank, south of Bornholm. The areas are described in section 7.22. No permits have been issued for the areas.

The potential activities comprise extraction of sediments. Potential cumulative impacts between NSP2 and the extraction areas at Rønne Banke are described below.

Potential cumulative impacts

Potential impacts from the activities associated with potential extraction activities and NSP2 have been evaluated. Table 12-3 provides an assessment of the potential cumulative impacts between NSP2 and the extraction areas at Rønne Banke.

Based on the nature of the projects, the spatial extent of the impacts (as assessed in section 9 and based on professional judgement and previous experience), cumulative impacts in relation to the following have been screened out of further consideration:

- Contaminants in the water column (construction);
- Conventional/chemical munitions and CWA (construction);
- Airborne noise (construction)
- Change of habitat (operation);
- Temperature difference (operation); and
- Release of metals from anodes (operation).

Table 12-3 Assessment of potential cumulative impacts from NSP2 and Extraction areas at Rønne Banke

Potential impact	NSP2	Extraction areas at Rønne Banke	Potential cumulative impacts
Sediment disturbance, dispersion and sedimentation (construction)	During construction of the NSP2 project, disturbance and spill of seabed sediments are expected in connection with seabed intervention works. The modelling and monitoring of impacts during NSP, and subsequent modelling for NSP2 has shown that post-lay trenching give rise to more sediment spill than rock dumping and pipe-lay activities. Still the impacts are local and short term.	The disturbance and sediment dispersion during extraction at Rønne Banke may lead to local, short-term increase in suspended sediments and sedimentation.	Due to the local extent of sediment spill for both activities, negligible potential cumulative impacts are expected.
Presence of vessels and restriction zones around vessels (construction and operation)	During construction of the NSP2 project, various vessels will be present for construction activities. During operation, vessels are limited to maintenance activities, which are expected to consist of surveys every 1-2 year. Impacts will be of a short duration and localised, and expected to be of no or negligible significance.	During extraction, additional vessels will be present in the area. Impacts will be localised to the extraction area and route to Bornholm.	Due to the local extent of the impacts for each project, no potential cumulative impacts are expected.
Underwater noise (construction)	During construction of the NSP2 project, underwater noise is expected in association with seabed intervention (trenching and/or rock placement) and pipe-lay activities. The underwater noise during NSP2 will be short-term, localised (within 500 m from the proposed pipeline route) and only in the construction phase, expected to be of no/negligible/minor significance.	During extraction, the noise generated from the extraction activities are likely to be of a similar magnitude to the NSP2 activities, and localised.	Due to the localised extent of noise impacts for both activities, negligible potential cumulative impacts are expected.
Emissions (construction and operation)	Emissions will arise from construction and operation activities of NSP2. Emissions have been calculated in section 8 and predict impacts of no or negligible significance.	During extraction, additional vessels will be present in the area. Impacts will be localised to the extraction area and route to Bornholm.	Due to the short duration of emissions during the construction and operation period, negligible cumulative impacts are expected.

On this basis, based on the characteristics and separation distance of the two projects, it is considered that there will negligible cumulative impacts in respect to the above impacts.

Protected areas

A number of protected areas are designated to protect the marine environment. As described above, no cumulative impacts are expected to occur to the marine receptors (plankton, benthic fauna, fish, marine mammals, seabirds), and as such no cumulative impacts are foreseen to the protected areas and/or Natura 2000 sites.

12.3 Existing projects

Only existing projects which are considered to be of particular relevance to the assessment have been considered (summarised in Table 12-4), determined on the basis of the following criteria:

- Whether they are located within the spatial boundaries set out above; and
- Whether they will result in impacts during the temporal boundaries set out above;
- Whether they have the potential to result in impacts on the same receptors as NSP2.

The impact assessment against the full baseline condition is presented in Section 9.

Table 12-4 Existing projects whose impacts have the potential to combine with those of the NSP2 project

Existing Project Name and Details	Distance from the NSP Pipeline Corridor	Status	Anticipated Activities	Considered further in this Assessment	Justification for scoping out of this Assessment
Existing Cables (including DK-PL1, DK-PL2, Baltica Seg1, DK-RU1 and Sea Lion cable.	0 km at minimum (DK-PL1, DK-PL2, DK-RU1 and Baltica Seq1 cross NSP2 in Danish TW). The Sea Lion cable runs parallel to NSP2 at northern part of Danish route.	Existing Cables are operational, with the exception of DK-PL1 which is out of service.	Presence of cables on seabed. Periodic maintenance surveys.	Yes	-
NSP Existing pipeline system which runs parallel to the majority of the NSP2 proposed route.	0 km minimum (crossing of NSP2 in Danish EEZ)	Existing Construction phase is complete, operational since 2011/2012. Will remain in operation during the construction and operation of NSP2.	Presence of pipeline on seabed. Survey vessels undertaking monitoring every 1-2 years.	Yes	-

As noted above, to avoid double-counting potential impacts, no additional cumulative assessment has been undertaken for existing projects. However, to ensure transparency and assist the reader, a summary of the potential cumulative impacts which may arise as a result of existing projects together with the NSP2 project has been provided. This is based on the findings presented in section 9.

The projects which are considered of particular relevance to the reader, and therefore have been presented in this section, include the existing cables within the Baltic Sea and the existing Nord Stream pipelines (NSP).

12.3.1 Cumulative impact assessment - Existing cables

Several cables are present in the Danish sector of the Baltic Sea, as described in section 7. The cables are either active or out of service. As described in section 9, NSP2 will liaise with infrastructure owners as relevant.

Potential cumulative impacts between NSP2 and existing cables are identified in Table 12-5 below, based on the findings of Section 9. Where no specific interactions between NSP2 and the existing cables are anticipated, these have not been summarised below. The impact assessment against the full baseline condition is presented in Section 9.

Table 12-5 Summary of potential cumulative impacts from NSP2 and existing cables

Potential impact	NSP2	Existing cables	Potential cumulative impacts
Presence of vessels (operation)	During operation, vessels will be present along the NSP2 route undertaking maintenance activities, which are expected to consist of surveys every 1-2 year.	Survey and maintenance vessels may be present along cable route.	No potential cumulative impact due to the distance between the two projects. Impact to existing ship traffic is assessed in section 9.
Change of Habitat (operation)	The presence of the NSP2 pipeline may introduce a new habitat type in an area which is currently quite homogenous consisting of sand and mud. However, the impacts will be highly localised and of low magnitude, and expected to be of minor significance.	The presence of the existing cables is likely to have introduced a new habitat type in an area which was previously quite homogenous consisting of sand and mud. However, any changes are likely to have been highly localised and of low magnitude.	As the NSP2 pipelines will cross some of the existing cables, there is potential for the established benthic habitat to spread onto the NSP2 pipelines. However, the impact is anticipated to be localised and of low magnitude. Therefore the overall cumulative impact would be of negligible significance.

As discussed in Table 12-5, there are negligible potential cumulative impacts to the marine environment from existing cables and NSP2. Therefore, no detailed description of the cumulative impacts to receptors is required.

12.3.2 Cumulative impact assessment – Existing pipeline – NSP

Several pipelines are present in the Danish sector of the Baltic Sea, as described in section 7.

The only pipeline in the vicinity of NSP2 is NSP, which runs approximately parallel for the majority of the route (approximately 1,200 m apart within the Danish section), with a crossing also proposed within the Danish EEZ. NSP is in operation and as described in section 9, NSP2 will liaise with infrastructure owners as relevant.

Potential cumulative impacts between NSP2 and NSP are identified in Table 12-6, based on the findings of Section 9. Where no specific interactions between NSP2 and the NSP are anticipated, these have not been summarised below. The impact assessment against the full baseline condition is presented in Section 9.

Table 12-6 Assessment of potential cumulative impacts from NSP2 and existing pipelines

Potential impact	NSP2	Existing pipelines (NSP)	Potential cumulative impacts
Presence of pipelines on the seabed (operation)	During operation, the pipelines will be present on the seabed (more or less embedded, as described in section 6) which may result in impacts on bathymetry, hydrography, benthic flora and fauna, fish and commercial fisheries.	The NSP pipelines are present on the seabed (more or less embedded, as described in section 6).	Given the similarity and proximity of the two projects, it is considered that there is the potential for cumulative impacts. This potential is assessed further below.
Presence of vessels (construction and operation)	During construction of the NSP2 project, various vessels will be present for construction activities. During operation, vessels are limited to maintenance activities, which are expected to consist of surveys every 1-2 year. Impacts will be of a short duration and localised, and expected to be of negligible significance.	Survey vessels will be periodically present along NSP pipeline route.	Construction activities for NSP2 may overlap with NSP surveys. It is considered unlikely that the survey period for NSP and NSP2 would coincide. However, should the construction/ survey efforts overlap on a temporal basis, given the approximate distance of 1,200 m between NSP and NSP2 pipeline for the majority of the route and the length of the entire route, no potential cumulative impacts are anticipated.
Release of metals from anodes	During operation, release of metals from anodes will take place	During operation, release of metals from anodes will take place	Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity. However, elevated concentrations of metals will be localized to the area around the crossing (within 15 m), and it is assessed that the combined impact from the two pipelines will be negligible.

As discussed in Table 12-6, the presence of two pipeline systems on the seabed may lead to cumulative impacts. The receptors susceptible to cumulative impacts are identified as Bathymetry, Hydrography, Benthic flora and fauna, Fish and Commercial Fishery, as identified in section 8.

Bathymetry
The presence of NSP and NSP2 form long term impacts on the bathymetry of the seabed, as the pipelines and any rocks which are placed as part of seabed interventions works will be different to the original seabed.

Trenching is estimated to be carried out in three sections in Danish waters will displace the sediment from the trench and deposit sediment to the sides of the trench. Although the trench after pipeline installation by trenching is left open, monitoring of the installation of the NSP showed that the impact on the bathymetry were insignificant. Furthermore, the monitoring of the trenching during NSP construction revealed that within the Danish waters around Bornholm, no measurable physical effects on the seabed could be detected more than 25 m from the pipelines.

Based on the above, it is assessed that negligible cumulative impacts will arise as a result of NSP in combination with NSP2.

Hydrography

Potential cumulative impacts on hydrography from NSP2 include the changes in seabed topography, and deep water current patterns resulting from changes in the seabed topography.

By installing the NSP2 pipelines a cumulated impact from in total four pipelines is created. Since the pipeline routes do not pass through the Bornholm Strait or the Stolpe Channel, the main gateways for inflowing seawater to the Baltic Proper, there will be no hydraulic effect on the bulk flow /243/.

Results from the hydrographic monitoring of NSP suggest that the mixing caused by the pipelines in the Bornholm Basin is far below the worst case estimations in the theoretical analysis, which were already considerably below any level of effect. One reason for this is that embedment of at least 50% of the pipelnes are expected in most locations in Danish waters. The main reason for the reduced estimate of the mixing effect by the pipelines is due to a better understanding of the currents in the Bornholm Basin /398/.

The cumulative impact as a result of NSP in combination with NSP2 is therefore assessed to be negligible.

Benthic flora and fauna

There is no benthic flora in the project area, therefore only benthic fauna is discussed.

The presence of pipelines (a solid construction) on the seabed in a vast soft bottom area mainly consisting of mud and sand will attract sessile organisms that otherwise are rare in the region, and can be considered an artificial reef. However, as described in section 9, the beneficial impact of the pipeline construction on the ecological conditions in the region must not to be overestimated. Because the pipelines only occupy a negligible part of the total productive volume dominating the region and which sustains the ecosystem in this part of the Baltic Sea, no cumulative impacts on the benthic fauna will occur.

Fish

The presence of pipelines (a solid construction) on the seabed in a vast soft bottom area mainly consisting of mud and sand will attract sessile organisms that otherwise are rare in the region, and can be considered an artificial reef. However, as described in section 9, the beneficial impact of the pipeline construction on the ecological conditions in the region must not to be overestimated. Because the pipelines only occupy a negligible part of the total productive volume dominating the region and which sustains the ecosystem in this part of the Baltic Sea, no cumulative impacts on fish are assessed to occur.

Commercial fishery

During operation the presence of the NSP2 will present a cumulative impact together with the NSP, as there will be four pipelines relatively close to each other.

This will have an impact to the fishermen in the area. Experiences from the NSP show that the fishermen can co-exist with the pipeline. So far no gear has been reported lost or damaged. Natural embedment (and post lay trenching) of the pipeline has in most locations - depending on the seabed conditions – significantly reduced the risk and hassle for bottom trawling activities.

Protected areas

A number of protected areas are designated to protect the marine environment. As described above, no cumulative impacts are expected to occur to the marine receptors (plankton, benthic fauna, fish, marine mammals, seabirds), and as such no cumulative impacts are foreseen to the protected areas and/or Natura 2000 sites.

12.4 Management and mitigation of cumulative impacts

The cumulative impact assessment has not identified any significant cumulative impacts which would require implementation of management or mitigation measures.

12.5 Summary of cumulative impacts

Potential cumulative impacts are the overall impacts from the project in addition to potential impacts from other planned activities in the area. In this section, a summary of the potential impacts from the project in combination with key existing projects in the area has also been provided.

The assessment of the potential cumulative impacts is summarized in Table 12-7.

Table 12-7 Assessment of the cumulative impacts during construction and operation of NSP2

Cumulative Project	Status	Overall cumulative impact
Planned projects		
Bornholm Wind Farm	Planned, EIA completed	Negligible
Extraction Areas – Rønne Banke	Reserved areas, no valid permits	Negligible
Existing projects		
NSP	Existing, in operation	Negligible
Existing cables	Existing, in operation	Negligible

13 UNPLANNED EVENTS AND RISK ASSESSMENT

Construction and operation of NSP2 give rise to a number of hazards which may present risks to the environment, the public/third parties[51] and workers. The focus of this chapter is to describe the risk assessments that have been undertaken to assess the risks to the environment and to the public during construction and operaton of NSP2. Risks to workers have also been assessed; however these risks and the necessary mitigation measures will be addressed by the safety management systems of Nord Stream 2 and its construction/contractor organisations, and are not therefore included here.

The identified risks to the environment and public during construction and/or operation of NSP2 assessed in this section relate to the following unplanned events:

- Vessel collisions and subsequent oil spill;
- Gas release;
- Unplanned munitions encounter;
- Unplanned maintenance works;
- Unplanned above-water tie-in.

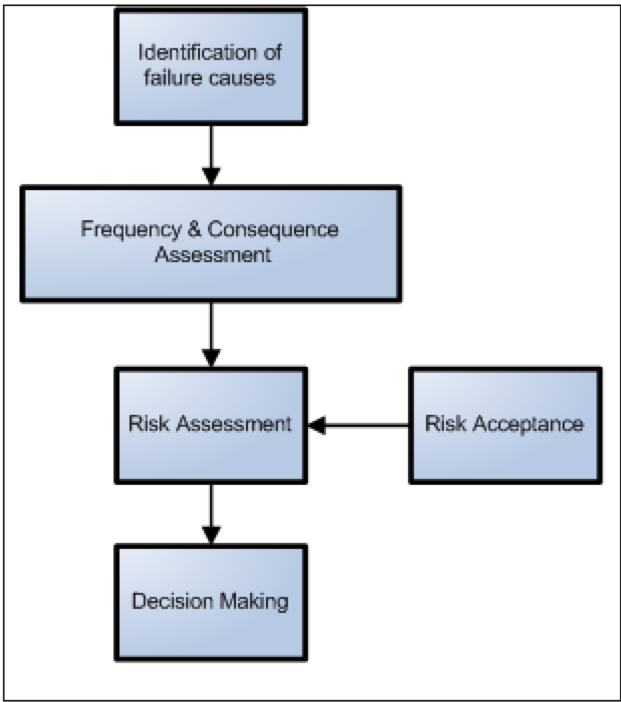
Risks for environment and public are presented for the construction and operational phases in sections 13.2 and 13.3, respectively, including an assessment of potential environmental impacts from unplanned events. Based on the undertaken risk assessment (section 13.1), Nord Stream 2 AG has prepared a strategy for emergency preparedness, which is summarized in section 13.4.

Unplanned events, such as munitions encounter, maintenance works and above-water tie-in are presented separately. These are events where a detailed risk assessment has not been undertaken, but which are described at a high-level along with potential consequences and mitigation measures.

13.1 Risk assessment methodology

The risk assessment regarding risks to the environment and public during construction and/or operation of NSP2 follows a classic risk assessment procedure as illustrated in Figure 13-1. The procedure begins with the identification of failure causes followed by an assessment of the relevant frequencies and consequences. The risks are then assessed with respect to the risk acceptance criteria, and decisions are made in order to reduce the risks to a level as low as reasonably practicable (ALARP). This includes applying mitigation measures where relevant to avoid or reduce the risk.

[51] The public and third parties are used interchangeably in this chapter to refer to people who are not connected to the project, for example, the crews and passengers of commercial shipping in the Baltic Sea.



Guidelines used for the risk assessment

- An assessment of potential risks in the construction phase according to the Det Norske Veritas (DNV) guideline DNVRP-H101 /399/ and International Maritime Organization (IMO) guidelines for risk management and formal safety assessment in marine and subsea operation /400/ (performed by Global Maritime together with the construction contractor);
- An operational risk assessment related to fatalities, environment, economical losses and reputation performed according to the DNV guidelines DNV-OS-F101 /401/ for pipeline integrity and DNV-RP-F107 /402/ for potential environmental risks in the operation phase (performed by the detailed engineering contractor, SAIPEM).

Figure 13-1 Risk assessment methodology and guidelines used for the risk assessment.

Figure 13-2 illustrates the ALARP principle and defines three regions for risks. Risks in the upper region are considered generally intolerable and generally cannot be justified, and risk reducing measures must be implemented to bring the risk down. Risks in the middle region are considered tolerable (or ALARP). For these risks, effort should take place to reduce the risk, and it should be justified that possible risk-reducing measures are grossly disproportional to the achieved risk reduction. Risks in the lower region are considered broadly acceptable, and further risk reducing measures are in general not required.

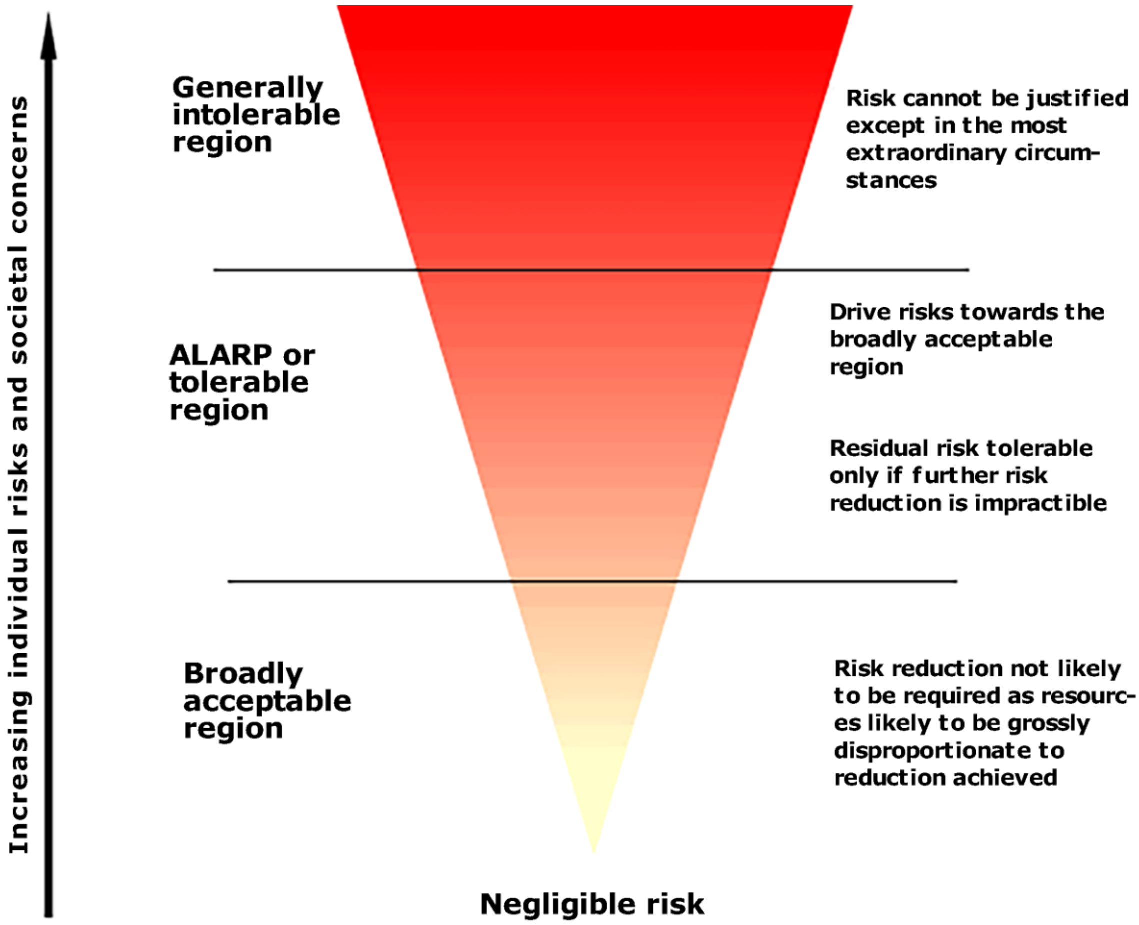


Figure 13-2 The ALARP triangle defines three regions for risks: intolerable, tolerable and acceptable.

All documents pertaining to the risk assessment are part of the independent third-party verification of the engineering work performed by DNV-GL. Subsequently, DNV-GL will provide final certification of compliance for the overall pipeline system.

