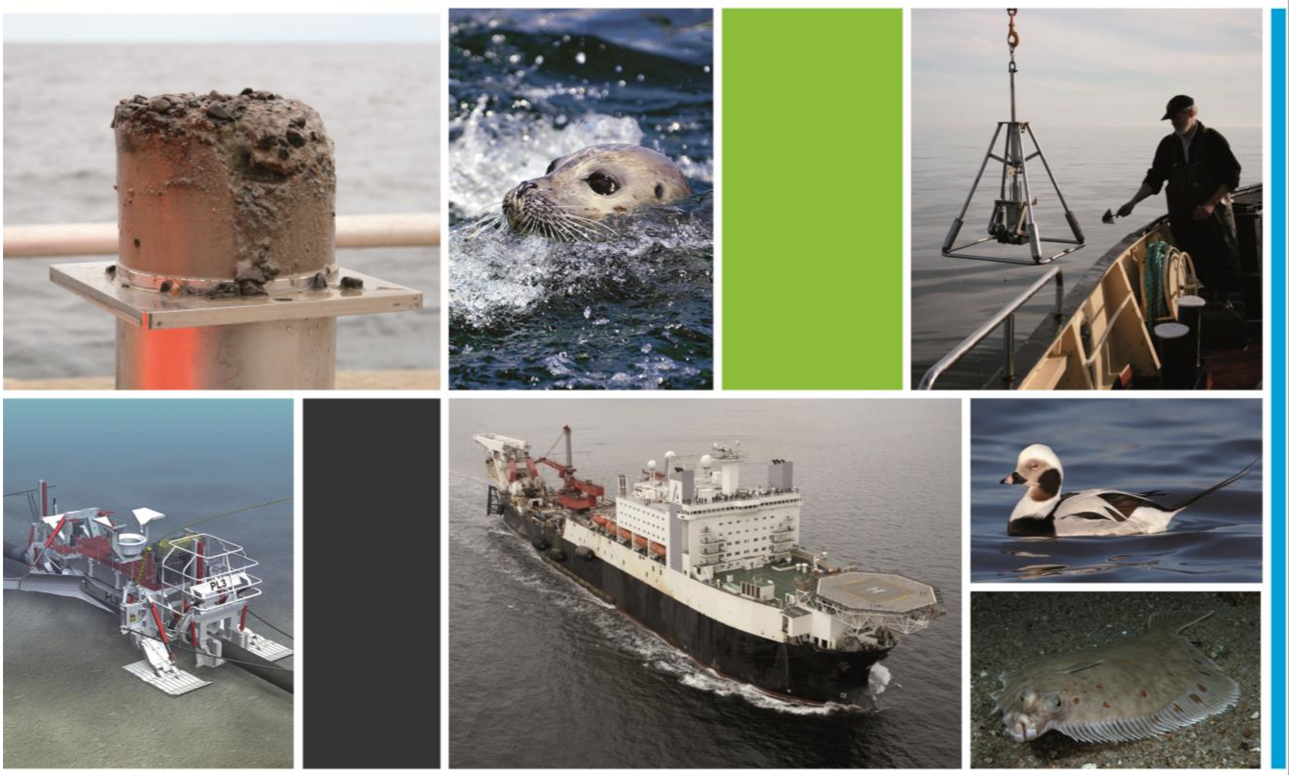
Nord Stream 2 AG

April 2019



NORD STREAM 2
ENVIRONMENTAL IMPACT ASSESSMENT, DENMARK, SOUTH-EASTERN ROUTE

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NORD STREAM 2
Environmental Impact Assessment, Denmark,
South-eastern route

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Ramboll
Hannemanns Allé 53
DK-2300 Copenhagen S
Denmark
www.ramboll.com