To support assessment of the unplanned events the following additional assessments have been performed:

- Oil spill modelling (section 13.2.1);
- Gas release modelling (section 13.3.1).

13.2 Construction phase risks

A risk assessment has been undertaken for the construction phase /403/.

13.2.1 Environmental risks

The environmental risk assessment of the construction phase /403/ covers the following activities:

- Preparation of the landfall facilities (not relevant for the Danish sector);
- Pre-lay intervention works/rock placement including vessel loading operations;
- Pipe-lay including the pipe load-out and transportation;

- Post-lay intervention works, rock placement and ploughing including vessel loading operations;
- Pre-commissioning operations.

It is noted that during the construction phase, the assessment of environmental risks is limited to spills, which previous experience has shown is the main risk for the environment.

13.2.1.1 Identification of environmental hazards

The identified assessed hazards related to the NSP2 activities which can lead to breaking containment and release of hazardous substances to the environment are the following /403/:

- Spill of fuel oil from construction activities onshore or at landfall areas (not relevant for the Danish sector);
- Passing vessel collision;
- Construction vessel collision;
- Vessel fire;
- Vessel grounding;
- Vessel sinking;
- Oil spill – bunkering.

The identified environmental hazards all result in an oil spill, which is detailed further below.

13.2.1.2 Risk assessment

As part of the risk assessment /403/, the probability and the potential spill quantities have been calculated for each of the environmental hazards. The results are shown in Table 13-1.

Table 13-1 Findings of the environmental quantitative risk assessment for the entire NSP2 pipeline route /403/. Note that shallow water lay is not relevant for the Danish sector.

Item	Hazards	Probability of oil spill (per year)	Potential spill quantities (tonnes)
Passing vessel collision			
a	Third-party vessel collision 1-10 tonnes spill	$2.1 \cdot 10^{-5}$	1 – 10
b	Third-party vessel collision 10-100 tonnes spill	$4.2 \cdot 10^{-5}$	10 – 100
c	Third-party vessel collision 100-1000 tonnes spill	$6.1 \cdot 10^{-5}$	100 – 1.000
d	Third-party vessel collision 1000-10,000 tonnes spill	$2.9 \cdot 10^{-5}$	1,000 – 10,000
e	Third-party vessel collision >10,000 tonnes spill	$8.0 \cdot 10^{-5}$	> 10,000
Construction vessel collision			
f	Pipe-laying vessels	$2.6 \cdot 10^{-5}$	750 – 1,250
g	Diving support vessel (DSV)/trench support vessel	$3.0 \cdot 10^{-5}$	500 – 850
h	Rock placement vessel	$1.5 \cdot 10^{-5}$	500 – 850
i	Pipe carrier & supply vessel	$8.0 \cdot 10^{-5}$	300 – 500
j	Anchor-handling tug (AHT)	$3.5 \cdot 10^{-5}$	300 – 500
k	Shallow water lay	$6.7 \cdot 10^{-6}$	300 – 500
Vessel fire			
l	Pipe carrier/AHT/supply vessel	$1.0 \cdot 10^{-4}$	100
m	Rock placement vessel	$5.6 \cdot 10^{-5}$	170
n	Pipe-laying vessels	$1.0 \cdot 10^{-4}$	250
o	DSV/trench support	$1.9 \cdot 10^{-5}$	250
p	Shallow water lay	$2.8 \cdot 10^{-5}$	100
Vessel grounding			
q	Pipe carrier	$1.4 \cdot 10^{-4}$	300 to 500
r	Rock placement vessel	$1.5 \cdot 10^{-5}$	500 to 850
s	Supply vessel	$5.8 \cdot 10^{-5}$	300 to 500
Vessel sinking			
t	DSV/trench support vessel	$5.3 \cdot 10^{-7}$	750 to 1,250
u	Pipe carrier/AHT/supply	$3.0 \cdot 10^{-6}$	300 to 500
v	Pipe-laying vessels	$3.0 \cdot 10^{-6}$	750 to 1,250
w	Rock placement vessel	$1.6 \cdot 10^{-6}$	500 to 850
x	Shallow water lay	$7.9 \cdot 10^{-7}$	300 – 500
Oil spill – bunkering			
y	AHT	$2.0 \cdot 10^{-3}$	0 to 10
z	Pipe-laying vessel	$5.0 \cdot 10^{-2}$	0 to 10
aa	Shallow water lay	$1.2 \cdot 10^{-2}$	0 to 10

The findings of the environmental quantitative risk assessment for the construction phase of the entire NSP2 pipeline route are indicated on the DNV-GL risk matrix in Figure 13-3. The risk items ‘a’ to ‘aa’ refers to Table 13-1. It can be seen that there are no high-risk events and only three medium-risk events that relate to third party and DP pipe-lay vessel collision and oil spill (items d, e and f see Figure 13-3).

Consequences		Probability (increasing probability)			
Descriptive	**Environment**	**Remote** (< 10^{-5}/year)	**Unlikely** (10^{-5}-10^{-3}/year)	**Likely** (10^{-3}-10^{-2} /year)	**Frequent** (10^{-2}-10^{-1} /year)
1 Extensive	Global or national effect. Restoration time > 10 yrs.				
2 Severe	Restoration time > 1 yr. Restoration cost > USD 1 mil.	t,u,v	d,e,f		
3 Moderate	Restoration time > 1 month. Restoration cost > USD 1 K	k,w,x	c,g,h,i,j,m,n,o,q,r,s		
4 Minor	Restoration time < 1 month. Restoration cost < USD 1 K		a,c,l,p	y,z,aa	
HIGH	The risk is considered intolerable so that safeguards (to reduce the expected occurrence frequency and/or the consequences severity) must be implemented to achieve an acceptable level of risk; the project should not be considered feasible without successful implementation of safeguards				
MEDIUM	The risk should be reduced if possible, unless the cost of implementation is disproportionate to the effect of possible safeguards				
LOW	The risk is considered tolerable and no further actions are required				

Figure 13-3 Findings of the environmental quantitative risk assessment for the entire NSP2 pipeline route /403/. Note that shallow water lay is not relevant for the Danish sector.

Three medium-risk events are related to third party and DP pipe-lay vessel collision and oil spill (items d, e and f, see Figure 13-3).

Regarding item d "3rd party vessel collision 100 – 1,000 t spill", e "3rd party collision > 10,000 t spill" and f "DP Pipe-lay collision" in Figure 13-3, these risks are related to passing vessel collision and collision risk reduction is required to minimise the potential for environmental damage. It will therefore be necessary to be able to respond quickly to any oil spills. The construction vessels are all required to have SOPEP emergency oil spill procedures and equipment on board, however SOPEP kits rarely include provisions for anything beyond a minor spill (tier 1) and therefore NSP2 has requested that all marine contractors have plans to deal with Tier 2 and Tier 3 spills, most likely through agreements with suppliers of oil spill response equipment /403/.

Since risk items d, e and f are the only ones with medium risk, further analysis of environmental consequences are further detailed at below.

13.2.1.3 Spill frequency and consequence assessment (oil spill)

The spill frequencies (pollution frequency per year) resulting from the construction activities are summarised in Table 13-2.

Table 13-2 Spill frequencies (pollution frequency per year) for Denmark (excluding NSP2) /403/.

Spill size	1-10 t	10-100 t	100-1,000 t	1,000-10,000 t	>10,000 t
Denmark	$6.6 \cdot 10^{-7}$	$1.3 \cdot 10^{-6}$	$1.9 \cdot 10^{-6}$	$9.2 \cdot 10^{-7}$	$2.6 \cdot 10^{-7}$

Statistically, the number of oil-spill accidents in the Baltic Marine Area is estimated to be 2.9 per year. Comparing this with the estimated increased risk of oil spill introduced during the construction phase, it can be concluded that construction of NSP2 will theoretically increase the risk. The theoretical increase in the annual oil spill frequency due to the NSP2 project is assessed to be less than 0.1‰, which is considered a very low risk. The amount of traffic caused by the activities related to the NSP2 will occur within a limited time, and the introduction of mitigation measures will further decrease the risk of spills.

In the event of a collision, the cargo and/or fuel of the involved ships can be spilled into the environment. The fuel types are provided in Table 13-3.

Table 13-3 Liquids that potentially can be spilled from the NSP2 vessels and third-party vessels.

Type of vessel	Fuel type	Cargo
NSP2 vessel	Fuel oil, diesel	-
Third-party vessel	Diesel, bunker fuel	Oil products or crude oil

Potential spill quantities are listed in Table 13-1. When oil is spilled it goes through physical processes such as evaporation, spreading, dispersion in the water column and sedimentation to the seafloor. Eventually, the oil will be eliminated from the marine environment through biodegradation. The effects of oil spills at sea depend on numerous factors, such as:

- The amount of oil spilled;
- The properties, toxicity, and stability of the oil;
- The rate of spread of the oil slick;
- The size and location of the spill;
- The time or season of the accident;
- Biological processes occurring at the spill site, such as evaporation, dissolution, dispersion, emulsification, photo-oxidation and biodegradation.

Oil spill modelling has been undertaken for a scenario with collision (see section 13.2.2). Various mitigation measures developed by NSP2 will be in place to minimise the risk of oil spill caused by accidents (see section 13.3.3).

Based on HELCOM Recommendation 11/13, it is assumed that countries around the Baltic Sea are capable of controlling a major oil spill within two days of a release, and thereby impacts on the marine environment will be minimised. The HELCOM countries have adopted a recommendation on the development of national ability to respond to the accidental oil spills and other harmful substances. The recommendation specifies response times for combatting oil spills. Within six hours the spill location shall be reached in the response region of the respective country. An adequate and substantial on-site response action must be implemented within 12 hours and countermeasures against a spill of oil or hazardous substances should be initiated within two days.

13.2.1.4 Oil spill modelling

The environmental risk assessment identified no high risks. However, there are some medium risks, including: third-party vessel collision, pipe-lay vessel collision and rock placement vessel collision. For events with a medium risk, the most severe spill size is estimated based on the bunker capacity of the DP pipe-lay vessel. The assumption used in the modelling are based on that 50% of the bunker oil would be spilled. This corresponds to a spill of approximately 1,250 tonnes of oil.

The physical parameters of the oil determine the conditions under which the oil is transported and degraded. The major factors are meteorological and hydrographic parameters.

Modelling has been carried out to assess the oil spreading and oil concentrations from an accidental oil spill during construction. For the modelling of oil spill the MIKE Ecolab/Oil spill model has been used. It is a Lagrangian model for predicting the fate of spilled oil in the marine environment, including both the transport of oil and changes in its chemical composition. For further details on the modelling refer to /395/.

Oil spill locations in the Baltic Sea have been chosen for the oil spill simulations (Figure 13-4), based on likelihood and sensitivity. In Denmark, one location has been considered. This location is situated where the pipeline route crosses the shipping lane Rostock-Gdynia and at the same time is situated close to Natura 2000 sites.

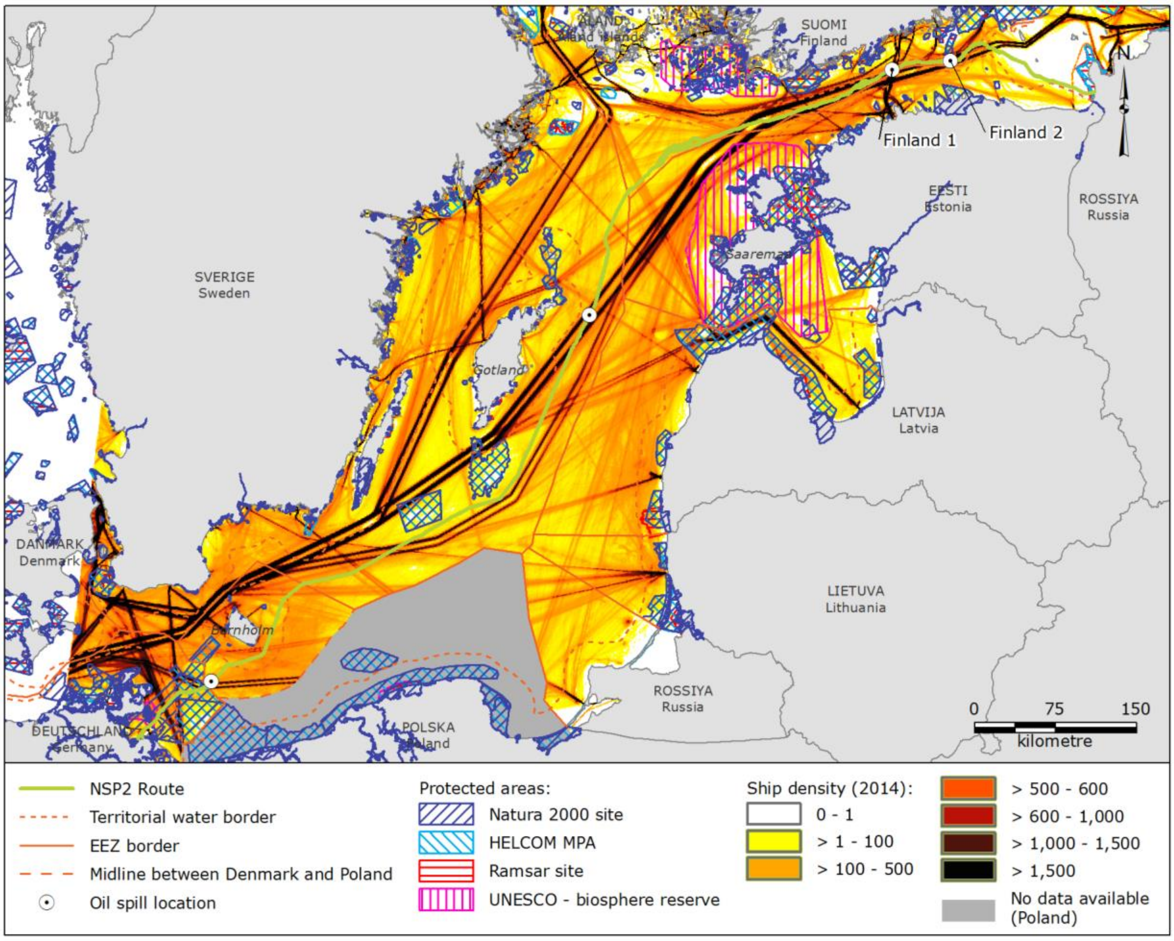


Figure 13-4 Positions of accidental oil spill simulations, planned pipeline route, ship traffic intensity and protected areas in the Baltic Sea.

It is assumed that the duration of the spill is six hours, corresponding to the time in which the spill location should be reached by the oil spill standby force, according to HELCOM recommendations.

Drift simulations have been carried out to determine the likelihood of an area being contaminated by spilled oil. The spill simulations are based on an ensemble of 120 oil spills. The 120 simulations were distributed over the period of one year in order to get all seasons represented.

On the basis of the 120 oil spill simulations, the coverage areas of the oil slick after an oil spill of 1,250 tonnes are given in Table 13-4. According to MARPOL, exceedance of 15 mg/l is considered a critical limit for oil contamination.

Table 13-4 Mean and maximum area coverage from 120 simulations at the spill location in Denmark.

Area coverage for concentration: >1 mg/l		Area coverage for concentration: >15 mg/l	
Mean [km^2]	Max [km^2]	Mean [km^2]	Max [km^2]
117	236	13	37

The exposed coastlines are the southern coastlines of Bornholm and Sweden as well as the northern coastlines of Germany and Poland. The calculated maximum oil concentration, average maximum and average mean concentrations are given in Table 13-5.

Table 13-5 Calculated oil concentrations after two days.

	Bornholm, southern coast-line	Sweden, southern coastline	Germany, northern coastline
Probability of oil occurrence after two days	<5 %	<1%	<5 %
Maximum oil concentration (mg/l)	50	190	230
Average maximum oil concentration (mg/l)	1	1.6	3.8
Average mean oil concentration (mg/l)	0.1	0.4	0.1

Based on the results of the oil spill modelling, there is a risk of impacts to coastal areas, Natura 2000 sites and other protected areas. It is noted that the spill scenarios are similar to those which would be generated even without NSP2 as a result of the existing shipping in the area.

13.2.1.5 Sensitivity to oil spills

Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea (BRISK) was undertaken in 2009-2012, and was initiated and implemented by the national authorities responsible for oil spill preparedness around the Baltic Sea as well as the European Maritime Safety Agency /421/.

As part of BRISK, the environmental sensitivity to oil spills on the sea surface for the entire Baltic Sea was determined. The applied method is based on the traditional approach to sensitivity assessments. Seventeen key environmental parameters were selected and mapped including several habitats, species of marine flora and fauna, and protected areas, as well as human activities.

The sensitivity was determined for the Baltic Sea for each of the four seasons. The results show that the sensitivity is highest in coastal areas, in archipelagos and in shallow water areas. In the Danish sector of the Baltic Sea, the sensitivity is highest in summer. The sensitivity is considered low-medium low /421/.

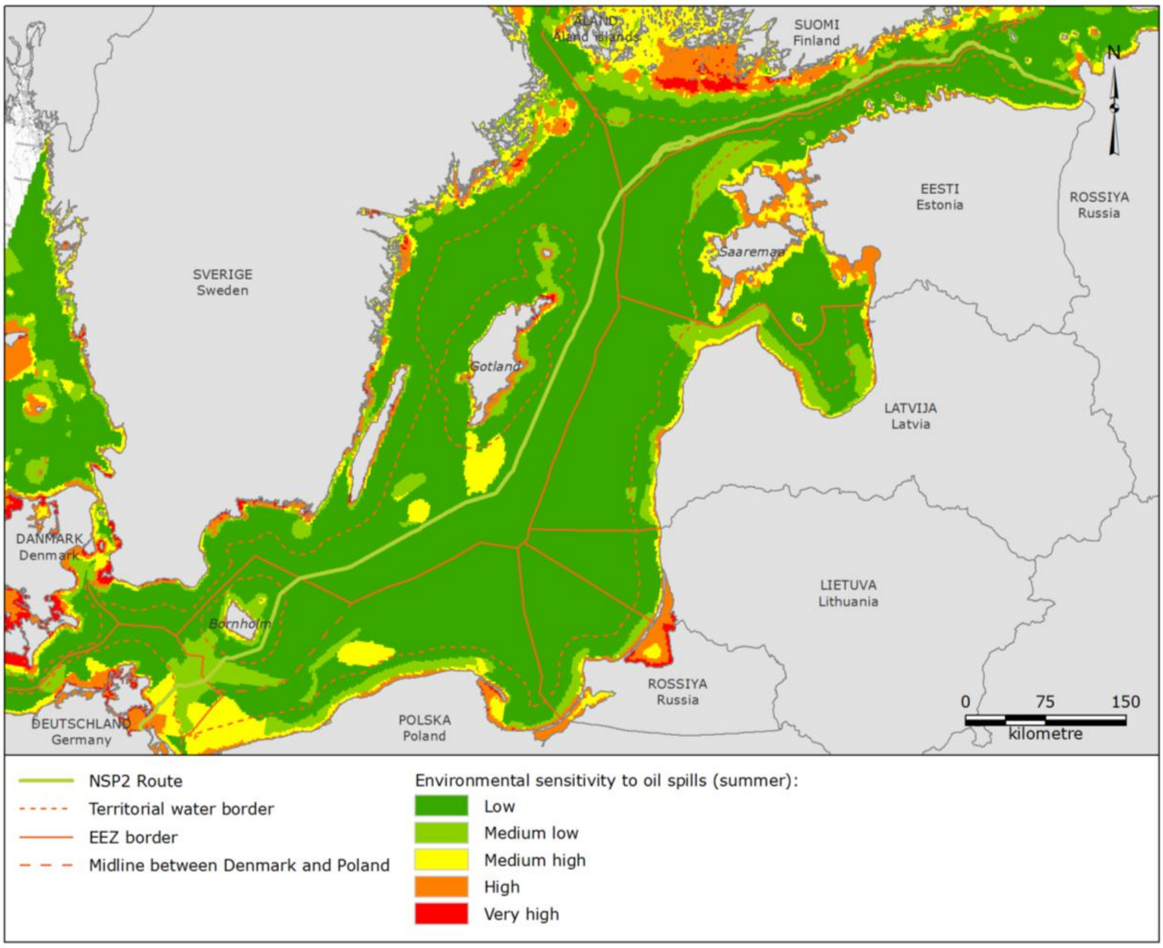


Figure 13-5 Environmental sensitivity to oil spills during summer /421/.

13.2.1.6 Potential impacts on the environment

There are no planned discharges but accidents causing oil spill due to presence of vessels during construction or operation, is a potential risk. During the construction phase of the NSP2 pipeline system, there will be a slight increase in ship traffic in the Baltic Sea due to the movements of the construction vessels. The increase in ship traffic slightly increases the probability of ship collision during the construction period.

Oil spills pose a risk to marine organisms and may damage offshore and coastal ecosystems. Many of the petroleum-related chemicals that are spilled are potentially toxic or can be bioaccumulated in the tissues of marine organisms. Such chemicals may then be biomagnified up the marine food web from phytoplankton to fish, birds and marine mammals /418/.

Marine organisms may be affected by oil in several ways:

- As a result of physical contamination (smothering);
- By toxic effects of chemical components; and
- By accumulation of substances leading to physiological effects.

Potential impacts to fish, birds and marine mammals are further described below.

Fish

Fish may be exposed to spilled oil in different ways. The water column may contain volatile components of oil that may be absorbed by fish at different stages of development.

Direct contact with oil may cause blockage of the gills, and fish exposed to oil may suffer from changes in heart and respiratory rates, enlarged livers, reduced growth, fin erosion, as well as a variety of biochemical and cellular changes, and reproductive and behavioural responses /418/.

Fish eggs and larvae are much more sensitive to oils spills than adult fish and laboratory experiments have shown that oil is very toxic to fish eggs and larvae. There is no evidence of impacts to fish population in cases of oil spill and massive kills of eggs and larvae is probably because the fish produce extremely large numbers of eggs and larvae and because most species have extensive spawning grounds /432/. Fish spawning and nursery areas may be particularly vulnerable, depending on the species.

<u>Marine mammals</u>
A major oil spill may impact marine mammals which come into contact with the spill. In general, whales, porpoises and seals in the open sea do not appear to be particularly at risk from oil spills as they can avoid the oil slicks. However, marine mammals such as seals that breed on shorelines are more likely to encounter oil. Impacts to seals are related to direct contact with the oil, where smothering of seals may occur leading to inflammation, infection, suffocation, hypothermia and reduced buoyancy. Seals can also lose their habitat if oil washes up on their haul-out sites /418/.

Marine mammals may also be quite sensitive the first few days following an oil spill, when toxic petroleum hydrocarbons and other chemicals evaporate from the surface of the oil slick. If they emerge at the surface to breathe in the middle of an oil slick they may inhale toxic vapours. Exposure to toxic petroleum hydrocarbon fumes may irritate eyes and lungs, cause drowsiness, or impair breathing /421/.

<u>Seabirds</u>
Seabirds are often the most visible victims of an oil spill are seabirds, who spend significant amounts of time on the water surface or along the shoreline. The primary effect on seabirds of oil contamination is smothering, i.e. the loss of body insulation that is provided by the feathers. The plumage of seabirds is water-repellent but oil absorbent. When the feathers get in contact with oil, the natural water-repellent effect cease and water penetrates the normally insulating cover of the plumage. This may lead to hypothermia and possibly death. Furthermore, large amounts of oil cause the feathers to stick together, impairing flight and buoyancy. In the Baltic Sea, it is mainly birds that spend a large part of their time on the sea surface(e.g. aucks, ducks and divers that are at risk of being smothered in oil, but all groups of birds can be affected /421/.

Secondary impacts to seabirds include ingestion and/or inhalation of oil while trying to preen, or ingestion of contaminated food. As a consequence of such intake, seabirds may suffer short-term or long-term effects, such as damage to the lungs, kidneys and liver, and gastro-intestinal disorders /418/.

13.2.1.7 Conclusion

As a consequence of the increased traffic in the construction phase, NSP2 will cause a minor increase in the risk of an accidental oil spill. The conclusion in the construction risk assessment /388/ with respect to the environment risks is that there are no high-risk events and three medium-risk event relevant for the Danish sector. The medium-risk events are third-party vessel collision.

Based on a scenario with spill of bunker oil from DP pipe-lay vessel, oil spill modelling has been undertaken. The results show that there is a risk of impacts to coastal areas, Natura 2000 sites and other protected areas, in case of an accidental oil spill. It is noted that the spill scenarios are similar to those which would be generated even without NSP2 as a result of the existing shipping in the area.

Potential transboundary impacts of unplanned events are addressed in section 14.2.

13.2.2 Risks to the public

A risk assessment has been undertaken for the construction phase /403/. The risk assessment of the construction phase covers the following activities:

- Preparation of the landfall facilities (only relevant for German and Russian sectors);
- Pre-lay intervention works/rock placement including vessel loading operations;
- Pipe-lay including the pipe load-out and transportation;
- Post-lay intervention works, rock placement and ploughing including vessel loading operations;
- Pre-commissioning operations.

The assessment considers risks to the public, i.e. vessel crews, onshore crews, third part personnel (e.g. on passing ships).

In the Danish sector, the risk assessment for the public is limited to the crews and passengers of passing vessels that could collide with construction vessels. Shallow water and landfall specific risks are not relevant for the Danish sector.

13.2.2.1 Identification of hazards

The assessment considers risks to the public, i.e. vessel crews, onshore crews, third part personnel (e.g. on passing ships).

In the Danish sector, the risk assessment for the public is limited to the crews and passengers of passing vessels that could collide with construction vessels. Shallow water and landfall specific risks are not relevant for the Danish sector.

The pipeline will cross several existing ship traffic routes. These are illustrated in Figure 13-6, which also includes the weight-coating plants and interim stockyards. For more detailed information on the ship traffic in the Danish sector see section 7.15.

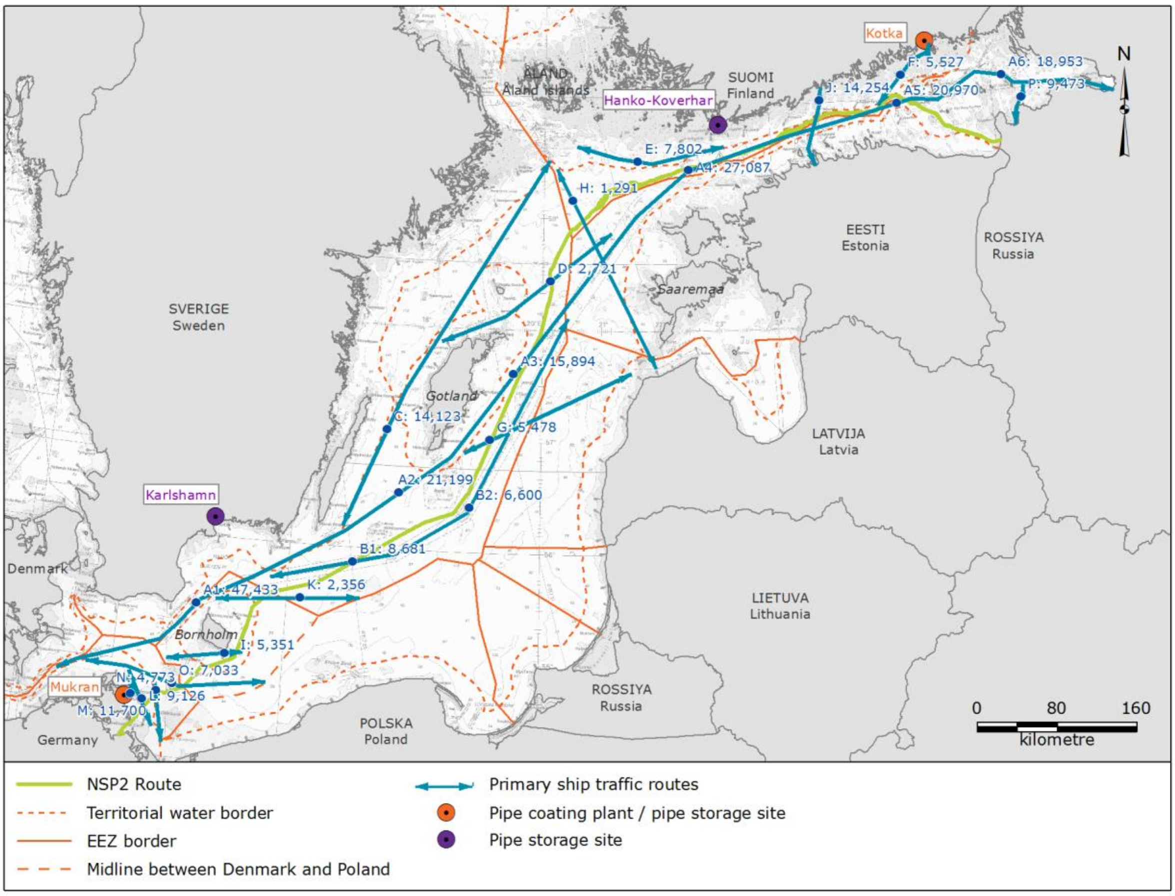


Figure 13-6 Illustration of the major ship traffic routes, and the weight-coating plants and interim stock-yards. The annual number of ship movements for each route during 2014 and the route name are presented in boxes.

Before and during the construction of NSP2 there will be an increase in ship traffic in the Baltic Sea due to the movements of the intervention work vessels, pipe carriers and pipe-lay vessels. When a construction vessel crosses an existing shipping route there is a risk of a ship-ship collision.

13.2.2.2 Frequency and consequence assessment

An assessment of the frequency of ship collisions between the construction vessels (pre-lay intervention work vessels, pipe carriers and pipe-lay vessel) and the general ship traffic are presented in the ship-ship collision report /407/.

The yearly ship collision frequency has been estimated for the section of pipe in each country along the route. This has been carried out using the same methodology, and the results for the Danish section of the pipeline are summarised in Table 13-6.

Table 13-6 Frequency of ship collisions in the Danish sector /403/.

Denmark	Cargo Ship	Tanker	Passenger Ship	Total
Frequency of collisions per year	$3.3 \cdot 10^{-5}$	$1.0 \cdot 10^{-5}$	$3.1 \cdot 10^{-6}$	$4.51 \cdot 10^{-5}$

The total increase in the annual ship collision frequency in the Danish sector during construction of NSP2 is calculated to $4.51 \cdot 10^{-5}$ collisions per year, which is equivalent to one collision in 20,000 years on average.

The ship traffic in the Baltic Sea is dense, and each year a number of ships are involved in accidents. Most of the observed ship-ship collisions occur closer to shore mainly in the vicinity of ports. The observed number of ship-ship collisions in the Baltic Sea area, involving vessels of similar size as in the ship-ship collision study, in the period from 2007-2013 has on average been 24 ship-ship collisions per year /409//410/. Comparing this with the estimated increased frequency of ship collisions introduced during the construction phase, it can be concluded that construction of NSP2 will have a theoretically low impact on the current frequency of ship-ship collisions. However, the increase in the collision frequency due to the construction of the NSP2 will be very limited.

The consequences of a collision, with respect to third-party fatalities, have been assessed by reference to Lloyd's Maritime Intelligence Unit data on ship-ship collisions and the associated statistics relating to the number of deaths and missing persons /408/.

The individual risk and group risk have been estimated for the section of pipe in each country along the route. This has been carried out using the same methodology, and the results for the Danish section of the pipeline are summarised in Table 13-7.

Table 13-7 Individual risk for third-party fatalities in the Danish sector /388/.

Denmark	Cargo Ship	Tanker	Passenger Ship
Individual risk (probability for fatalities per year)	$9.1 \cdot 10^{-8}$	$2.3 \cdot 10^{-8}$	$3.9 \cdot 10^{-10}$

13.2.2.3 Risk assessment

Individual risk and group risk for third-party fatalities have been calculated, and assessed towards tolerability criteria /403/.

The individual risk (probability for third-party fatalities) are shown in Table 13-7. The tolerability criteria for individual risk in the offshore industry (probability of a fatal accident) are set as given in Table 13-8. It can be seen that the individual risks for third-party fatalities are below both tolerability criteria, and the risk is therefore considered acceptable /403/.

Table 13-8 Tolerability criteria for individual risk in the offshore industry /403/.

	Tolerability criteria for individual risk (probability of a fatal accident)
Maximum tolerable risk for the public	10^{-4} per person per year
Broadly acceptable risk	10^{-6} per person per year

Group risk, or the risk experienced by the whole group of personnel working on the installation or otherwise affected by it, is usually expressed as an F-N curve, showing the cumulative frequency (F) of events involving N or more fatalities, see Figure 13-7. In /403/ this criterion is used to evaluate the risk for third party fatalities.

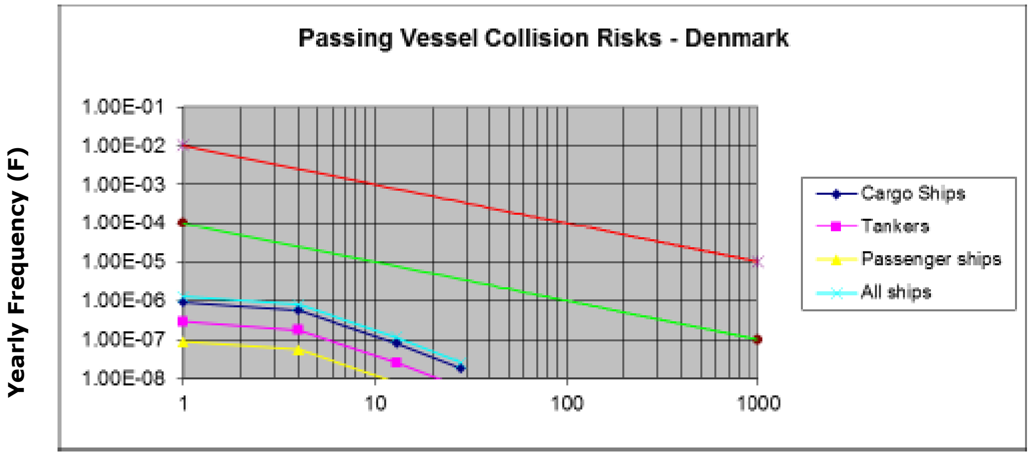


Figure 13-7 Group risk for third-party person fatalities from ship-ship collisions in the Danish sector during the construction phase of NSP2. The area between the red and green line shows risks which are in the tolerable region (ALARP), while the area below the green line shows risks which are in the broadly acceptable region /403/.

The F-N curve (Figure 13-7) is used to evaluate the risk for third-party person fatalities. Risks above the red line are in the unacceptable region, i.e. risks which cannot be justified with the exception of extraordinary circumstances. Risks between the red and green line are in the tolerable region (ALARP), i.e. risks are only tolerable if risk reduction would exceed the improvement gained. Finally, risks below the green line are in the broadly acceptable region, i.e. the level of residual risk is regarded as insignificant and further effort to reduce risk is not likely to be required /403/.

As can be seen from Figure 13-7, the group risks for third-party fatalities from ship-ship collisions in the Danish sector during the construction phase of NSP2 is within the broadly acceptable region /403/.

13.2.2.4 Conclusion

The assessment considers risks to the public, i.e. vessel crews, onshore crews, third part personnel (e.g. on passing ships). The frequency of ship collisions between the NSP2 construction vessels and the general ship traffic has been assessed, and the potential consequences of a collision, with respect to third-party fatalities, have been evaluated and compared to risk tolerability criteria. It is concluded, that the risk to the public (third-party personnel) in the construction phase is within the broadly acceptable region /403/.

13.2.3 Above-water tie-in – construction phase

During the installation of the NSP2 pipeline, above water tie-in (AWTI) operations are needed to join pipeline ends and complete the construction. A detailed risk assessment has not been undertaken, but is described at a high-level along with potential consequences and mitigation measures.

Such an AWTI operation is proposed in the TSS Adlergrund southwest of Bornholm in Danish waters due to the water depth being ideal for this type of procedure. The operation would create temporary disturbance to the commercial traffic using the traffic scheme due to the potential location of the installation vessel (multi-point anchored barge or jack-up platform).

The positioning of the equipment is temporary and would remain for 10 to 14 days including the pipe lifting/lowering, AWTI procedure, inspection and stabilising of the pipeline. During the operation a safety zone with a suggested radius of 1.5 km would be established. The proposed location of the AWTI operation including the safety zone is illustrated in Figure 13-8. The location of the

AWTI and the radius of a safety zone will need to be discussed with the relevant Danish authorities.

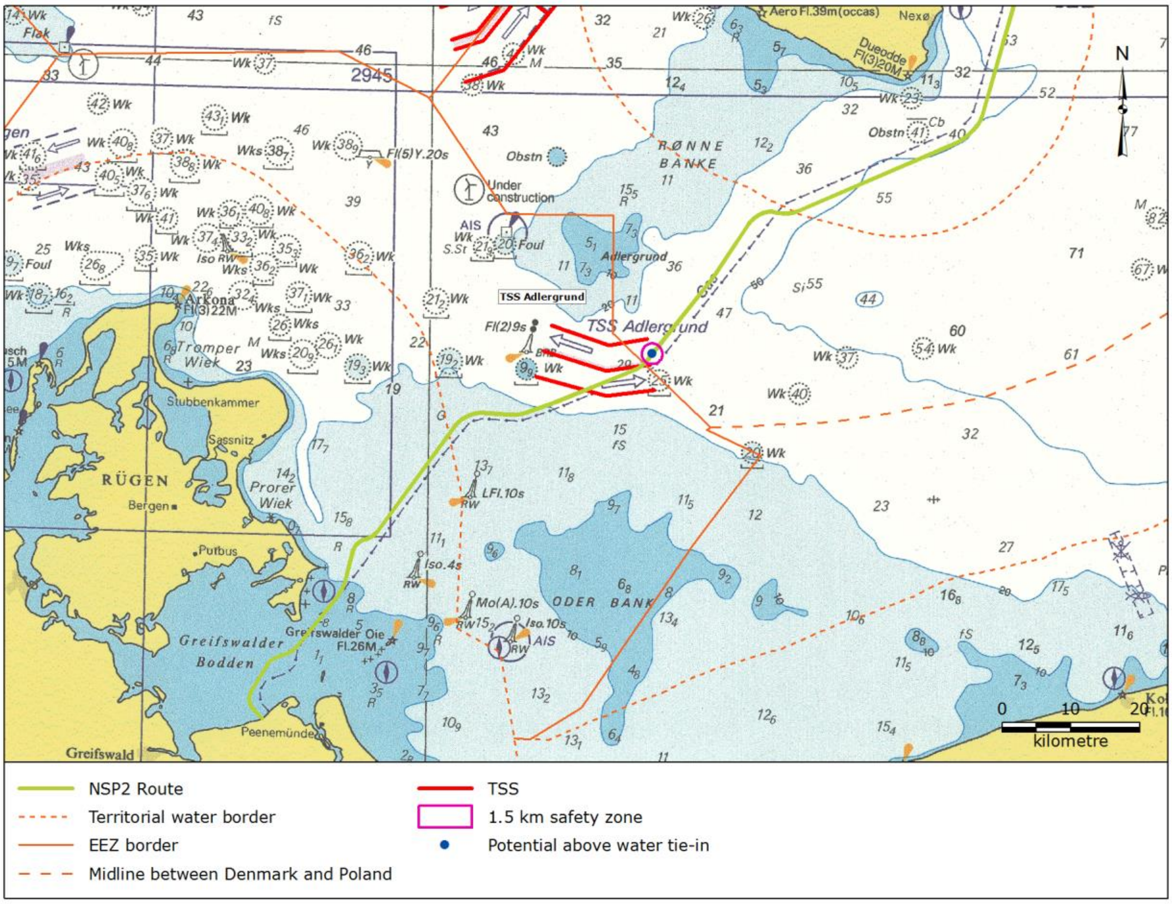


Figure 13-8 TSS Adlergrund with the proposed AWTI location and defined safety zone

Approximately 7,000 vessels were passing through the TSS Adlergrund in 2014 (i.e. average of 10 per day per lane), see section 7.15. The vessels passing through the TSS Adlergrund are mainly cargo vessels with length less than 200m and a maximum draught of 15 meters. This imply that the water depth north of the TSS is large enough to let ships pass north of the safety zone around the AWTI vessel and then enter the west bound lane of TSS Adlergrund.

In relation to navigational safety it is considered a safe operation regardless of the position of the AWTI in the entrance to the west bound lane of the TSS Adlergrund. This is due to the traffic intensity in the TSS in combinations with the precautionary measures and the relatively short time frame of the operation.

13.3 Operational phase risks

The documents related to the operational phase are part of the technical description included in the permit application. The operational risk assessment consists of the three documents "Offshore Pipeline Frequency Of Interaction - Denmark" /404/; "Offshore Pipeline Damage Assessment - Denmark" /405/; and "Offshore Pipeline Risk Assessment - Denmark"/406/.

13.3.1 Environmental risks

The environmental risks during the operational phase are related to damage to the pipeline, and the potential for gas release and ignition, that may be caused by interactions with vessels in the Baltic Sea. The potential interactions include dropped objects (e.g. containers from cargo vessels), dropped anchors, dragged anchors, sinking ships and grounding ships (close to the landfall areas). There is also a risk of fishing gear becoming snagged on the pipeline, and in extreme cases of incorrect handling, the loss of a fishing vessel.

The main steps of the risk assessment are described in the following subsections.

13.3.1.1 Identification of environmental hazards

The possible failure causes leading to unplanned releases of gas are identified on the basis of literature data on offshore gas pipeline incidents, /412/, and the hazard identification (HAZID) report /413/.

The following failure causes are identified as applicable and considered in this risk analysis:

- Corrosion (internal and external);
- Mechanical defects;
- Natural hazards (storm, scouring);
- Seismic activity and geotechnical instability;
- Other/unknown (sabotage, accidental transported mines, etc.);
- Interaction with third-party activities (commercial ship traffic).

The identified environmental hazards all result in a gas leakage, which is detailed further below.

These failure causes are included in the risk analysis described in the following sections.

Risk assessments will be undertaken for planned construction activities in military exercise areas and liaison with the relevant authorities for the safe crossing of these areas will be undertaken.

The following failure causes that may threaten the integrity of the pipeline are managed adequately through the application of the relevant DNV-GL standards. These failure causes are therefore not described further in the present report.

- Natural hazards due to current and wave action – DNV RP-F109-2011;
- Pipeline free spanning sections – DNV RP-F105-2006;
- External interference with fishing activities – DNV RP-F111-2014. The interaction between trawl gear and the pipeline has been analysed. Regarding the Danish section of the pipeline it is concluded that interaction with trawling devices is not an issue for the pipeline structural integrity, according to design procedures and acceptance criteria provided in DNV /401/;
- Operating temperature and pressure conditions – DNV RP-F110-2007.