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APPENDICES

ABBREVIATIONS

AA-EQS	Annual Average Environmental Quality Standard
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
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
ASEAN	Association of Southeast Asian Nations
AUT	Automated ultrasonic testing
BAC	Background assessment criterion
BAT	Best available techniques
BCM	Billion cubic metres
BES	Bad environmental status
BGR	Bundesanstalt für geowissenschaften und Rohstoffe
BNetzA	Bundesnetzagentur (Germany)
BUCC	Back-up control centre
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
CI	Confidence interval
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	Centimetre(s)
CMS	Convention on the Conservation of Migratory Species of Wild Animals
Co	Cobalt
CO	Carbon monoxide
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	Department of Energy & Climate Change (United Kingdom)
DEPA	Danish Environmental Protection Agency
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
EPR	Emergency preparedness and response
ER	Eutrophication ratio
ERL	Effect-range low
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
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	Health and Safety Executive (United Kingdom)
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	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
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 Marine Intelligence Unit
LNG	Liquefied natural gas
LOI	Loss on 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
MSP	Marine spatial planning
MWh	Megawatt hours
m/h	Metres per hour
N	Nitrogen
n	Number
NA	Not applicable
NCEP	National Centers for Environmental Prediction (United States)
NE	North-east
ng/kg	Nanograms per kilogram
Ni	Nickel
NIS	Non-indigenous species
nm	Nautical mile
NOAA	National Oceanic and Atmospheric Administration (United States)
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
SEA Directive	Strategic Environmental Assessment Directive
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
SSS	Side-scan sonar
T	Tonne(s)
TAC	Total allowable catch
TANAP	Trans-Anatolian Pipeline
TAP	Trans-Adriatic Pipeline
TAPI	Turkmenistan-Afghanistan-Pakistan-India pipeline
TBT	Tributyltin
tcm	Trillion cubic metres
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
UNCLOS	United Nations Convention on the Law of the Sea
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
WFD	Water Framework Directive
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 an anchored pipe-lay vessel, to ensure that there is a free corridor for anchoring the pipe-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.
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.
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals
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.
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.
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 minimising the environmental impacts.
Descriptor	A high-level parameter characterising 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.
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, which 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 be 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 Framework 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.
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
Peter Gaz	A previously considered pipeline route through the disputed area between Denmark and Poland, which was never realised.

PIG	Pipeline inspection gauges 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.
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.
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.
Weight-coated pipes	Pipe joints coated with concrete to increase weight.

0 NON-TECHNICAL SUMMARY

0.1 Background and justification for the project

The relevance of gas as a primary energy source is projected to stay stable or even increase over the next decades, given the necessity to reduce coal consumption due to climate reasons and phase-out of nuclear in large parts of the European Union (EU). In view of declining EU28 domestic production, the EU needs to import additional volumes of gas by as early as 2020 to ensure sufficient gas supply for the coming decades.

The Nord Stream 2 Pipeline System (NSP2) comprises two pipelines through the Baltic Sea planned to deliver natural gas from vast reserves in Russia directly to the EU gas market to fill the growing gas import demand. The approximately 1,230 kilometre (km) twin subsea pipelines will have the capacity to supply 55 billion cubic metres (bcm) of gas per year in an economical, environmentally safe and reliable way, compensating for the drop in the EU's domestic production. The privately funded, €9.5 billion infrastructure project will ensure long-term access to an important, low-emissions energy source, thereby contributing to the EU's climate protection efforts. Additional supplies will boost competition in the market and support the EU's global industrial competitiveness. Nord Stream 2 follows in the footsteps of the successful experience of construction and operation of the existing Nord Stream Pipeline (NSP), which has been recognised for its high environmental and safety standards, green logistics, open dialogue and public consultation.

Nord Stream 2 AG is a project company established for the 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. Five European energy companies, ENGIE, OMV, Shell, Uniper and Wintershall, have committed to provide long-term financing for 50% of the total cost of the project. The financial commitment by the European companies underscores the Nord Stream 2 project's strategic importance for the European gas market, contributing to competitiveness as well as medium- and long-term energy security, especially against the background of expected declining European production. At its headquarters, Nord Stream 2 AG has a strong team of over 200 professionals of over 20 nationalities, covering survey, environmental, health and safety, engineering, construction, quality control, procurement, project management and administrative roles.