13.3.1.2 Risk assessment

A risk assessment has been undertaken for identified hazards which may lead to a gas release. Some hazards have been assessed based on existing databases; these hazards include corrosion; mechanical defects; natural hazards; seismic activity and geotechnical instability. Other hazards have been assessed using the risk assessment methodology. These hazards include hazards are related to interaction with third-party activities (commercial ship traffic) has been.

<u>Frequency estimation for corrosion, mechanical defects, natural hazards, seismic activityand unknown</u>

The release frequencies for these failure causes are estimated from Pipeline and Riser Loss of Containment (PARLOC) 2001 database /412/ and (PARLOC) 2012 database /415/. The PARLOC database contains incidents and related loss of containment from offshore pipelines operated in the North Sea. It has been used because no specific data are available for the Baltic Sea.

Table 13-9 Frequency estimation for corrosion, mechanical defects, natural hazards, seismic activity and unknown.

Hazard	Frequency of release /415//412/	Reasoning
Corrosion (internal and external)	Negligible	• The transported medium is dry and sweet natural gas and the internal flow coating will also reduce the probability of internal corrosion; • External corrosion protection is achieved by an external corrosion coating in combination with the cathodic protection system; • Wall thickness of the pipelines (i.e. 26.8-41.0 mm) is considerable and intelligent pigging is foreseen to detect any possible loss of thickness caused by corrosion before the wall thickness achieves the critical size; • The anode potential will be measured to verify anode operability and anode consumption, which is indicative of coating deficiencies; • An inspection and maintenance programme is obligatory.
Mechanical defects	Negligible	• All materials, manufacturing methods and procedures will comply with recognised standards, practices or purchaser specifications; • Non-destructive testing (NDT) examinations at fabrication site will be performed according to DNV-GL standards.
Natural hazards (storm, scouring)	Negligible	According to the PARLOC 2001 database /412/, 13 incidents due to natural hazards (including waves and current action) have been reported. However, none of these caused loss of containment (release) from steel pipelines. Only three lines sustained damage, this being to their coating. In the PARLOC 2012 database /415/ natural hazards are included in the category "Other". No incidents are reported for steel pipelines in the midline section under this category. Furthermore, natural hazards due to current and wave action are managed adequately through the application of the relevant DNV-GL standard DNV RP-F109, as mentioned above.
Seismic activity and geotechnical instability	Negligible	In the analysis of the existing conditions in the project area with respect to geology (see section 7.3.1) it is described that during the planning of NSP, a probabilistic seismic hazard analysis was prepared for the entire route and region and seismic design parameters were defined at selected points at approximately 100 km intervals along the route /51/. It was concluded that seismicity in the region, and hence along the route, is "very low to low", also compared with other regions in Europe. The same was concluded for the risk of seismic hazard. Furthermore, it is mentioned in the hazard identification report /413// that the documentation related to seismic activity, developed during design of NSP, shall be evaluated and included in the design of NSP2. With respect to geotechnical instability it is mentioned, in the hazard identification report /413/, that loss of foundation and pipeline stability is an item covered under normal design, based on information from geotechnical surveys performed for NSP2 (see section 6.1.2).

Hazard	Frequency of release /415//412/	Reasoning
Other/unknown (sabotage, etc.)	Negligible	No leakage has been recorded for large diameter operating steel lines. For this project, the design systematic failures will be reduced to negligible level applying appropriate quality assurance/quality control (QA/QC) procedures, design review meeting and dedicated health, safety, environmental and social (HSES) reviews and studies. Only sabotage, military exercises and/or accidentally transported mines are identified as possible "other/unknown" causes but are considered very unlikely. Other interferences that may derive from surveys and construction of nearby/crossing installations foreseen to be installed once NSP2 is in operation are considered to be negligible, as they will be addressed with dedicated interfaces between project teams at the design stage.

Frequency estimation for interaction with third-party activities

For offshore pipelines, interaction with third-party activities is related to commercial ship traffic. The following initiating events are identified:

- Sinking ships;
- Dropped objects;
- Dropped anchors;
- Dragged anchors.

Release frequencies due to interaction with third-party activities related to commercial ship traffic are evaluated by means of mathematical modelling in the frequency of interaction assessment /404/ and pipeline damage assessment /405/.

Initially a number of sensitive pipeline sections have been identified. The sensitive pipeline sections are those where the frequency of ships crossing the pipeline exceeds a criterion value of 250 ships/km/year. The criterion value corresponds to less than one ship/km/day. For each identified section where this level or greater of ship activity exists, the interaction frequency is estimated. The sensitive pipeline sections within Danish waters are shown in Table 13-10. The total length of the sensitive pipeline sections (sections of NSP2 with more than 250 ship crossings per km per year) comprises approximately 20% of the total pipeline length in the Danish section.

Table 13-10 Sensitive pipeline sections related to ship traffic threats within Danish waters /406/

Section	From KP (km)	To KP (km)	Section length (km)
1	9	18	10
2	70	79	10
3	131	140	10

For each of the sensitive sections, the annual pipeline failure frequency has been assessed /389/. A summary of the results is shown in Table 13-11.

Table 13-11 Failure frequency per section per year for the Danish section /406/

Section	Dropped objects	Dropped anchors	Dragged anchors	Sinking ships	Total
	(failure/section/year)				
1	$2.74 \cdot 10^{-9}$	$7.58 \cdot 10^{-13}$	$2.90 \cdot 10^{-7}$	$1.57 \cdot 10^{-7}$	$4.50 \cdot 10^{-7}$
2	$2.28 \cdot 10^{-9}$	$9.12 \cdot 10^{-13}$	$1.52 \cdot 10^{-7}$	$2.76 \cdot 10^{-7}$	$4.30 \cdot 10^{-7}$
3	$4.94 \cdot 10^{-9}$	$2.86 \cdot 10^{-12}$	$7.88 \cdot 10^{-7}$	$2.73 \cdot 10^{-7}$	$1.07 \cdot 10^{-6}$

It should be noted that not all pipeline failures lead to a gas release; i.e. gas release frequencies are only a subset of the pipeline failure frequency.

Three different gas-release scenarios are considered: gas release from a pinhole (20 mm), a hole (80 mm) and a full-bore rupture (>80 mm):

- Pipeline failure with a gas release due to a dragged anchor scenario is 30% of the pipeline failure frequencies. Conservatively, it is associated with a full-bore rupture.
- Pipeline failure with a gas release due to a sinking ship scenario is equal to 100% of the pipeline failure frequencies. It is distributed as: 5% pinhole, 5% hole and 90% full-bore rupture.
- No gas release is expected in case of dropped object and dropped anchor interactions, as stated in /406/.

The gas release frequencies due to failure of the pipeline distributed according to pinhole, hole and full-bore rupture are shown in Table 13-12.

Table 13-12 Gas release frequency per year per section for pinhole, hole and full-bore rupture scenarios for the Danish section /406/

Section	Pinhole	Hole	Rupture	Total
	(occurrence/sect/year)			
1	$7.87 \cdot 10^{-9}$	$7.87 \cdot 10^{-9}$	$2.29 \cdot 10^{-7}$	$2.44 \cdot 10^{-7}$
2	$1.38 \cdot 10^{-9}$	$1.38 \cdot 10^{-8}$	$2.94 \cdot 10^{-7}$	$3.21 \cdot 10^{-7}$
3	$1.37 \cdot 10^{-9}$	$1.37 \cdot 10^{-8}$	$4.83 \cdot 10^{-7}$	$5.10 \cdot 10^{-7}$

13.3.1.3 Consequence analysis

The consequence analysis of subsea gas releases involves several steps, from depressurization calculations, underwater release, through the effects at the sea surface and the atmospheric modelling of gas dispersion, to the assessment of the physical effects of the final outcome scenario /406/. The physical effects are related to the exposure to the thermal effects in case of ignition of the released fluid.

The assessment of the consequences of a potential gas release has been performed for three damage categories, according to the hole dimension (pinhole, hole and full-bore as defined in section 13.3.1.2).

Following a loss of containment event from the NSP2 pipelines, the possible outcome scenarios are atmospheric dispersion and flash fire.

13.3.1.4 Risk assessment and risk acceptance

According to the HSES plan for engineering /416/, the overall residual risk of the installation shall be evaluated against the risk tolerability criteria. Specific criteria are detailed in the following paragraphs. The proposed criteria are the same as those adopted during NSP /417/.

The risk acceptance criteria for asset, environment and reputation are implemented in the form of a risk matrix, as shown in Figure 11-8. A semi-quantitative approach has been adopted by means of the risk matrix methodology to predict the risk level for the environment and reputation. According to the risk matrix, all scenarios are acceptable (‘Low’ risk in Figure 11-8).

Consequences		Probability (increasing probability)			
Descriptive	**Environment**	**Remote** (< 10^{-5} /year)	**Unlikely** (10^{-5}-10^{-3} /year)	**Likely** (10^{-3}-10^{-2} /year)	**Frequent** (10^{-2}-10^{-1} /year)
1 Extensive	Global or national effect. Restoration time > 10 yrs.				
2 Severe	Restoration time > 1 yr. Restoration cost > USD 1 mil.				
3 Moderate	Restoration time > 1 month. Restoration cost > USD 1 K				
4 Minor	Restoration time < 1 month. Restoration cost < USD 1 K				
HIGH	The risk is considered intolerable so that safeguards (to reduce the expected occurrence frequency and/or the consequences severity) must be implemented to achieve an acceptable level of risk; the project should not be considered feasible without successful implementation of safeguards				
MEDIUM	The risk should be reduced if possible, unless the cost of implementation is disproportionate to the effect of possible safeguards				
LOW	The risk is considered tolerable and no further actions are required				

Figure 13-9 Risk matrix for risk assessment on asset, environment, reputation /403//404/.

Furthermore, the risk to assets has been evaluated according to the DNV-GL acceptance criteria. DNV-GL acceptance criteria /401/ for asset (medium safety class) is:

- Maximum overall annual failure frequency per sensitive section: $1 \cdot 10^{-4}$ per year;
- Maximum overall annual failure frequency per kilometre of pipeline: $1 \cdot 10^{-5}$ per year.

The DNV-GL targets for the safety class 'Medium' are respected at all sensitive sections /416//417/.

13.3.1.5 Gas release modelling

The impact will depend on the type of leak, its magnitude and the type of repair required. Dispersion of gas has been modelled for three types of gas spill (pinhole, hole and rupture).

On reaching the surface, the gas will begin to disperse within the atmosphere. The nature of the dispersion depends upon the molecular weight and on the source conditions at the surface. In general, the resulting source has a large diameter but the gas has a very low velocity.

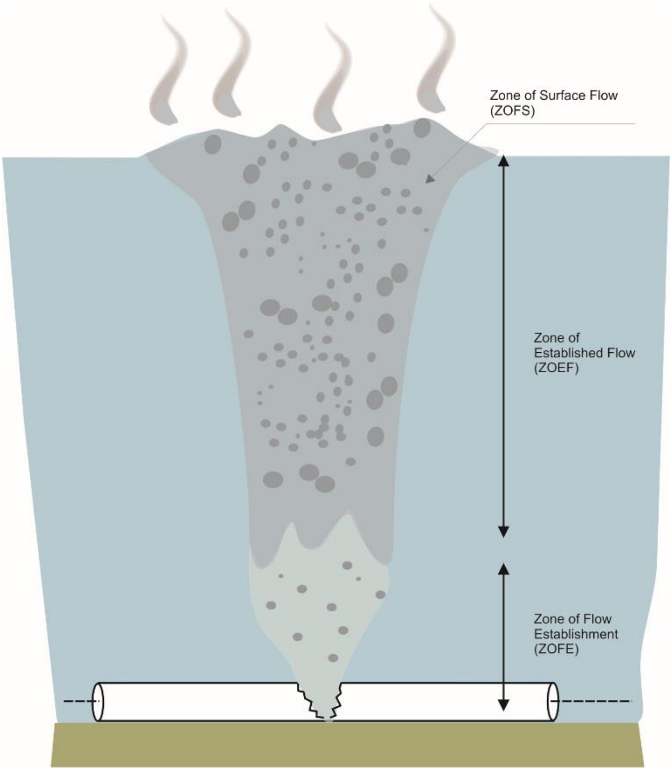


Figure 13-10 Schematic drawing of the release of gas from an offshore pipeline.

The subsea dispersion is modelled in order to provide parameters such as plume width, gas volume fraction and mean velocities at the sea surface. These parameters constitute the input to the atmospheric dispersion model. Subsea dispersion calculations have been performed by means of the computer program POL-PLUME. The radii of the zone of surface flow (central boil region) for the three scenarios are summarised in Table 11-8. The results show that the gas plume at the sea surface can be up to 18 m in radii.

Table 13-13 Results of underwater gas dispersion calculations /406/

Leakage	Water depth (m)	Radius at surface (m)
Pinhole	58.9	6.2
Hole		7.5
Rupture		18.0

13.3.1.6 Potential impacts on the environment

There is a risk of a gas leakage in case of pipeline rupture. The risk is limited to the existing ship traffic in the Baltic Sea where some vulnerable sections (e.g. high traffic intensity) have been identified. The probability of pipeline failure related to dragged anchors or sinking ships has been assessed to be low.

Natural gas is primarily composed of methane, but also often contains related organic compounds, as well as carbon dioxide, hydrogen sulphide, and other components. Methane is a greenhouse gas and is known to influence the climate with a warming effect.

Natural gas exhibits negligible solubility in water, and thus has little effect on water quality. The gas will rise to the water surface and be released into the atmosphere. The movement of gas through the water column would have the potential to impact upon marine organisms (such as fish and marine mammals), resulting in potential acute or chronic impacts depending upon exposure levels. In the unlikely event of gas release, it is estimated that fish, marine mammals and birds within the gas plume or the subsequent gas cloud will die or flee the area. The impact would thus be restricted to the area immediately surrounding the rupture.

A short thermal impact in form of a temperature drop caused by gas expansion may occur in the surrounding water. Another possible impact on water quality from an accidental pipeline rupture and gas release is a possible updraft of bottom water. This could cause bottom water to be mixed with surface water, with a local impact on salinity, temperature and oxygen conditions.

The gas is not toxic and atmospheric dispersion has no impact or risk for human fatalities or explosions. However, in the unlikely event of a flash fire it can be assumed that anyone directly exposed to the flash fire will be exposed to impacts which could be fatal to some species.

13.3.1.7 Conclusion

From the operational risk assessment carried out for the NSP2 route. The risk to environment and reputation has been evaluated by means of a semi-quantitative approach based on a risk matrix. There is a risk of a gas leakage in case of pipeline rupture. The probability of pipeline failure related to e.g. dragged anchors or sinking ships has been evaluated according to the DNV-GL target failure criteria /406/. The assessment shows that the risk for the environment is 'low' for all scenarios.

Furthermore, the assessment shows that:

- According to the DNV-GL acceptance criteria, the target failure rate per sensitive section ($1 \cdot 10^{-4}$ failure/section/year) is fulfilled for all sections;
- The target failure rate of $1 \cdot 10^{-5}$ failure/km/year is fulfilled along the entire pipeline.

During the operational lifetime of the pipeline it is also recommended to:

- Monitor the real ship traffic trend;
- Implement an adequate integrity management plan and an emergency and repair plan.

13.3.2 Risks to the public

There is a risk of a gas leakage in case of pipeline rupture. The risk is limited to the existing ship traffic in the Baltic Sea where some vulnerable sections (e.g. high traffic intensity) have been identified. The probability of pipeline failure related to dragged anchors or sinking ships has been assessed to be low.

13.3.2.1 Identification of hazards

Following a loss of containment event from the NSP2 pipelines, the possible outcome scenarios are:

- Atmospheric dispersion;
- Flash fire.

Since the gas is not toxic, atmospheric dispersion has no impact on risk for fatalities. The risk of fatalities is caused by the exposure to thermal radiation following the ignition of a released gas.

13.3.2.2 Frequency and consequence assessment

The effects of outcome scenarios are assessed using the software DNV PHAST 6.7. The results of the dispersion calculations, giving the extension of the gas cloud to lower flammable limit[52] (LFL) is shown in Table 13-14.

[52] LFL is the lower end of the concentration range over which a flammable mixture of gas or vapour in air can be ignited.

Table 13-14 Extent of hazardous gas cloud /406/.

Hole size	Distance of flammable limits at 10 m height above the sea	
	LFL (m)	½LFL (m)
Pinhole	Not reached	Not reached
Hole	60	92
Rupture	65	84

A flash fire occurs if a flammable cloud engulfs an ignition source before it is diluted below its flammable limits (delayed ignition).

Flash fires generally have a short duration and therefore do less damage to equipment and structures than to personnel on a ship directly exposed to a flash fire. It is conservatively assumed that anyone directly exposed to the flash fire will suffer fatal consequences. To determine the area covered by the flash fire, and therefore the effect on the public, flammable gas dispersion results (distances of LFL/2 concentration) will be considered in the risk analysis.

No congested or confined areas can be reached by a flammable cloud along the offshore pipeline, thus explosion scenarios cannot occur.

13.3.2.3 Frequency of outcome scenarios

Flash fire is considered to represent the only possible scenario, caused by the pipeline in the operation phase, which may lead to third party fatalities offshore. These may occur if the mixed gas cloud engulfs an ignition source while drifting due to the wind. The only ignition source that the mixed gas cloud may encounter is a ship navigating across the hazardous area. The hazardous area is assumed to be the cloud envelope at LFL/2 gas concentration.

In order to assess the ignition probability, two contributions have been evaluated:

- Probability of a ship crossing the hazardous area in the time interval of cloud persistence;
- Conditional probability of delayed ignition given a ship present in the area.
-

The frequency of each specific scenario (flash fire and dispersion) has been calculated by event tree analysis, taking into account the probability of ignition. The event tree is illustrated in Figure 13-11.

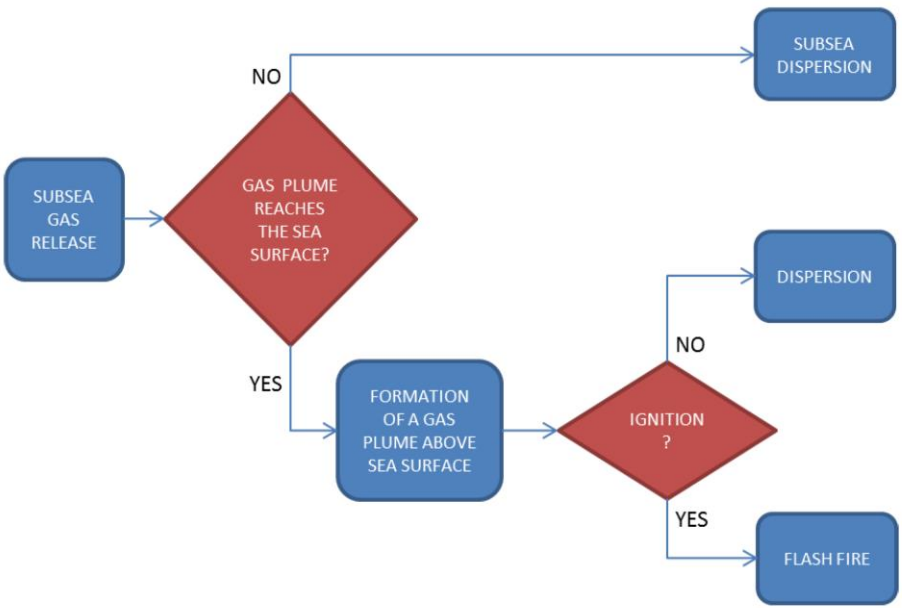


Figure 13-11 Event tree for subsea release.

In the estimation of the ignition probabilities, see Table 13-15, the cloud persistence time has been assumed in analogy to NSP taking into account leak detection time and local ship traffic.

Table 13-15 Conditional ignition probability and cloud persistence time

Release size	Conditional ignition probability	Persistence time (h)
Pinhole	0.09	6
Hole	0.23	4
Rupture	0.64	2

The most exposed third party is the crew members/passengers on board the vessels crossing the pipelines. For each identified scenario the number of fatalities has been evaluated based on the number of individuals present on board and their vulnerability.

13.3.2.4 Risk assessment

The risk assessment is intended to limit the total risk of fatalities imposed by the pipeline system on any third party. This is expressed as an F-N diagram, in which the fatality frequency per year per system (F) is represented versus the number of fatalities (N). The F-N curve for each section is shown in Figure 13-12 for the preferred pipeline route and compared with the risk acceptance criteria. In all sections, the risk falls in the broadly acceptable region and therefore no further actions are required.

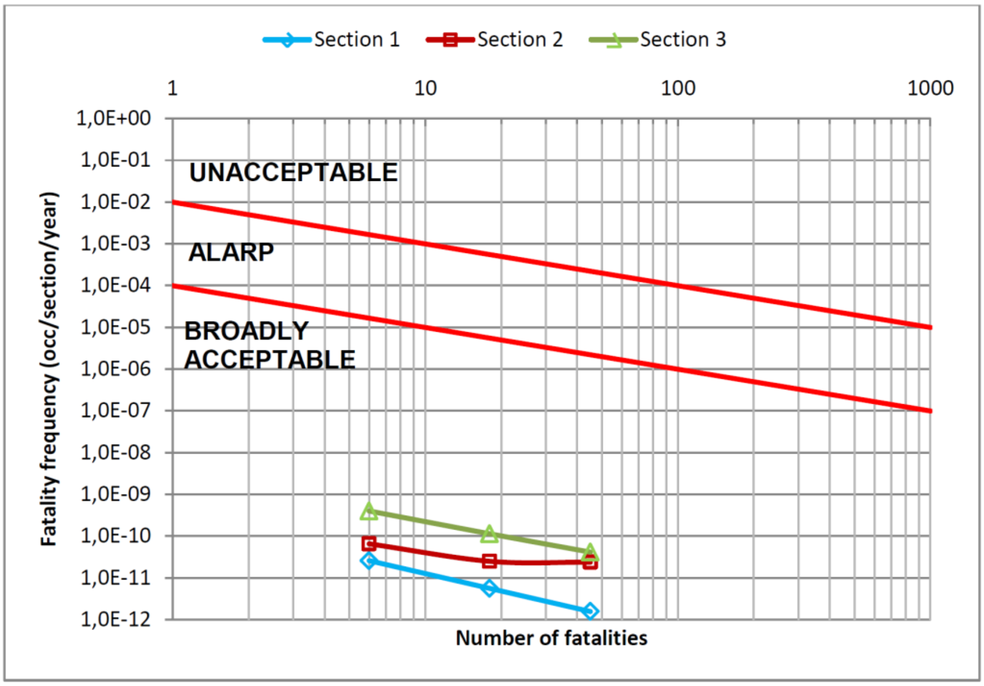


Figure 13-12 F-N diagram and F-N curve of each section, preferred pipeline route.

13.3.2.5 Conclusion

The risk of fatalities is caused by the exposure to thermal radiation following the ignition of a released gas. The most exposed third party is the crew members/passengers on board the vessels crossing the pipelines. The risk for fatalities has been evaluated by means of a quantitative approach based on an F-N curve, and it is shown that the evaluated risk for all sections is within the acceptable region.

13.3.3 Maintenance and repair works – operational phase

No repair works are planned during operation of the pipeline.

However, the dynamic forces in the sea (the combined current and wave loading) may cause unforeseen erosion of the seabed around the pipelines (the so-called scouring) so that parts of it become unsupported, i.e. free spans emerge. To ensure the integrity of the pipelines, such free spans might require support established by e.g. rock placement. No other maintenance and repair works are assessed to have a potential for environmental impacts.

The environmental impacts from rock placement that may be required for free span corrections will be of the same type, but of a lesser magnitude compared to the planned rock placement required during construction of the pipelines (see section 9, sections on bathymetry, seabed quality, hydrography and water quality). The environmental impacts of such repair works will therefore be less than those assessesed for the planned rock placement during the construction phase. Thus it is concluded that impacts from the unplanned maintenance and repair works during operation of the NSP2 are not significant.

13.4 Emergency preparedness and response

Although the NSP2 pipelines will be designed and constructed to operate safely throughout its operating life, it is prudent to have plans and procedures in place to respond to foreseeable emergencies. Emergency Preparedness and Response (ERP) is an integral part of the Nord Stream 2 Health, Safety, Environmental and Social Management System (HSES MS).

The ERP plans and procedures will be in place to minimise the HSES effects as follows:

- All NSP2 worksites, including those operated by contractors and suppliers, will have an emergency notification plan and assigned emergency responders to ensure proper and fast reaction to and management of emergencies.
- Emergency plans will be documented, accessible and easily understood.
- The effectiveness of plans and procedures will be regularly reviewed and improved, as required.
- Plans and procedures will be supported by training and, where appropriate, exercises.

Methods to prevent or mitigate potential impacts from unplanned events during construction include (but are not limited to):

- Compliance with MARPOL requirements related to discharge of oil and waste products.
- The development of offshore spill response plans.
- Oil spill clean-up kits on vessels and construction sites to address any local spills.
- Preparation of procedures, hazard identification exercises and toolbox talks before any construction activities start.
- Safe work procedures for anchor-handling in line with HELCOM requirements to mitigate any risk of contact with munitions or the remains of chemical weapons.
- Preparation and practising of emergency response procedures.

Contractors working for Nord Stream 2 AG are required to have HSES management systems in place. This includes the requirement for Company approved HSES plans that are specific to the hazards and risks associated with the contractor's scopes of work and work sites. Nord Stream 2 AG, through audits and inspections at the contractor's worksites, will ensure that the above requirements are adhered to. Plans and procedures will be periodically tested and improvements made.

All incidents and nonconformities are reported to the appropriate level of management. Immediate notification of the authorities in the event of emergencies is part of the emergency response plans. Procedures are in place to immediately respond to incidents and nonconformities in order to minimise their consequence. HSES incidents are investigated in order to determine root causes and to prevent recurrence.

13.4.1 Operations Phase

Nord Stream 2 AG will develop and implement an emergency response plan for the operational phase. This will be supported by the following:

- Pipeline inspection
- Monitoring and pipeline emergency shutdown equipment including automation
- Redundancy in control systems
- Response procedures
- Training and drills
- Cooperation and coordination with relevant Baltic Sea emergency response agencies
- Communication protocols
- Ongoing review and improvement

13.4.2 Spill response and preparedness

During the construction phase of NSP2, and to a much lesser extent during operation phase, contractors will handle fuels, lubricants and chemicals that could be accidentally spilled and have the potential to have adverse environmental impacts.

To minimise the probability of occurrence of a spill and to ensure that all contractors associated with the project activities have suitable procedures in place to respond to a spill, Nord Stream 2 will develop a Spill Prevention and Response Plan as part of its ESMS. All construction and survey contractors working on the project will develop their own Spill Prevention and Response Plan tailored to the activities that each contractor will be performing on the project.

The International Petroleum Industry Environmental Conservation Association has a tiered response approach, distinguishing three levels of oil spill:

- Tier 1 spills are the mildest, characterised as being related generally to operational activities at a fixed location or facility.

- Tier 2 spills are larger in size and are likely to extend beyond the remit of the Tier 1 response area, requiring additional resources from a variety of potential sources and involving a broader range of stakeholders.

- Tier 3 spills are the most severe and that, due to their larger scale and likelihood of causing major impacts, call for substantial further resources from a range of national and international sources.

An Oil Spill Prevention and Response Plan (OSPRP) will be produced as a contingency for Tier 2 and 3 spills. Oil spill contingency plans will include but not be limited to, a strategy section describing the scope of the plan including likely case scenarios, identify perceived risks, describe roles and responsibilities of those charged with implementing the plan and the proposed response strategy, and define response arrangements. The OSPRP will set out the emergency procedures that will enable assessment of the spill and mobilization of appropriate response resources. The plan will also include a data directory, containing all relevant maps, resource lists, equipment inventories and data sheets to support an oil spill response effort.

Tier 1 oil spills will be responded to using an approved Shipboard Oil Pollution Emergency Plan (SOPEP). The SOPEP will cover hazardous materials, waste and oil. In line with IFC Guidelines on shipping, spill prevention procedures will include but will not be limited to, bunkering activities in port and at sea (e.g. ensuring that hoses are checked, spill trays are in place, spill kits are in place, and scuppers are blocked) and hazardous materials handling. Oil spill response equipment, including IMO approved spill kits, will be held on project vessels and equipment lists will be maintained. Project vessels will be equipped with emergency oil spill response procedures and staff will be trained in the application of such procedures.

13.4.3 Navigation and vessel safety

Vessel safety during construction particularly, will be assured through a number of management actions:

- Communication and navigation systems and aids and associated procedures will be in place to ensure avoidance of collisions at sea.
- A single vessel will act as the centralized point of radio communications for each construction spread in order to manage movements.
- Tailored exclusion zones for the various construction vessel types will be maintained to ensure safe distances with 3rd party marine traffic.
- The relevant authorities in each country will be notified of key construction events.
- Special precautions will be taken to safeguard shipping traffic installation when crossing shipping zones and traffic separation zones.
- Weather forecasting will be used to identify the potential onset of unstable/poor weather conditions and establishment of criteria for suspending construction activities.
- Pull tests & monitoring of construction vessel anchors will be undertaken to minimise the possibility of a dragged anchor.

13.4.4 Consultation Activities

NSP2 will ensure that there is a suitable emergency response plan (in line with HELCOM requirements) in place to mitigate impacts caused by unplanned environmental accidents (e.g. fuel/oil spill, disturbance of munitions, pipeline failure or sea accidents/collisions).

The emergency plan will include measures such as assignment of responsibilities for key safety protocols, safety equipment, training and drills. Key consultation activities included as part of this plan include:

- Communicating the results of the risk assessment to local authorities and emergency management personnel before construction begins to ensure that they are aware of project related risks and that they can take precautions accordingly.

Ongoing liaison with public authorities, particularly before major works or project activities will be carried out to ensure that they are aware of major project phases and project development activities that could have implications for public safety.

13.5 Munitions encounters – construction and operational phase

Conventional and chemical munitions are considered an important topic in relation to the planning, construction and operation of NSP2 since the possible disturbance of munitions by any project activities may lead to impacts on the environment or present a risk to humans.

A detailed risk assessment has not been undertaken, but the risk is described at a high-level along with potential consequences and mitigation measures.

13.5.1 Risks from conventional munitions

The areas of the Danish EEZ and TW around Bornholm, especially the eastern part including Bornholm Basin, present with higher risk of encountering chemical munitions dumped into the sea after the World War II. Conversely, Danish waters were neither mined nor used as a known water battle field during the wars and conventional munitions were mostly dumped in the German coastal waters. Therefore, Danish waters generally have a lower risk of encountering conventional munitions.

According to the analysis undertaken by the Danish Naval EOD (Explosive Ordnance Disposal) Service, no conventional munitions are present within the NSP2 route corridor in Danish waters. The risk of encountering conventional munition along the route in Danish waters is assessed as minimal. The absence of conventional munitions was also confirmed during the construction of NSP, when no conventional munitions were found.

Based on the findings of the munitions screening survey, it is highly unlikely that any interaction with non-detected munitions would occur during the construction activities or during operation of NSP2. To supplement the munitions screening survey, a detailed anchor corridor survey will be performed prior to construction in case an anchored lay vessel is used for the pipe-lay activities. Route planning will take the presence of conventional unexploded ordnance (UXOs) on the seabed into account and where possible, the pipeline will be routed around UXOs to avoid the impacts associated with clearing. If consistent with safe practise and in agreement with relevant authorities, conventional munitions that cannot be avoided through pipeline rerouting, will be either recovered for onshore disposal or relocated away from the pipeline corridor. Conventional munitions that are identified as chance finds during construction and over the operating life of the pipeline will be managed through the Chance Finds Procedure. The identification and handling of munitions will be agreed with the Admiral Danish Fleet (ADF).

No munitions clearance by controlled detonation is planned in Danish waters.

13.5.2 Risks from chemical munitions

Potential impacts from chemical munitions during the construction and operational phase relate to the risk of contact with pipelines/vessels and the public. When chemical munitions are left undisturbed they should not represent any risk to the pipelines or the marine environment.

<u>Risks to pipelines/vessels</u>
Contact of chemical munitions with the pipelines during the pipe-lay activities could result in detonation of the munition that has the potential to affect the pipelines and the surrounding environment. However, it is assumed that chemical munitions dumped after World War II are not armed since shock-sensitive detonators for the explosives were removed before disposal. In general, the charges of the chemical munitions are not sufficient to cause any significant damage.

The ADF was informed of the 12 potential chemical munitions/munitions-related objects, asked to evaluate the munitions and propose a method to handle these findings. In this regard, the Danish munitions expert has advised to leave the chemical munitions where found and has suggested a minimum safety distance of 20 m.

To minimize the risks of encountering unexpected chemical munitions on the NSP2 pipeline route, a pre-lay survey will be conducted in advance of commencement of pipe-lay to identify any anomalies along the pipeline route and anchor corridor (in case an anchored lay vessel is used for the pipe-lay). In addition, an ROV will be used for touchdown monitoring through critical areas such as crossings, lay-down locations etc.

Contact with identified chemical munitions will be avoided by marking the positions of the munitions in the navigation database as "areas to avoid". The anchor touchdown points and anchor wire sweep will then be planned to circumvent the positions of the identified chemical munitions. This procedure is considered to negate the impacts from known chemical munitions.

In the event chemical munitions are encountered through design surveys local rerouting will be performed to avoid interaction. Chemical munitions that are identified as chance finds during construction and over the operating life of the pipeline will be managed through the Chance Finds Procedure. The identification and handling of munitions will be agreed with the Admiral Danish Fleet (ADF).

No adverse events connected with chemical munition encounter occurred during the construction of NSP. Post-lay munitions monitoring of NSP indicated that the condition of all identified munition objects was unchanged /314/. Hence there were no impacts as a result of chemical munitions during the construction of NSP in Danish waters.

Inspection surveys and maintenance seabed works may be required during the operational phase, and it is possible that placement of fill material may have to be carried out in certain areas if unacceptable free spans develop. Seabed intervention works have the potential to result in detonation of the munition. However, the extent of seabed intervention works is less compared to the intervention works during construction phase, and the same avoidance measures would be implemented.

<u>Risks to the public</u>
Chemical agents containing in chemical munitions are extremely toxic, and as such, contact with chemical munitions has the potential to cause severe impacts on humans.

The only possibility of exposure to humans would be through direct contact with a chemical agent recovered from the seabed, e.g. when anchors or any other equipment that was in contact with the seabed is lifted. In areas with potential risk of chemical munitions, precautionary measures to prevent human contact with chemical agents will be undertaken. This will include adequate training of staff and the provision of equipment in accordance with the HELCOM guidelines for preventative measures and first aid.

However, as noted above, contact with any dumped chemical munitions will be avoided and munitions will be left where they were found. On this basis, pipeline construction in areas with chemical munitions is assessed to be manageable if adequate precautionary measures are implemented. Construction of NSP in Danish waters was supervised by the ADF, and similar measures are anticipated to be applied for NSP2.

In line with the construction phase, contact with any dumped chemical munitions will be avoided in the operational phase and munitions will be left where found. In areas with potential risk of chemical munitions, precautionary measures to prevent human contact with chemical agents will be undertaken. This will include adequate training of staff and the provision of equipment in accordance with the HELCOM guidelines for preventative measures and first aid.

The ADF will be informed about all finds of potential munitions identified near the pipelines.

13.5.3 Conclusion

Munitions clearance by controlled detonation and other type of contact is not planned in Danish waters. The risk of munitions is addressed with adequate UXO surveys in the pipeline corridor during the design phase, and specified criteria to avoid certain areas in pipeline routing activities.

Given the low risk and the fact that rerouting around identified munitions will take place, it is assessed that there is no risk of impacts to the environment from munitions in Danish waters.

14 TRANSBOUNDARY IMPACTS

NSP2 will cross the TW of Russia, Denmark and Germany and will run within the EEZs of Finland, Sweden, Denmark and Germany. Transboundary impacts are considered within this section in accordance with the Espoo Convention.

The Espoo Convention promotes international cooperation and public participation when the environmental impact of a planned activity is expected to cross a national border. It applies, in particular, to activities that have the potential to cause significant cross-border (transboundary) environmental impacts and aims at preventing, mitigating and monitoring such potential impacts.

For NSP2, the Espoo procedure is proposed to run almost in parallel to all of the national EIA procedures. NSP2 proposes to prepare the documentation for the consultations under the Espoo Convention in English and to arrange for translation into the nine local languages of the Baltic Sea countries. In this section, project activities planned within the Danish EEZ that may have transboundary impacts are described.

14.1 Transboundary environmental impacts from planned activities within the Danish EEZ

Section 9 identifies where transboundary impacts may occur as a result of planned NSP2 activities within Danish waters (during construction and operational phase). This section describes each of these potential transboundary impacts in turn for each country.

It is noted that construction related ship traffic (e.g. service vessels or pipe carrying vessels sailing from storage yards to the pipe-lay vessel), which will move with normal sailing speed and obey the same navigation rules as all other commercial ships sailing in the Baltic Sea, is not considered to cause any transboundary impacts or transboundary restrictions on existing ship traffic. Therefore, no further consideration has been given to this type of construction related ship traffic in this section.

Furthermore, potential impacts on fisheries of other nationalities fishing in the Danish waters are assessed to be of the same level as impacts on the Danish fishery. An assessment of impacts on the commercial fishery is provided insection 9.15.

14.1.1 Transboundary impacts on Sweden

In the northernmost part of the Danish sector, the pipeline route enters the Swedish EEZ from the Danish EEZ. The environmental conditions around the Danish-Swedish EEZ border are quite similar. The depth at the border of the Danish and Swedish EEZs where the route is planned is 80 m, and the seabed sediment consists of mud and sand.

During construction, there will be emissions from vessels in the Danish TW. The emissions may spread across borders, but are not expected to have any significant transboundary impacts. Total emissions from the NSP2 project will be described in the Espoo report /60/.

Post-lay trenching is planned in three sections within Danish waters, spanning up to maximum 20.5 km, while rock placement is planned at the pipeline crossing of NSP and may also be used as an alternative measure the three locations for trenching. The distance between the closest section for post-lay trenching/rock placement in Denmark and the Swedish EEZ is approximately 35 km. Numerical modelling has been performed in order to assess the sediment dispersion from post-lay trenching and rock placement within the Danish EEZ, see section 8.4.1. Increased concentrations of suspended sediment are expected near the pipeline. However, for all modelling scenarios, no suspended sediment will reach Swedish waters.

Remobilization and redistribution of CWA and contaminants during construction activities is assessed to occur in the close vicinity of the proposed pipeline, where the sediment is disturbed. The level of sedimentation is not considered sufficient to alter the contamination levels of the surrounding seabed environment. Based on modelling of sediment dispersion and the distance to Swedish waters, it is assessed that there will be no transboundary impacts to Swedish waters.

Numerical modelling has also been performed for underwater noise from the rock placement activities at two locations within Danish waters, including that which is closest to the Swedish EEZ (see 8.4.3) under two scenarios (winter and summer conditions) and it has been concluded that no sound levels above ambient will reach the Swedish EEZ.

The Swedish EEZ will experience some impacts during the construction phase in the Danish EEZ close to the Swedish EEZ. Local impacts of negligible significance are expected on the seabed and marine benthos in Sweden due to construction activities in Denmark. These impacts are related to pipe-lay, anchor- handling and general construction and vessel movement. Identical impacts originating in the Swedish EEZ are expected in the Danish EEZ during pipe-lay activities in Swedish EEZ close to Danish EEZ.

In conclusion, there are no significant transboundary impacts on Sweden from pipe-lay or sediment dispersion and underwater noise due to trenching and rock placement in the construction phase.

The EEZ border between Sweden and Denmark cuts through an important area of fishery that is closed for fishing between 1 May and 31 October in order to enable undisturbed cod spawning and to avoid catches of fish before they have spawned. The main spawning grounds for cod are within the Bornholm Deep, where no trenching or rock placement is planned to take place.

No parts of the NSP2 pipeline within the Danish EEZ are close to protected environmental areas inside the Swedish EEZ. Hence the construction or operation of the pipelines is assessed not to cause any transboundary impacts on protected areas in Sweden.

No transboundary impacts from NSP2 activities in the Danish sector will prevent the long term goals in the MSFD, the WFD and the BSAP in Swedish waters.

14.1.2 Transboundary impacts on Germany

In the southernmost part of the Danish EEZ the route enters the German EEZ. The seabed sediment in this area consists of mainly sand. The depth at the border where the route is planned to be laid is less than 30 m and gets shallower within the German EEZ.

During construction, there will be emissions from vessels in the Danish TW. The emissions may spread across borders, but are not expected to have any significant transboundary impacts. Total emissions from the NSP2 project will be described in the Espoo report /60/.

Post-lay trenching is planned at three locations in the Danish section of NSP2, while rock placement is planned at the pipeline crossing of NSP in Danish TW. The distance between the closest section for post-lay trenching/rock placement in Denmark and the German EEZ is approximately 20 km. Numerical modelling has been performed in order to assess the sediment dispersion from post-lay trenching and rock placement within the Danish EEZ, see section 8.4.1. Increased concentrations of suspended sediment are expected near the pipeline. However, for all modelling scenarios, no suspended sediment will reach German waters.

Remobilization and redistribution of CWA and contaminants during construction activities is assessed to occur in the close vicinity of the proposed pipeline, where the sediment is disturbed.

The level of sedimentation is not considered sufficient to alter the contamination levels of the surrounding seabed environment. Based on modelling of sediment dispersion and the distance to German waters, it is assessed that there will be no transboundary impacts to German waters.

Numerical modelling has also been performed for underwater noise from rock placement activities at two locations in Danish waters. Underwater noise has been modelled for two scenarios (winter and summer conditions), and it has been concluded that no sound impact will reach the German EEZ.

The German EEZ will experience some impacts during the construction phase in the Danish EEZ close to the German EEZ. Local impacts of negligible significance are expected on the seabed and marine benthos in Germany due to construction activities in Denmark. These impacts are related to pipe-lay, anchor-handling and general construction and vessel movement. Identical impacts originating in the German EEZ are expected in the Danish EEZ during pipe-lay activities in German EEZ close to Danish EEZ.

In conclusion, there are no significant transboundary impacts on Germany from pipe-lay or sediment dispersion and underwater noise due to trenching and rock placement in the construction phase.

There is a designated German Natura 2000 site where the pipeline route enters the German EEZ. There are no planned seabed intervention works near the German Natura 2000 site, and any potential impact is expected to be temporary and correlated to the pipe-lay itself and the presence of vessels. No significant impacts to German Natura 2000 sites are expected associated with activities in the Danish sector.

No transboundary impacts from NSP2 activities in the Danish sector will prevent the long term goals in the MSFD, the WFD and the BSAP in German waters.

14.1.3 Transboundary impacts on Poland

The route does not enter the Polish EEZ, and the shortest distance from the pipeline to the midline between Denmark and Poland is approximately 11 km.