NSP2 will deliver reliable and sustainable transportation capacity for natural gas under sound environmental and economic conditions, closing the upcoming EU import gap and covering imminent security of supply risks.

0.2 EIA procedure and public participation

0.2.1 EIA procedure

Construction of pipelines for the transportation of hydrocarbons (i.e., petroleum products) on the Danish continental shelf requires a permit pursuant to the Act on the Continental Shelf and Certain Pipeline Installations in Territorial Waters and the Administrative Order on Pipeline Installations. The permit application must be submitted to the Danish Energy Agency (DEA), which processes the application and issues the permit on behalf of the Danish Minister for Energy, Utilities and Climate.

Gas, oil and chemical pipelines with a diameter exceeding 800 mm and a length of more than 40 km may only be granted a permit on the basis of an Environmental Impact Assessment (EIA). The EIA report must contain, as a minimum, the information listed in the Danish EIA Act, including a description of the resources or receptors likely to be significantly affected by the project, both inside and outside of Danish territory and during both the construction and operational phases of the project. The EIA report must also describe the main realistic alternative approaches to the project.

Denmark has signed the Convention on Environmental Impact Assessment in a Transboundary Context ("Espoo Convention"), which promotes international cooperation and public engagement when the environmental impact of a planned activity is expected to cross a national border. The NSP2 project is subject to the requirements of the Espoo Convention, as the pipeline will cross the territories of five countries and may cause transboundary impacts on four additional countries located in the Baltic Sea region.

The Danish EIA Act requires that a non-technical summary be prepared in conjunction with an EIA so that all interested members of the public may become informed about the project. This non-technical summary covers the Danish part of the NSP2 project. As described in section 0.3 below, the Danish part of the project includes the proposed pipeline route from the Swedish Exclusive Economic Zone (EEZ) border north-east of Bornholm through the Danish EEZ south and west of Bornholm to the German EEZ border south-west of Bornholm. Additional information on the project is available on the NSP2 website, www.nord-stream2.com.

0.2.2 Public participation

In accordance with the Danish EIA Act, the EU EIA Directive and the Aarhus Convention, the Danish authorities must enable public participation in environmental decision-making. Therefore, the DEA must publish information concerning the application, the EIA report and the draft permit on the Agency's website and allow at least eight weeks for public consultation. Public participation may also involve stakeholder meetings and public presentations of technical material.

Furthermore, Nord Stream 2 AG is dedicated to transparent communication and active consultation with relevant stakeholders, including regulatory bodies, non-governmental organisations, experts, affected communities, and other interested and affected parties. The communication strategy incorporates best practices and lessons learnt from the NSP process. Nord Stream 2 AG has already engaged with various stakeholders to inform them about the envisaged project and to understand their views. Further information on Nord Stream 2 AG's communication strategy can be found on the NSP2 website.

0.3 Pipeline route alternatives

0.3.1 Investigation of route alternatives

Nord Stream 2 AG investigated several route alternatives through Danish waters. The objective was to find the most effective way of meeting the purpose and need of the project while also avoiding or reducing potentially significant negative impacts.

The route alternatives were identified based on previous planning and experience from NSP, supplemented with new route surveys and seabed investigations, including geophysical and geotechnical investigations. Environmental, socio-economic, and technical criteria were then assessed for each of the route alternatives to determine the preferred route.

Alternative routes, all of which traverse Danish waters, are shown in Figure 0-1.