During construction, there will be emissions from vessels in the Danish TW. The emissions may spread across borders, but are not expected to have any significant transboundary impacts. Total emissions from the NSP2 project will be described in the Espoo report /60/.

Post-lay trenching is planned at three locations in the Danish section of NSP2, while rock placement is planned at the pipeline crossing of NSP in Danish EEZ. Numerical modelling has been performed in order to assess the sediment dispersion from rock placement and trenching within the Danish EEZ. Increased concentrations of suspended sediment are expected near the pipeline. However, for all modelling scenarios, no suspended sediment will reach Polish waters.

Remobilization and redistribution of CWA and contaminants during construction activities is assessed to occur in the close vicinity of the proposed pipeline, where the sediment is disturbed. The level of sedimentation is not considered sufficient to alter the contamination levels of the surrounding seabed environment. Based on modelling of sediment dispersion and the distance to Polish waters, it is assessed that there will be no transboundary impacts to Polish waters.

Numerical modelling has also been performed for underwater noise from rock placement activities at two locations in Danish waters. Underwater noise has been modelled for two scenarios (winter and summer conditions), and it has been concluded that no sound impact will reach the Polish EEZ. The modelling confirmed that noise from rock placement activities will propagate through the surrounding water mass in all directions and the sound level decreases with distance.

Additional rock placement activities, which were not specifically modelled, are proposed on the pipeline route slightly closer to the Polish EEZ border. However, based on the results of the noise modelling and the fact that the shortest distance to the Polish EEZ is 11 km, it is reasonable to assume that no sound levels above ambient will reach the Polish EEZ.

No parts of the NSP2 pipeline within the Danish EEZ are close to protected environmental areas inside the Polish EEZ.

No transboundary impacts from NSP2 activities in the Danish sector will prevent the long term goals in the MSFD, the WFD and the BSAP in Polish waters.

In conclusion, there are no transboundary impacts on Poland from pipe-lay or sediment dispersion and underwater noise due to trenching and rock placement during the construction phase.

14.1.4 Transboundary impacts to the Baltic Sea caused by altered hydrography

The marine environment in the Baltic Sea is heavily dependent on the rare, major inflows of saline water through the Danish Straits, as these are essentially the only means of water exchange in the deep parts of the basins in the Baltic Proper. It is therefore essential to ensure that the inflow of oxygenated deep water to the inner parts of the Baltic Sea via the Bornholm Basin is not negatively affected by the presence of the pipeline.

Impacts on hydrography are assessed in section 9.3.

Due to the potential effect on the Baltic Sea ecosystem, the effect of the pipeline structure on water flow patterns and sediment accretion/erosion has been thoroughly studied. The possible hydrographical effects upon inflowing deep water were modelled during NSP, and the results showed that the effect was minor. Since the NSP pipelines as well as the proposed NSP2 route do not pass through the Bornholm Strait or the Stolpe Channel, the main gateways for inflowing seawater to the Baltic Proper, there will be no hydraulic effect on the bulk flow. From these findings, the report concluded that the impact of the presence of pipelines on the deep water in the Baltic Proper will be negligible.

The mean height of the pipelines above the seabed was assumed to be 1 m, as a conservative assumption for the theoretical analysis. Analysis of the embedment of NSP pipeline in Danish waters shows that five years after installation the pipeline is embedded at least 50 % in most locations.

A hydrographic monitoring programme was carried out in the Bornholm Basin in order to verify the assumptions for the theoretical analysis of the possible blocking and mixing effects of the water inflow to the Baltic Sea caused by the presence of the Nord Stream pipeline /429/. Results from this monitoring suggest that the mixing caused by the pipelines in the Bornholm Basin will at most be 20% of the worst-case estimations presented in the theoretical analysis, which was described above. Estimations were considerably below any level of effect that could be measured to result from the pipelines lying on the seabed.

Potential impacts from the presence of the pipelines on the hydrography during the operational phase are assessed to be local, long term, and of low intensity, and the overall significance to be negligible. In conclusion, there are no significant transboundary impacts on the Baltic Sea caused by the presence of the pipelines and altered hydrography.

14.2 Transboundary environmental impacts from unplanned events within the Danish EEZ

Potential unplanned events could be, e.g., an oil spill following a ship collision or a gas leakage. Such events are discussed in section 13.

14.2.1 Risk and transboundary impacts from oil spill

The risk consequences of an oil spill are described and evaluated in section 13, where the additional annual frequency of ship collisions (because of the Nord Stream pipelines) is calculated and presented.

Depending on where a ship collision with consequent oil spill occurs (i.e. inside or outside Danish waters), there may be a risk of transboundary impacts. The risk is low, but if a larger oil spill occurs the impacts on the marine environment can be significant, depending on when contingency measures are initiated.

In HELCOM recommendation 11/13, it is recommended that Governments of the Contracting Parties to the Helsinki Convention should, in establishing national contingency plans, aim at developing the ability of their combating services:

- To deal with spillages of oil and other harmful substances at sea so as to enable them:
  - To keep a readiness permitting the first response unit to start from its base within two hours after having been alerted.
  - To reach within six hours from start any place of spillage that may occur in the response region of the respective country.
  - To ensure well-organized, adequate and substantial response actions on the site of the spill as soon as possible, normally within a time not exceeding 12 hours.
- To respond to mayor oil spillages:
  - Within a period of time normally not exceeding two days of combating the pollution with mechanical pick-up devices at sea; if dispersants are used it should be applied in accordance with HELCOM Recommendation 1/8, taking into account a time limit for efficient use of dispersants.
  - To make available sufficient and suitable storage capacity for disposal of recovered or lighter oil within 24 hours after having received precise information on the outflow quantity.

Based on HELCOM Recommendation 11/13, it is therefore assumed that countries around the Baltic Sea are capable of controlling a major oil spill within two days of a release, and thereby impacts on the marine environment, both regional and transboundary, will be minimised.

14.2.2 Risk and transboundary impacts from gas release

The consequences of a gas release are described and evaluated in section 13. The probability of such an event is extremely low.

Based on assessment of different scenarios for gas release, it is assessed that a gas release may be a safety issue for the ship traffic, but will not pose a threat to the safety of people on Bornholm or at the German, Swedish or Polish coasts.

The impact will depend on the type of leak, its magnitude and the type of repair required. Depending on the location where a gas release occurs, inside or outside Danish waters, there may be transboundary impacts. The impacts on the marine environment will be local, and of relatively short duration, while impacts on sea traffic (changing shipping routes) will be of longer duration, owing to repair activities at the location.

The transboundary impacts from a gas release would primarily be related to the emission of methane to the air, as methane is a greenhouse gas which is present across all countries and contributes to climate change (see section 13).

14.3 Conclusion

A German Natura 2000 site is located at the border to the Danish EEZ. Besides that, no parts of the NSP2 pipelines within the Danish EEZ are close to environmentally critical areas outside the Danish EEZ.

Where the pipelines enter the German and Swedish EEZs the nature and magnitude of the potential environmental impacts arising from the activities within the Danish EEZ, which have the potential to affect these countries will be of the same nature, but of a significantly smaller magnitude than those resulting from similar construction activities within the German and Swedish EEZs, respectively.

In general it is assessed that the contribution from the activities within the Danish EEZ on the other countries will be negligible, which is in line with the monitoring results during construction and the first years of the operation of NSP.

The construction and operation of the NSP2 pipeline within the Danish EEZ will have no significant impact on protected areas, including internationally protected areas (Natura 2000 sites, Ramsar sites) in other countries. However, minor temporary impacts of underwater noise and sediment dispersion are expected in the German Natura 2000 site that borders the Danish EEZ to the south.

In conclusion, it is assessed that the transboundary impacts arising as a result of the construction and operational activities within the Danish EEZ will be insignificant. Furthermore activities within the Danish waters would not pose any risk of significant transboundary impacts on designated species and habitats of Natura 2000 sites within neighbouring countries. This is in line with the monitoring results during construction and the first years of the operation of NSP.

15 MITIGATION MEASURES

15.1 General

NSP2 AG is committed to designing, planning and implementing the pipeline project with the least impact on the environment as is reasonably practicable. The environmental and social management system (ESMS) for dealing with planned impacts and emergency response is detailed in section 17 of this report.

A key objective during the planning and designing of NSP2 has been to identify the means of reducing the impact of the project on the receiving environment. To achieve this, mitigation measures have continually been developed and integrated into the various phases of the project according to the mitigation hierarchy. These mitigation measures have been identified through consideration of legal requirements, best practice industry standards, applicable international standards (including World Bank EHS Guidelines and IFC Performance Standards), experiences from NSP and other infrastructure projects, as well as application of expert judgement.

In developing mitigation measures, the primary goal of the process has been to prevent or reduce any identified negative impacts. If it has been impossible to avoid an impact (i.e., there is no other technical or economically feasible alternative), minimisation measures have been planned. In cases where it is not possible to reduce the significance of negative environmental impacts through management actions, restoration or offset measures will be considered. This so called "mitigation hierarchy" is described further in the box below.

Mitigation philosophy and approach

Avoidance

Avoidance or prevention of potentially negative impacts can be achieved through an iterative planning and design process. For example, it has been possible to prevent potentially negative environmental impacts by locating the pipelines away from sensitive or valuable receptors such as Natura 2000 areas and cultural heritage and by avoiding areas contaminated by chemical warfare agents. Avoidance reduces the need for later steps in the mitigation hierarchy.

Minimisation

For impacts that cannot be completely avoided, management actions can be implemented to minimise the duration, intensity, extent and/or likelihood of impacts (addressing noise levels, turbidity thresholds, discharge limits, communications and so on). For example, potential impacts from interaction with military practice areas can be mitigated by advance contact and coordination with the appropriate authorities.

Restoration

Restoration involves the re-establishment of an ecosystem`s composition, structure and function with the aim of bringing it back to its original (pre-disturbance) state or to a healthy state close to the original.

Offset measures

Generally considered as the final stage in the mitigation hierarchy, offset measures will be considered for impacts that cannot be avoided, minimized or reversed. "Offsets" can be physical (e.g. contributing to long-term biodiversity improvements) or economic (e.g. compensating fishermen for reduced fishing areas).

NSP2 will be compliant with applicable international standards, including the IFC Performance Standards, and national standards.

Mitigation measures during construction and/or operation of NSP2 have been proposed for the resources, receptors and activities discussed below.

15.2 Water quality

Impacts to water quality arising from rock placement activities during the construction phase will be mitigated via material and instrument selection measures. Specifically, clean rock will be used offshore and will be free of clay, silt and lime, and contaminants such as heavy metals that can be dissolved in the water. Rock placement will be a controlled operation utilizing a fall pipe and instrumented discharge head located near the seabed to ensure precise placement of rock material. Where vessels using fall pipes are used, the rock placement process will be monitored and final geometry will be controlled through surveys.

To ensure the protection of water quality during all phases of the project, all project vessels will be compliant with the requirements of the Helsinki Convention (Convention on the Protection of the Marine Environment of the Baltic Sea Area) and the prescriptions for the Baltic Sea Area as a MARPOL 73/78 Special Area.

- Oily Water. In accordance with MARPOL 73/78, there will be no discharges of oil or oil mixtures into the Baltic Sea area from project vessels. The oil content of discharges from machinery spaces (bilge water) will not exceed 15 parts per million.
  - For ships of 400 gross tonnage and above, oil filtration equipment will be provided with arrangements to ensure that any discharge of oily water is automatically detected and stopped when the oil content in the effluent exceeds 15 parts per million.
  - Ships lacking bilge water filtration equipment will be provided with sludge and oily water holding tanks of sufficient capacity for the time spent way from port. Oily water will be retained onboard for disposal at an on-shore reception facility.
  - Oil Record Books will record all oil or sludge transfers and discharges from vessels. Records will also be maintained for ballasting or cleaning of oil tanks and the discharge of dirty ballast or cleaning waster from fuel oil tanks.
- Sewage. In the Baltic Sea area, there will be no discharge of sewage from ships within 12 nautical miles of the nearest land unless sewage has been comminuted and disinfected using an IMO approved system and the distance to the nearest land is greater than 3 nautical miles. No discharge of sewage will take place from stationery ships or ships moving at a speed of less than 4 knots.
- Garbage. There will be no discharge of garbage from vessels. Food waste will not be discharged within 12 nautical miles of the nearest land.
- Dumping at sea. There will be no dumping of any project waste at sea, including cement dust, packaging materials and swarf generated from the milling of the pipe ends. All project generated waste (i.e. waste not deriving from the normal operation of the ship) will be retained for disposal at licensed waste facilities ashore.

15.3 Non-indigenous species

The risk of invasive non-indigenous species can be significantly reduced by effective ballast water management. Ballast water management plans will include measures to ensure adherence to OSPAR/HELCOM General Guidance on the Voluntary Interim Application of the D1 Ballast Water Exchange Standard in the North East Atlantic.

To reduce the risk of non-indigenous species invasion through ballast water, project vessels will conduct ballast water exchange before entering the Baltic Sea Area.

Vessels leaving the Baltic and transiting through the North-East Atlantic to other destinations will not exchange ballast water in the Baltic or until the vessel is 200nm off the coast of North-West Europe and in waters deeper than 200m.

Ballast tanks will be cleaned regularly and washing water delivered to reception facilities ashore in line with IFC EHS Guidelines on shipping and the International Convention for the Control and Management of Ships Ballast Water and Sediments.

15.4 Shipping and shipping lanes

The contractor will implement a safety zone in the order of 3,000 m (approximately 1.5 nm) for anchor lay barge, 2,000 m (approximately 1 nm) for DP pipe-lay vessel, and 500 m radius for other vessels with restricted in their manoeuvrability to be agreed with the authorities.[DEN-EPH-009] Contractors will be required to develop and implement monitoring (including tracking of vessels through AIS data) and communication protocols and procedures to address vessels approaching the safety zone.

NSP2, in conjunction with relevant construction contractors and the Danish Maritime Authority, will announce the locations of the construction vessels and the size of the requested Safety Exclusion Zones through Notices to Mariners in order to increase awareness of the vessel traffic associated with the project.

15.5 Commercial fishery

Where appropriate for construction activities, a fisheries representative will be present on one of the construction vessels to provide direct information to the fishermen and other marine users. This was also done successfully during the construction of NSP. Construction activities, as confirmed by fishermen on several occasions, are not considered a big problem by the fishermen. They will simply avoid the lay vessel and other construction activities.

Offshore pipelines in Danish waters are automatically assigned a 200 m wide protection zone along each side of the pipeline in which e.g. bottom trawl activities are not allowed[53]. However, the NSP2 pipeline in Danish waters is designed to be resistant to impacts from any interaction with fishing gear and other larger objects and NSP2 will apply for a dispensation to remove the fishery restriction zone around the pipelines to allow fishing activities.

15.6 Cultural heritage

Based on the findings from the route survey and the evaluation by the Recognised marine achaeology agency, exclusion zones are to be defined around wrecks identified as cultural heritage and possible cultural heritage objects. In the pipeline routing process for NSP2, an initial avoidance buffer of up to 200m (to be determined in consultation with individual regulations) will be placed around all CHOs within the nearshore and offshore regions of the project area to provide for sufficient separation distances between wrecks and the pipeline route. Route alternatives will be assessed to avoid impacts to wrecks and measures will be undertaken to ensure that wrecks of cultural heritage importance are protected. The final exclusion zone will be agreed with the relevant authorities once the route has been finalised and installation vessel type has been confirmed.

In the event that a CHO is located in a position which cannot be avoided by re-routing the pipeline due to other constraints, an object-specific management plan will be prepared.

In the event that an anchored lay vessel is used, an anchor corridor survey will be undertaken to identify, verify, and catalogue all obstructions. Plans and procedures for the placement and use of

[53] Order no. 939 of 27 November 1992 - Order on Protection of Submarine Cables and Pipelines

pipe-lay vessel anchors will be prepared to ensure that wires and chains are used in a manner that avoids impacts on known cultural heritage sites. The pipe-lay vessel anchoring plans shall include provisions to ensure that at no time (immediately after deployment, after dragging on the seabed and during recovery/redeployment) the anchor or the anchor wire are within a certain distance (measured on the horizontal and vertical plane) of any identified CHO. The distances will be agreed with the Danish Agency for Culture and Palaces. Anchor patterns in the proximity of CHOs will be approved prior to construction in consultation with national cultural heritage agencies as required.

Not all objects of potential cultural importance are identifiable in the geophysical data, and even the highest standard of geophysical survey may not identify every single archaeological object. A chance finds procedure will be implemented to manage actions in the event of chance finds of objects that could potentially be cultural heritage objects, munitions, or existing installations. The chance finds procedure will prescribe notification instruction to inform the national cultural heritage agencies of the finds, contractor roles, management actions, responsibilities and lines of communication.

For the construction of underwater rock berms, fall pipes will be used to direct rock placement in a precise manner for all areas within a certain distance fromof known cultural heritage sites. The distances will be agreed with the Danish Agency for Culture and Palaces.

15.7 Conventional and chemical munitions

15.7.1 Conventional munitions

Route planning will take the presence of conventional unexploded ordnance (UXOs) on the seabed into account and where possible, the pipeline will be routed around UXOs to avoid the impacts associated with clearing. If consistent with safe practise and in agreement with relevant authorities, conventional munitions that cannot be avoided through pipeline rerouting, will be either recovered for onshore disposal or relocated away from the pipeline corridor. Conventional munitions that are identified as chance finds during construction and over the operating life of the pipeline will be managed through the Chance Finds Procedure.

The identification and handling of munitions will be agreed with the Admiral Danish Fleet (ADF).

15.7.2 Chemical munitions

In the event chemical munitions are encountered through design surveys local rerouting will be performed to avoid interaction. Chemical munitions that are identified as chance finds during construction and over the operating life of the pipeline will be managed through the Chance Finds Procedure.

During pipe-laying activities, there is the risk of accidental contact with chemical munitions. Contact with identified chemical munitions will be avoided by marking the positions of the munitions in the navigation database as "areas to avoid". The anchor touchdown points and anchor wire sweep will then be planned to circumvent the positions of the identified chemical munitions. This procedure is considered to negate the impacts from known chemical munitions.

In areas with potential risk of chemical munitions, precautionary measures to prevent human contact with chemical agents will be undertaken. This will include adequate training of staff and the provision of equipment in accordance with the HELCOM guidelines for preventative measures and first aid.

15.8 Existing and planned installations

Where the pipeline crosses existing infrastructure such as cables and pipelines, Nord Stream 2 will agree designs for safe crossing with the owner of the installations and implement the agreed design. Cable-crossing designs will ensure that:

- A separation is maintained between the pipeline and the cable;
- The operation of the cable will not be impaired.

15.9 Military practice areas

NSP2 will, in due time, contact and coordinate with the appropriate authorities to ensure that there will be no conflict between military activities and the construction of the NSP2 pipeline.

Risk assessments will be undertaken for planned construction activities in military exercise areas and liaison with the relevant authorities for the safe crossing of these areas will be undertaken.

15.10 Environmental monitoring stations

Should construction works be scheduled to be performed in the vicinity of long term monitoring stations, at a similar time to the planned measurement/sampling programme, then Nord Stream 2 AG will consult with the authority to minimise interference.

15.11 Risk assessment

Risk assessments will be undertaken for planned construction activities in military exercise areas and liaison with the relevant authorities for the safe crossing of these areas will be undertaken.

For the operational lifetime of the pipeline, consideration will be given to:

- Monitoring trends in shipping volumes and assessing the associated ship collision risk and consequential damage to the pipeline;
- Implementing a pipeline integrity management plan
- Implementing an emergency and repair plan.

15.12 Management of hazardous materials and wastes

15.12.1 Hazardous materials management

Hazardous materials management plans will be developed and implemented to safeguard both environmental and human health. Contractor plans and procedures for hazardous materials handling will detail management and safety controls such as document requirements, equipment specifications, operating procedures and verification measures, including but not limited to: the definition of roles and responsibilities, competency and training requirements, labelling and storage requirements, inspection schedules, audit programmes, risk assessment and chemical approval process, PPE, safety information and documentation on risks and precautions (including basic emergency procedures).

15.12.2 Waste management

A waste management strategy and plan will be developed and implemented for waste generated offshore.

Contractor waste management plan(s) and supporting procedures will be developed and implemented for each vessel.

15.13 Spill prevention and response

During the construction phase of the project, and to a much lesser extent during operation of the pipeline system, contractors will handle fuels, lubricants and chemicals that could be accidentally spilled and have the potential to have adverse environmental impacts. Additionally, unplanned events, including ship collision and gas release from the pipelines, also require the establishment of robust spill prevention and response measures. Risk assessments concerning impacts from unplanned events are presented in section 13.

An Oil Spill Prevention and Response Plan (OSPRP) will be produced as a contingency for Tier 2 and 3 spills.

Strategy. Oil spill contingency plans will include but not be limited to, a strategy section describing the scope of the plan, including geographical coverage, describe the maximum credible and most likely case scenarios, identify perceived risks, describe roles and responsibilities of those charged with implementing the plan and the proposed response strategy, and define response arrangements.

Action and operations. The OSPRP will set out the emergency procedures that will enable assessment of the spill and mobilization of appropriate response resources. The plan will also include a data directory, containing all relevant maps, resource lists, equipment inventories and data sheets to support an oil spill response effort.

Tier 1 oil spills will be responded to using an approved Shipboard Oil Pollution Emergency Plan (SOPEP). The SOPEP will cover hazardous chemicals and oil. In line with IFC Guidelines on shipping, spill prevention procedures will include but will not be limited to, bunkering activities in port and at sea (e.g. ensuring that hoses are checked, spill trays are in place, spill kits are in place, and scuppers are blocked) and hazardous materials handling. Oil spill response equipment, including IMO approved spill kits, will be held on project vessels and equipment lists will be maintained. Project vessels will be equipped with emergency oil spill response procedures and staff will be trained in the application of such procedures.

Construction contractors will be required to develop their own spill prevention and response plans tailored to their activities.

15.14 Environmental monitoring

The environmental management and monitoring programme which includes monitoring before, during and after construction of the pipelines, will be elaborated in consultation with the relevant Danish authorities.

Environmental and socio-economic monitoring results will be made publicly available.

16 PROPOSED ENVIRONMENTAL MONITORING

The purpose of an environmental monitoring programme is to confirm assumptions in the EIA and to verify the environmental impacts described and evaluated in the EIA. Furthermore, data from a monitoring programme may establish the need for environmental mitigation measures if, contrary to expectations, data indicate unwanted environmental impacts.

Evaluating environmental impacts caused by construction and operation of the planned NSP2 pipelines within the EEZ and TW of Denmark should include monitoring activities before, during and after construction activities, depending on the respective objective.

- Monitoring activities prior to construction will aim to establish baseline conditions.
- Monitoring activities during construction will aim to verify the input parameters used for e.g. the modelling of sediment and underwater noise.
- Monitoring activities after construction will aim to verify the EIA findings regarding the impact of construction works and of the pipeline on/in the seabed.

The environmental management and monitoring programme which includes monitoring before, during and after construction of the pipelines, will be elaborated in consultation with the relevant Danish authorities.

The proposed monitoring programme (what to include and what to exclude) for the Danish EEZ and TW is to a large extent established on the basis of the massive knowledge and experience acquired during the monitoring programme for NSP. Therefore the conclusions of the NSP monitoring programme are presented below in section 16.1.

The overall conclusion from the NSP monitoring programme is that the activities had a minor to insignificant impact on the marine environment and were limited to the immediate vicinity of the pipelines. This is in accordance with the EIA for the project.

16.1 Experience from NSP

As part of the permit requirements for construction of the pipelines, an environmental monitoring programme covering activities within the EEZ and TW of Denmark was elaborated in collaboration with the Danish authorities. Table 16-1 presents a brief overview of the environmental and socio-economic monitoring programme carried out in Denmark.

Table 16-1 Overview of the environmental and socio-economic monitoring programme in Denmark during NSP.

Programme	Reference	Started	Ended	Prior to construction	During construction	During operation
Environmental parameters						
Fish along the pipeline	/442/	2010	2014	X		X
Benthic fauna	/419/	2010	2013	X		X
Epifauna (reef effect)	/442/	2011	2014			X
Water quality	/420/	2011	2012		X	
Chemical warfare agents in sediment	/419/	2008	2012	X		X
Hydrographical conditions in the Bornholm Basin	/422/	2010	2011	X		X
Socio-economic monitoring parameters						
Cultural heritage	/423/	2010	2014	X	X	X
Chemical munitions	/423/	2010	2012	X	X	X
Maritime traffic	/424/	2010	2012	X	X	

All monitoring results have been reported and presented to the Danish authorities on a yearly basis. Monitoring activities and results are contained in the following five yearly monitoring reports:

- Monitoring activities and results for 2010 /425/;
- Monitoring activities and results for 2011 /292/;
- Monitoring activities and results for 2012 /293/;
- Monitoring activities and results for 2013 /426/;
- Monitoring activities and results for 2014 /427/.

The findings from the various monitoring activities carried out for NSP showed that impacts were in line with assessments carried out in the EIA. No significant impacts were identified. A short summary of the conclusions from the monitoring of NSP is presented below.

16.1.1 Monitoring of fish along the pipeline

The purpose of the programme for the monitoring of fish along the pipeline was to describe the qualitative and if possible the quantitative changes in the fish community in the immediate vicinity of the NSP and to compare the findings with the fish community of the surrounding seabed. The aim of the monitoring was to investigate whether the pipelines lead to a so-called "reef effect" and to determine the extent of changes in fish abundance caused by the presence of the pipeline on the seabed.

Fish registered in the survey include: cod, herring, flounder, hooknose, plaice, lumpfish, four-bearded rockling, three-bearded rockling, whiting, smelt and sprat.

The structure of the demersal fish assemblage within the studied locations during the final year of the monitoring programme for fish along the pipeline (2014) was similar in comparison with the previous surveys. Cod was the dominant species in catches throughout the entire monitoring programme. A temporal variation in the composition of the fish assemblage, and in some cases in the biomass and abundance of cod, was observed over the years. However, the monitoring of demersal fish did not find evidence of a reef effect. In some cases there were differences in catches of dominant species between years, but these differences can be attributed to natural variations in the studied areas.

16.1.2 Monitoring of benthic fauna

The purpose of the monitoring programme for benthic fauna was to describe and evaluate before, during and after construction of NSP the changes in the benthic communities in the vicinity of the pipeline or in the vicinity of areas where seabed intervention works (trenching) where carried out.

In the period 2010-2013 the number of species observed during monitoring varied between 18 and 23. The species composition was characteristic for the low saline area of the Baltic Sea. The abundance and biomass of the benthic fauna was dominated by a few species of polychaetes (*Pygspio elegans* and *Scoloplos armiger*), bivalves (*Astarte borealis*, *Mytilus edulis* and *Macoma balthica*) and crustaceans (*Distylis rathkei*).

None of the variations in species composition, abundance and biomass found between the years could be attributed to the construction or operation of NSP.

On the basis of the results from the monitoring of NSP for the final year of monitoring of benthic fauna (2013), it is concluded that effects and impacts on the marine environment were limited to the immediate vicinity of the pipelines. This is in accordance with the assessments in the Danish EIA. Furthermore, impacts were assessed to be local and of minor to insignificant effect.

16.1.3 Monitoring of epifauna

The purpose of the monitoring programme for epifauna was to enable the assessment of a potential reef effect caused by the physical presence of the pipelines on the seabed. The monitoring programme included video recordings and still images at 10 different monitoring stations along a 250 m stretch of the pipeline in Danish waters. At each of these locations, 250 m of the pipeline were recorded by three video cameras covering the top and sides of the pipeline. The cameras were mounted on an ROV.

Since the first monitoring survey in 2011, a general increase in the abundance of epifauna was detected. In 2013, the establishment of mussels on the pipeline was confirmed at 4 of the 10 locations. The final survey carried out in 2014 revealed the establishment of mussels at 8 out of 10 locations. In addition, single bryozoans were observed at 5 locations; opossum shrimp were observed at 2 stations and the crustacean *S. entomon* was observed at 1 station.

The monitoring of epifauna along NSP has revealed the establishment of sessile epifauna consisting of mainly blue mussels. However, there is not yet any clear evidence of a reef effect for the demersal fish assemblage. Sessile epifauna appear to have increased since the first monitoring survey in 2011, and a stable hard-bottom community may be established on the pipeline over the next 5 to 10 years. This will create new habitats and increase access to food and shelter, which may thereby affect the presence of fish in the vicinity of the pipeline (reef effect) in the future.

16.1.4 Monitoring of water quality

The purpose of the water quality programme was to monitor the sediment plume during post-lay trenching in order to validate the assumptions of the EIA for the Danish part of the pipeline. Monitoring of water quality was carried out in 2011 /292/ and 2012 /293/.

The monitoring results showed that the plough created a plume of suspended sediment. The plume was most dense near the plough, where concentrations up to 22.3 mg/l were observed during turbidity measurements. The plume widened and concentrations decreased with distance from the plough. The observed concentrations 500 m behind the plough were less than 4 mg/l. This shows that the plume was diluted and that a significant quantity of the sediments had settled during the initial 500 m of transport.

The measurements showed 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 dispersion (16 kg/s) that comprised the basis for the Danish EIA.

The measurements of sediment concentrations and the measurements of sediment spill (based on measurements of sediment concentrations and currents) 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 were conservative (i.e. on the safe side). The sediment spill rate and the increase in sediment concentrations were less than assumed.

16.1.5 Monitoring of chemical warfare agents in the sediment

The purpose of the monitoring programme for CWA was to document potential changes in the concentration of CWA compounds in the seabed sediment as a result of construction of NSP and to assess the related potential risk to the biological environment. The monitoring focused on impacts from trenching, the activity that was assessed to have the greatest impact on the seabed environment and thereby the greatest potential for disturbing buried CWA-related compounds. The monitoring programme for CWA included surveys in 2008, 2010, 2011 and 2012, with the surveys in 2008 and 2010 regarded as baselines (before construction works).

A comparison of results from the sampling campaigns suggests that the detection frequencies and levels of CWA-related compounds were comparable between years and that the potential CWA-related risks to fish and benthic communities were also comparable and low /293/.

16.1.6 Monitoring of hydrographical conditions in the Bornholm Basin

The purpose of the monitoring of hydrographical conditions in the Bornholm Basin was to collect sufficient current data for the theoretical analysis of the possible blocking and mixing of the water inflow to the Baltic Sea as a result of the presence of NSP as reported in /428/. In that report it was concluded that the two pipelines might increase the mixing of the inflowing new deep water in the Bornholm Sea by 0-1%. However, when that report was written there was very little information about currents in the Bornholm Basin. It was assumed that the deep water inflows entering through the Bornholm Channel flow in a narrow and swift current along the bottom in the Bornholm Basin and that the dissipation is due to a combination of bottom and interfacial friction. The geographical location of the current was not known.

Monitoring of hydrographical conditions in the Bornholm Basin was undertaken in January 2010 and ended in January 2011 /429/.

Oceanographical measurements (velocity, temperature, salinity) were initially carried out over a period of nine months (including a down period of approximately one month) 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 were carried out by acoustic Doppler current profiler (ADCP). A total of six transects were carried out.

The results of the monitoring of hydrographical conditions in the Bornholm Basin suggest that the deep water inflows usually traverse the basin in the halocline layer, normally in the depth interval 40-60 m. Only on rare occasions, with very dense inflows, will it flow beneath the halocline layer. This suggests that much of the energy dissipation of the new deep water in Bornholm Basin actually will occur in the halocline layer.

In conclusion, the findings of the monitoring programme argue that the mixing caused by the pipelines in the Bornholm Basin will at most be 20% of the worst-case estimations presented in /428/. Furthermore, the findings were well below any measurable level of effect that could be considered a result of the pipeline being established on the seabed.

16.1.7 Monitoring of cultural heritage

The purpose of the monitoring programme for cultural heritage was to document that protected cultural heritage sites were not damaged or disturbed during the construction of NSP and that the presence of the pipelines does not cause erosion around protected wrecks.

Monitoring of cultural heritage included monitoring of two wrecks located within 50 m of NSP. Monitoring was carried out as an ROV-based multi-beam survey and a visual inspection by ROV in 2010, 2011, 2012 and 2014.

Authority experts were on board of pipeline vessels to ensure cultural heritage objects were not disturbed by construction activities. Monitoring showed that both wrecks were in the same condition as they were prior to construction of NSP and that no erosion around the two wrecks had occurred /427/.

16.1.8 Monitoring of chemical munitions

The purpose of munitions monitoring in Denmark was to document that identified chemical munitions objects in the Danish EEZ and TW had not been disturbed during the construction or operation of NSP. Monitoring was conducted in 2010, 2011 and 2012.

Detailed munitions surveys led to the discovery of seven chemical munitions objects east of Bornholm. ADF assessed these objects, and it was agreed with ADF that the chemical munitions were to be left on the seabed and not disturbed during installation of NSP. This was ensured through the use of a controlled pipe-lay with ROV monitoring during the installation of Line 1 and Line 2. Authority experts were on board of pipeline vessels to ensure traces of chemical munitions were not brought on board the construction vessels.

Post-lay munitions monitoring for Line 1 was conducted in January 2011. Post-lay munitions monitoring for Line 2 was conducted in the summer of 2012. Monitoring indicated that the condition of all seven munitions objects was unchanged. Hence there were no impacts on these objects from the construction of NSP in Danish waters /293/.

16.1.9 Monitoring of maritime traffic

Monitoring of maritime traffic was conducted in 2010-2012. As assessed in the EIA, the effects on maritime traffic during the construction of NSP were local, short term and insignificant. Precautionary safety measures were successfully implemented, and the construction activities were performed without any accidents with third-party vessels.

16.2 Proposed monitoring for NSP2

On the basis of the results from monitoring carried out for NSP, it is concluded that the effects and impacts on the marine environment had a minor to insignificant effect that was limited to the immediate vicinity of the pipelines. However, some proposed parameters to be monitored for NSP2 are listed in Table 16-2. These parameters are suggested in order to:

- Verify the environmental impacts described and evaluated in the EIA
- Meet the expected high interest by various stakeholders and the public in general

The precise approach to the final monitoring programme including procedures, locations and periods of monitoring will be established in consultation with the Danish authorities. Environmental and socio-economic monitoring results will be made publicly available.

Table 16-2 Proposed parameters to be included in the environmental and socio-economic monitoring activities for NSP2.

Parameter	Prior to construction	During construction	During operation
Water quality			
Turbidity and sedimentation		X	
Cultural heritage			
Wrecks and other identified objects	X		X
Munitions			
Condition of nearby munitions	X		X
CWA			
CWA in seabed sediment	X	X*	X
Fishery			
VMS and logbook study	X		X
Maritime traffic			
Monitoring of maritime traffic (AIS data) to report to authorities and monitor appropriate and safe behavior of construction vessels		X	
*) ADF expert will likely be on board the pipe-lay vessel			

The purpose of the proposed monitoring is described in short below.

16.2.1 Water quality

During construction activities, suspended seabed sediments will spread in the water column, increasing the turbidity, and will re-settle thereafter. The extent of the affected areas will depend on the type and concentration of the suspended sediments and the physical properties of these specific areas. The assessments of environmental impacts caused by construction activities have been based on extensive model simulations of the spreading of sediment and experience from monitoring activities during Nord Stream.

The purpose of the water quality monitoring programme would be to confirm the model results, e.g. for the activity resulting in the most suspended sediments which has shown to be post-lay trenching..

16.2.2 Cultural heritage

Until now seven potential wrecks have been identified in the survey corridor for NSP2 in Danish waters. A recognised marine achaeology agency[54] will perform a screening of the geophysical data with the aim of assessing potential cultural heritage objects (CHO). Based on the evaluation by a recognised marine achaeology agency a visual inspection will be performed and/or exclusion zones will be established around protected wrecks upon agreement with the Danish Agency for Culture and Palaces. The pipe-lay contractor will be informed of all agreed restriction zones.

The purpose of cultural heritage monitoring programme in Danish waters would be to document the condition of wrecks before and after construction – thereby verify that construction of the NSP2 did not affect CHO.

16.2.3 Munitions on the seabed

Detailed munitions screening surveys along the pipeline corridor in Danish waters followed by an evaluation by the ADF have identified 12 objects to be possible chemical munitions objects. None of the targets were assessed to be a conventional munition.

The purpose of monitoring programme for munitions in Danish waters would be to document that identified munitions objects are not disturbed during the construction or operation of NSP2. The scope of monitoring during construction will depend on the type of lay vessel used.

16.2.4 Chemical warfare agents (CWA) in seabed sediment

Construction of NSP2 within Danish waters includes rock placement and trenching of the pipelines into the seabed in some section. Disturbance of the seabed may cause spreading of remains of CWA originally dumped after WWII. In general it is assumed that the chemical munitions dumped are not armed; typically, the canisters of artillery shells have corroded away so that only the warfare agent and some of the explosives remain. This means that if the remains of chemical munitions, e.g., lumps of mustard gas, are disturbed during construction, they will either be buried, pushed away and/or broken in pieces. It has in general been assessed that construction activities on the seabed may have only a very local effect on spreading of CWA.

During construction activities munitions experts from the ADF will most likely also be onboard the construction vessel to ensure that traces of CWA are not brought up onboard and that the proposed handling procedures are implemented.

The purpose of monitoring CWA would be to document any changes in levels of CWA in the marine sediment in comparison to the baseline conditions. Focus should be on locations where trenching is carried out – as this is the activity which results in the largest sediment disturbance.

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[54] Under The Agency for Culture and Palaces

16.2.5 Fishery

Fishing patterns for bottom trawling will need to be adapted because of the presence of the pipelines on the seabed. In areas where the pipeline is not trenched or does not naturally embed itself into the seabed, fishermen fishing with bottom trawl have to cross the pipeline at as steep an angle as possible – preferable 90 degrees – to reduce the risk of the trawl boards getting stuck. Alternative fishermen can lift up the bottom-trawl gear. Therefore the pipeline will to some small extent reduce the availability of fishermen to fish wherever they want as they to some extent will have to adapt their trawl patterns or lift their gear while crossing. Impact on fishing activities is only related to bottom trawling.

The purpose of the fishery monitoring programme would be to evaluate whether any changes to the fishery pattern and/or fish catch pattern will occur after the installation of NSP2.

16.2.6 Maritime traffic

The pipe-lay vessel and support vessels installing the pipeline will move along the pipeline alignment at a rate of 2.5 km per day. A temporary safety area will be established around the pipe-lay vessel. In the temporary safety area unauthorized navigation, diving, anchoring, fishery or work on the seabed is prohibited. Only vessels involved in the construction of the pipeline are allowed inside the safety area.

The sensitivity of the ship traffic towards the impact from the temporary safety area is low because there is sufficient space and water depth for the ships to plan their journey and safely navigate around the pipe-lay vessel and safety area as work progresses through the Danish EEZ.

The purpose of the monitoring in relation to marine traffic would be to minimize the risk of collisions or other accidents involving commercial ship traffic and/or vessels performing construction activities for the project. The ship traffic management procedures will be 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 activities. 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).

17 HEALTH, SAFETY, ENVIRONMENTAL AND SOCIAL MANAGEMENT SYSTEM (HSES MS)

17.1 HSES policy and principles

Nord Stream 2's HSES Policy outlines the general principles of HSES management. It sets the goals as to the level of health, safety, environmental and social responsibility performance required by Nord Stream 2 staff and contractors.

The implementation of the Policy is through a HSES Management System (HSES MS) aligned to the international standards OSHAS 18001[55] and ISO 14001 based on the Plan-Do-Check-Act cycle and the International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability. The system enables Nord Stream 2 to identify all relevant HSES requirements in the project and systematically control the risks.

This current HSES MS is applicable to the planning and construction phase of Nord Stream 2. It will be adjusted once the pipeline system is commissioned so as to manage HSES issues for the operations phase.

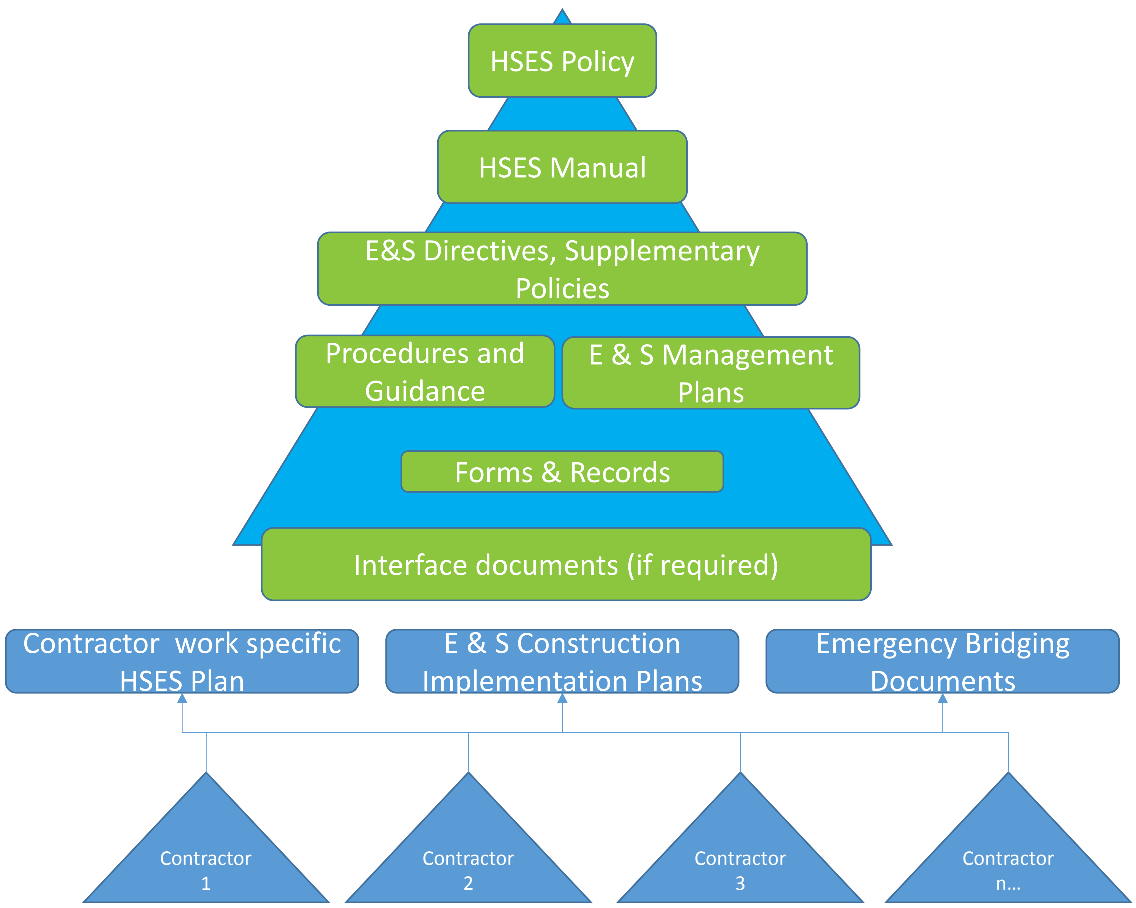

Figure 17-1 Structure of the HSES Management System (planning and construction phases)

[55] OSHAS 18001 is expected to be replaced by ISO 45001 by the end of 2016.