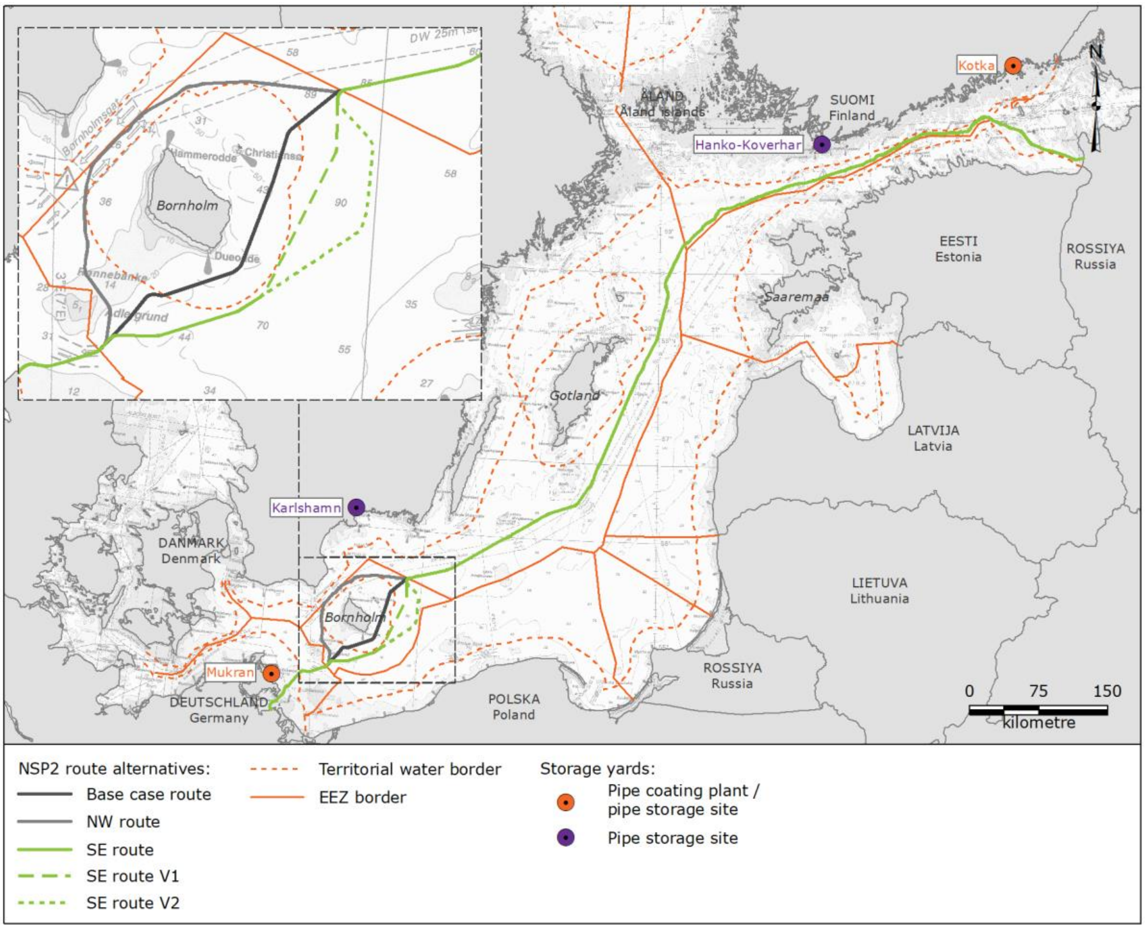


Figure 0-1 Route corridor options developed for the NSP2 project in Denmark.

0.3.2 Selection of the preferred route

A construction permit application for the NSP2 base case route, including EIAs and Espoo documentation, was sent to the relevant authorities for all involved countries in April 2017. Permits have been granted in Germany, Sweden, Finland and Russia. In Denmark, the NSP2 base case route application is being evaluated by the Minister of Foreign Affairs as a construction permit for a route in Danish Territorial Waters (TW) can only be granted if the activity is compatible with national foreign, security and defence policy interests, cf. section 3a(2) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters.

As it is not clear when a recommendation by the Minister of Foreign Affairs will be given, Nord Stream 2 AG developed a route outside of Danish TW to the north and west of Bornholm (NW route). This routing was selected after the Danish authorities informed in a letter dated November 2017 that the disputed area between Denmark and Poland was not available for the establishment of pipelines such as Nord Stream 2 /80/. The EIA and permit application for the NW route were submitted to the Danish Energy Agency (DEA) in August 2018.