Figure 17-1 shows the hierarchy of documentation in the HSES Management System and the interface with the management systems of contractors and suppliers. Contractor Plans and Bridging Documents may be combined in certain cases, depending on the scope of work and exposure to HSES risks.

Figure 17-2 shows in more detail the hierarchy of E&S Management documents and their relationship to permitting and financing documents.

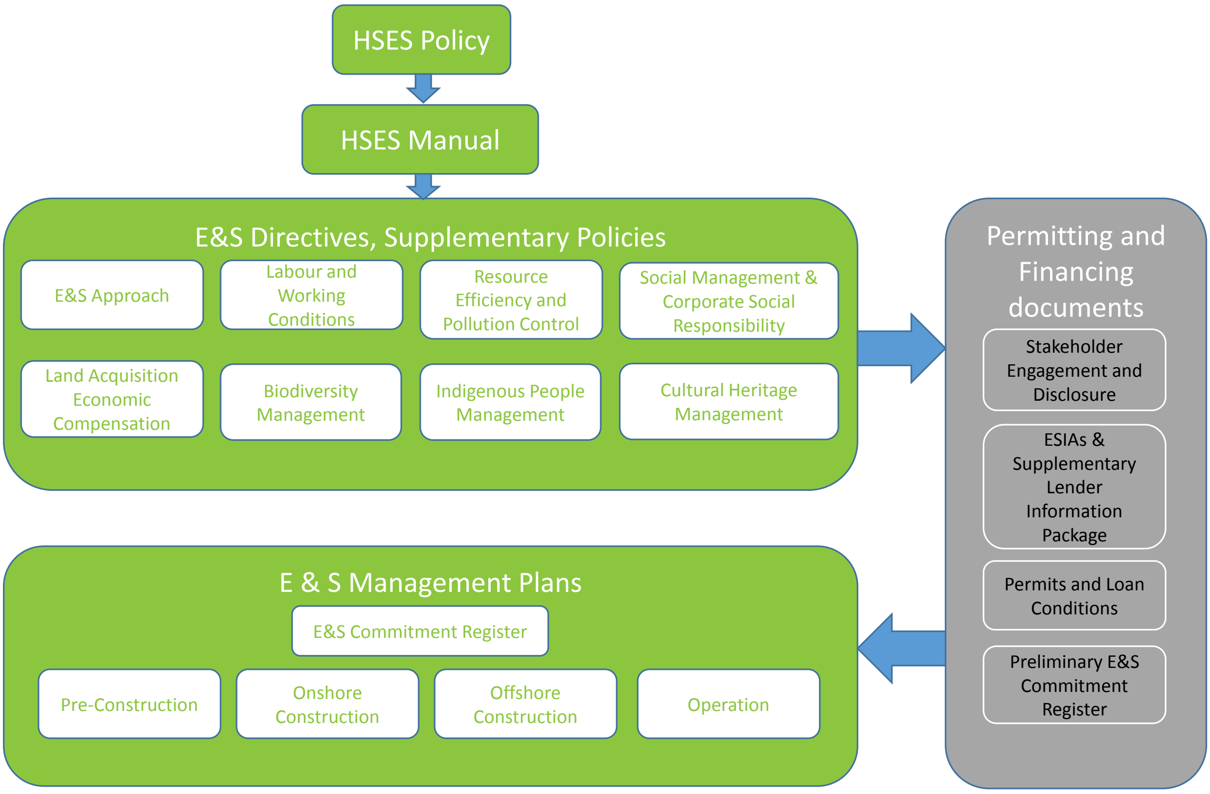

Figure 17-2 Sub-structure of the E&S Management System

The HSES MS is the umbrella under which the subordinate Health and Safety (HS) and Environmental and Social (ES) management system elements reside. The term ESMS (Environmental and Social Management System) is used here and elsewhere in this document, and refers to the environmental and social parts of the overarching HSES MS. The HS and ES parts of the management system share a common Policy and Manual and some of the procedures (audit and inspection, for instance) are common. Generally, however, the supporting procedures and elements for each sub system are tailored to these subject areas.

17.2 Scope of the HSES MS

The HSES MS covers the management of health, safety, environmental and social risks arising during the planning and construction of the Nord Stream 2 pipeline system. It also covers the management of security where this has an impact on the safety of personnel and project affected communities, the integrity of project assets and on the reputation of Nord Stream 2 AG.

Implementation of the HSES MS commenced in August 2015.

17.3 HSES Management Standards

Each of the 10 key principles which comprise the Management Standards are presented as a high-level statement of the Standard, followed by a number of Expectations that arise from the Standard and a list of supporting documents and references.

Figure 17-3 shows the relationship of the Management Standards to the Plan-Do-Check-Act (PDCA) concept that is designed to manage all aspects of an organisation's activities and to promote performance improvements.

Figure 17-3 The 10 Management Standards alignment to Management system model

17.3.1 Policy, Leadership & Commitment

Senior management will define the general HSES Principles, set the Expectations and provide the resources to develop, implement and maintain the HSES-MS. They will demonstrate commitment and leadership through example.

Expectations:

- The HSES Policy defines the general principles to be applied in NSP2; these principles include a recognition that harming people or the environment is not an acceptable or sustainable business practice. More detailed principles are provided in the E&S Directives and Supplementary Policies.
- The Policy commits to complying with all applicable standards, to strive for continual improvement in HSES performance and to set measurable objectives and targets.
- The Policy will be signed by Senior Management to demonstrate formal commitment to HSE management.
- Senior management of the company will provide leadership and visible commitment in order to drive the process for exemplary HSES performance. They will make available the necessary resources to develop and implement the HSES MS in order to achieve the objectives of the HSES Policy.

17.3.2 Organizational Structure, Roles and Responsibilities

HSES management is an essential part of the project. In order for all duties to be performed with due regard to HSES, specific roles and responsibilities will be defined and communicated.

Company and contractor personnel will be appropriately trained, experienced and competent to work in a way which minimizes HSES risk.

Expectations:

- HSES will be defined as a line management responsibility and will be integrated into all functions of the organisation.
- HSES roles and responsibilities will be defined for all safety, environmental and social critical functions (managers, supervisors, work force). Such activities will only be performed by personnel who can demonstrate the appropriate level of competence.

17.3.3 Aspects, Hazards & Risk Assessment

Activities will be planned so that the project can be conducted efficiently, where risk is minimised and legal compliance is assured. Planning involves the systematic identification of legal requirements, hazards, aspects and potential impacts, followed by an assessment of the risk and its control to a tolerable level.

Expectations:

- All activities will be conducted in a manner which complies with the relevant laws and regulations.
- There will be a systematic and documented identification of health, safety & security hazards and environmental & social aspects and potential impacts of all planned activities.
- Hazard and potential impact information will be used in order to make an assessment of risk in terms of likelihood and consequence during the implementation of the project activity.
- All project information that is relevant to project affected communities and any other external stakeholders will be disclosed as part of a comprehensive stakeholder engagement programme, Feedback from stakeholders will inform the HSES studies, risk assessments and management plans.

- Risk assessment information will be used to determine safeguards and mitigation measures which control risk to a tolerable level.
- The feasibility of risk control measures will be assessed with reference to the magnitude of the risk, legal requirements, accepted industry practice and the business needs of the company.
- Procedures will be established for updating hazard and risk assessments when there are changes to activities and when non-routine tasks are undertaken.
- Procedures will be established for ensuring that hazard and risk assessment information and documentation is communicated to those persons involved in the activity.

17.3.4 Objectives & HSES Plans

The general purpose of the management system is to prevent activities from putting people and the environment at risk. Specific objectives will be set, measured with KPIs and communicated in order for the system to be efficient and effective.

Expectations:

- NSP2 will set HSES objectives and targets following the Management Review of the management system). This will occur at least annually.
- Objectives and targets will relate to the significant risks and impacts of the activities.
- The objectives and targets will be measurable and performance during the year will be monitored by management.
- An HSES Plan will be developed which describes the actions, timeframes, and responsible persons required to reach the objectives and targets.

17.3.5 Support, Communication, Consultation and Documentation

Arrangements will be in place for the communication of relevant HSES information, both internally within the project and externally. Communication will be in a language and style that is appropriate to those persons receiving the information. Personnel will be consulted on HSES matters and will be encouraged to participate in improvement initiatives.

There will be active engagement with stake holders and all relevant information will be disclosed. Information on aspects, hazards and risks will be properly documented. Written procedures will define how these Management Standards will be implemented in order to achieve the Expectations.

Expectations:

- All personnel will have basic HSES training and induction, relevant to the risks in their workplace and any legal requirements.
- HSES roles and responsibilities will be communicated to the relevant persons.
- Resources will be made available to ensure the competence of personnel to undertake their HSES responsibilities.
- There will be the involvement of relevant personnel in the hazard and risk assessment processes and in the development and review of HSES procedures.
- The results of risk assessments and the risk control measures required (including emergency procedures) will be communicated to relevant personnel.
- There will be a system for disseminating HSES information throughout the project in order to promote lateral learning and the sharing of best practice.
- There will be a system for authorising communication of HSES information, including emergency response, to relevant external parties, in compliance with communication guidelines.

17.3.6 Operational Control

All company and contractor operations will be conducted according to the HSES standards that have been set to minimise risk. Contractors will be selected and appointed with due regard to their HSES capability and past performance. Detailed HSES requirements will be defined in ITTs and draft contracts and HSES will form part of the technical evaluation of bids.

The adverse HSES consequences of temporary and permanent changes in the project will be assessed, managed and authorised.

Expectations during planning and construction:

- Policies and procedures are developed to mitigate the risks that employees and project affected persons are exposed to.
- Activities undertaken by contractors, subcontractors and suppliers will be subject to detailed contractually binding HSES requirements.
- Company will ensure that contractors and suppliers are monitored to ensure compliance to the HSES requirements.

Expectations during operation:

- Procedures are developed and implemented to ensure that the risks associated with operating and maintaining the pipeline system are adequately controlled.
- All equipment is used within its safe operating limits and in compliance with the relevant regulatory requirements.
- Protective and safety systems are periodically tested and are subject to a preventative maintenance program.
- Systems are in place for re-assessing risk and applying appropriate controls when operational parameters change (management of change).
- Operational changes are approved by an appropriate authority who has taken proper regard of the risk implications.

17.3.7 Emergency Preparedness & Response

Plans and procedures will be in place to respond to foreseeable emergencies and to minimise the HSES effects. Plans and procedures will be periodically tested and improvements made.

Expectations:

- All NSP2 worksites, including those operated by contractors and suppliers, will have an emergency notification plan and assigned emergency responders to ensure proper and fast reaction to and management of emergencies.
- Emergency plans will be documented, accessible and easily understood.
- The effectiveness of plans and procedures will be regularly reviewed and improved, as required.
- Plans and procedures will be supported by training and, where appropriate, exercises.
- Equipment for detecting and responding to emergencies will be subject to a preventative maintenance program, testing and calibration, according to the relevant standards.

17.3.8 Monitoring & Measurement

Monitoring and measurement of HSES performance will be required in order to correct deficiencies in the system and to provide a quantifiable measure of improvement over time.

Expectations:

- The performance criteria selected by NSP2 in order to measure its HSES objectives and targets will be reported to Senior Management on a regular basis.
- The scope and frequency of inspections and audits will reflect the level of risk.
- An audit schedule will form part of the HSES Plan.
- Audits will be carried out according to an agreed and transparent system.
- There should be a balance between a program of self-assessment and external audit.
- Monitoring and measuring equipment will be installed at locations where a failure to detect a release of hazardous material or energy would result in a serious incident or breach of legal requirements.
- Good HSES performance will be recognised and rewarded.

17.3.9 Management Review

Management will formally review the effectiveness of HSES Management System implementation. Actual performance will be compared with the requirements of the Policy and the HSES MS and opportunities for improvement will be identified.

Expectations:

- Management of the project will undertake a review, at least on an annual basis.
- HSES performance will be reviewed in terms of incidents, audit findings and how well objectives and targets have been met.
- The effectiveness of the HSES Management System to deliver the requirements of the HSES Policy will also be reviewed, taking into account likely changes in legislation and project activities.
- Opportunities for improvement in HSES performance will be identified and will form the basis of the HSES Plan for the next period.

17.3.10 Incident and Nonconformity Reporting, Investigation & Corrective Action

Procedures will be in place to immediately respond to incidents and nonconformities in order to minimise their consequence. HSES incidents will be investigated in order to determine root causes and to prevent recurrence. Audits and inspections will be carried-out to assure HSES standards are being maintained and, where applicable, to correct deficiencies. All incidents and nonconformities will be reported to the appropriate level of management.

Expectations:

- Procedures will be in place for immediately responding to incidents.
- Procedures will be in place for reporting incidents (actual and potential accidents) to the appropriate level of management and, where applicable, to external authorities.
- The resources devoted to incident investigation and corrective action will reflect the potential consequence and not just the actual consequence of the incident.
- Investigations will be conducted in a fair and just manner in order to determine root causes and to identify corrective actions that will be effective.
- Preventative actions and lessons learned from incidents will be communicated appropriately in the project.
- The scope and frequency of inspections and audits will reflect the level of risk.
- An audit schedule will form part of the HSES Plan.
- Audits will be carried out according to an agreed and transparent system.
- Good HSE performance will be recognised and rewarded.

18 EVALUATION OF GAPS AND UNCERTAINTIES

18.1 General

There may be several reasons for technical deficiencies or lack of knowledge in an EIA. It is important to draw attention to the fact that the nature of an EIA is *predictive.* Therefore it is challenging to precisely predict what kind of impacts on the environment will occur and the duration of these impacts. Furthermore, the ranking of impacts or certain aspects in relation to each other (e.g. synergism) is sometimes subjective.

In the early phase of the project, preliminary assessments were made in order to identify the most important data and information needed for the EIA. Based on these assessments, a number of surveys and data-collection activities were initiated to minimise the data/information gaps prior to undertaking the environmental impact assessment.

Furthermore, section 16 of this report includes a proposal for a monitoring programme, the purpose of which is to collect additional data and information in order to fill any remaining gaps thus minimising the lack of knowledge as well as verify the predicted impacts from the project.

18.2 Technical deficiencies

The terminology "technical deficiencies" should be understood as shortcomings in relation to the description of the project (section 6). This may include deficiencies in describing the exact time/period for seabed intervention works, the exact plough to be used for seabed intervention works or the exact procedures to be followed if conventional munitions/CWA or cultural heritage objects are encountered along the pipeline route. Methods to handle several of these technical deficiencies must be agreed upon with the national authorities.

The technical aspects of the Nord Stream 2 Project have been developed in parallel with the evaluation of environmental impacts. At this stage the project has developed to a relatively high degree of detail. Nonetheless, there are still technical aspects that may be subject to further optimisations and, in some instances, conceptual developments. This is described below for the different project stages and specific issues.

18.2.1 Design

The high degree of detail of the project implies that, in all essentials, the routing and the technical designs have been established.

The routing of the pipeline throughout the design process has been subject to optimisations in order to identify the technically and environmentally best solution. Adjustments have been made to obtain pipeline stability while at the same time minimise the amount of seabed intervention works necessary to secure the integrity of the pipeline. Minimisation of intervention works also minimises the environmental impacts related to these activities. Optimisation of the route is ongoing and will continue during further detailed design stages; however, this optimisation seeks to minimise seabed intervention works such that any changes are likely to result in a reduction in the potential environmental impacts from the project.

The technical design includes selected engineering solutions and materials for the line pipe, antifriction and anticorrosion coating, weight-coating, field joints, cathodic protection, etc. Minor optimisations are still ongoing. These are not expected to affect the assessment of impacts.

18.2.2 Construction

Before commencement of the construction works, if an anchored lay vessel is being used, munitions surveys will be carried out in the anchor corridor. The purpose of such surveys is to have a full understanding of munitions present in the anchor corridor in order to develop an anchoring pattern that would allow avoiding munition objects. In the event that additional munitions are found in the anchor corridor, it is expected that they will be left untouched on the seabed. However, the survey results will allow the anchoring pattern to be established in a way that avoids contact with identified munitions or other objects in the corridor. The issue of munitions in the anchor corridor is therefore not expected to have any environmental impact.

The equipment used for construction may undergo development or changes depending on availability of the time that all permits have been granted. Pipe-laying could be anchor-based or DP. Throughout the EIA - where appropriate - a worst case assessment has been assessed which ensures that regardless of which equipment will be used, the assessed impacts from the construction works will be similar to or even lower than those stated in the impact assessment.

18.2.3 Above-water tie-in

A potential AWTI for both pipelines is foreseen in Danish waters at a depth of approximately 30 m. Decision on the location of the AWTI will be taken based on consultations with relevant authorities. It has not been decided yet whether the AWTI is to be placed in Danish waters and therefore potential impacts in relation to the AWTI has not been included in modelling of e.g. sediment spreading and assessment of potential impacts.

18.2.4 Pre-commissioning and commissioning

The concept for commissioning will be further developed and detailed. The offshore pipeline pre-commissioning concept for NSP2 will be completed after receipt of the pipe-laying bids and finalisation of the pipe-laying scenario. Two pre-commissioning concepts are under evaluation – "Wet" and "Dry". However, the main activities will take place from the landfall areas in Russia and Germany, and unforeseeable impacts from adjustments to these activities are not expected in the Danish part of the project area.

18.2.5 Operation

During the operations phase maintenance of the pipeline will be required in terms of internal and external inspection. The frequency of these inspections is expected to be every 1 -2 years for the first years and then may be adjusted on the basis of experience and requirements.

18.2.6 Decommissioning

As stated earlier the decommissioning strategy has not been finalised. It is expected that decommissioning methods will be more developed in 50 years' time because decommissioning of a number of pipelines and other installations in the North Sea and other parts of the world will have taken place by that time. Therefore future technologies and approaches and the corresponding environmental impacts cannot be assessed in detail at present.

18.3 Lack of knowledge

The terminology 'lack of knowledge' is understood as data that is missing or incomplete from a detailed baseline description/impact assessment. Furthermore, it is understood as the accuracy of the data and information used in the report as well as for assumptions and conclusions.

Lack of specific data or lack of knowledge, depending on the significance of the data and/or knowledge that is lacking, may result in an increase of assumptions in the EIA. Even with a very precise baseline and technical data, impacts are difficult to predict with certainty. Predictions can be made using a variety of means, ranging from qualitative assessment and expert judgement to quantitative techniques, such as modelling. Use of quantitative techniques allows a reasonable degree of accuracy in predicting changes to the existing environmental and socio-economic conditions and in making comparisons with relevant quality standards.

However, not all of the assessed impacts are easy to measure or quantify, and expert assumptions are necessary. The information, data and knowledge available for this EIA, it is evaluated sufficient for reliable assessments and it is considered unlikely that further data (e.g. from further surveying) would affect the overall conclusions of the assessment.

The following sections describe the lack of knowledge/data for the EIA for NSP2.

18.3.1 Modelling

Numerical modelling has been undertaken for noise propagation and sediment dispersion. Internationally recognised, state-of-the-art models have been applied, but as the models are dependent on input, some assumptions have been applied. These assumptions are described in section 8.4.

18.3.2 Environmental baseline surveys

Environmental surveys have been conducted in Danish waters in order to ensure an environmental baseline for the impact assessment. Conditions in of the water column, seabed sediment properties and infauna have been investigated at a number of stations along the NSP2 route as described in the Section 7.1. Monitoring results can differ based on the selection of a monitoring stations even for those which are located in the close proximity. Therefore, a certain degree in natural variability of the monitored parameters should be taken into account when interpreting monitoring results.

18.3.3 Commercial fishery

Data on fishery within Danish waters within ICES sub-squares for the period 2010-2014 have been collected from all the countries surrounding the Baltic Sea. However, data on fish catches by Polish vessels in 2014 were not available. Therefore fishery data from 2009-2013 have been used in the EIA. It has not been possible to obtain data from Russia on fishery in the Baltic Sea.

18.3.4 Marine strategic planning

The Danish Marine Strategy includes an analysis of the baseline in Danish waters. The analysis is very high level and underlying data is not publicly available. This represents a data gap which has required further data collection from other sources i.e HELCOM and has limited the ability to provide a compliance assessment.

18.3.5 Cultural heritage

Assessment of the general data quality and the cultural significance of discovered wreck sites by a recognised marine achaeology agency of Denmark is currently ongoing. Should any new assets be identified these would be managed through local re-routing of the NSP2 pipelines.

18.3.6 Munitions

Assessment of the general data quality and the cultural significance of discovered munitions is being performed by the Danish Centre for Environment and Energy (DCE). The identification and handling of munitions will be agreed with the Admiral Danish Fleet (ADF).

18.3.7 Environmental monitoring programme

The environmental management and monitoring programme as described in section 16, which includes monitoring before, during and after construction of the pipelines, must be elaborated upon in detail in agreement with the relevant Danish authorities.

18.4 Conclusion

The aim of this section has been to take the technical deficiencies and/or lack of knowledge into account in the impact assessment. Uncertainties related to, e.g., technical design have been minimised by close interaction between the Nord Stream 2 technical team, national authorities and other parties of interest. The technical deficiencies and/or lack of knowledge identified are not likely to change the outcome of the assessments done.

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