Given the recent delimitation of the EEZ borders between Denmark and Poland, Nord Stream 2 AG has now decided to develop a route outside of Danish TW to the south and east (SE) of Bornholm and the base case route, and has selected the SE route in the present EIA as a proposed route for NSP2 (hereafter referred to as the “NSP2 route”). The eastern part of the NSP2 route in Danish waters splits into two potential route variants, referred to as the “NSP2 route V1” or “V1” and the “NSP2 route V2” or “V2”, respectively. Both NSP2 route variants are described and assessed in this EIA, so that either may ultimately be selected as the preferred alternative.

The proposed NSP2 route has been evaluated as a feasible alternative compared to the base case route. Aspects considered as part of the route alternatives assessment included: maritime safety, chemical warfare agent (CWA) risk area, extent of intervention works, fishery in the area, maritime spatial planning, military practice areas and the biological environment. Based on the comparison, it is concluded that the reference base case route is the preferred route for the Nord Stream 2 project in Danish waters in relation to environmental and socio-economic aspects, but that the proposed NSP2 route (SE route) is also a viable route alternative.

0.3.3 No-action alternative

According to the regulations, an EIA should include a "no-action" (or "zero-") alternative, which describes a situation in which the planned project is not carried out. In the present case, should NSP2 not be constructed and operated in Danish waters, there would be no environmental or social impacts, neither adverse nor positive. Furthermore, the pipelines already installed in Germany, Sweden, Finland and Russia would not be used.

0.4 Project description

0.4.1 Project schedule

Nord Stream 2 AG has conducted research and carried out technical, geophysical and environmental surveys over several years to identify the optimal route alternative. The schedule for NSP2 planning, permitting and construction is outlined in Figure 0-2.

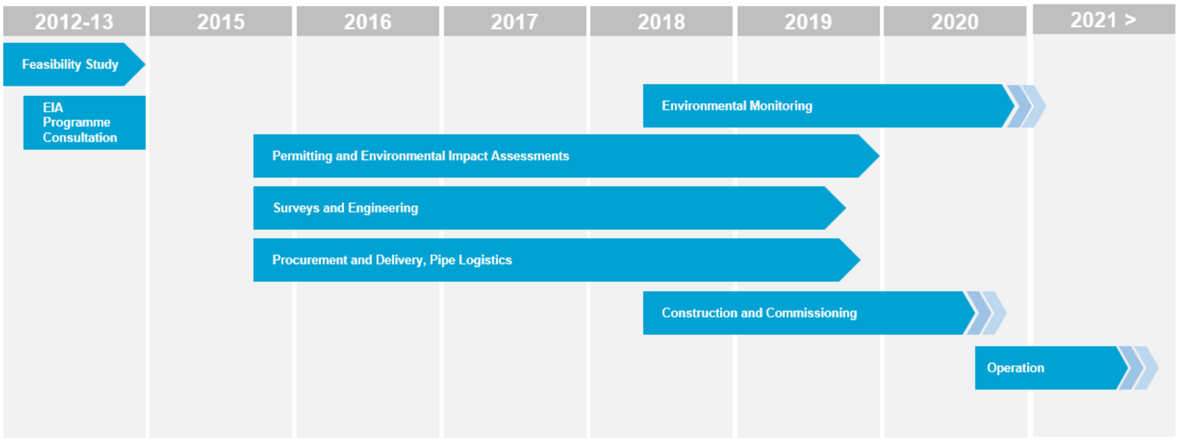


Figure 0-2 NSP2 project schedule.

0.4.2 Proposed NSP2 route

NSP2 is designed to transport natural gas and comprises two 48" diameter subsea pipelines and associated onshore facilities with the capacity to deliver 55 bcm of natural gas per year to the EU market. The pipelines will extend through the Baltic Sea from the southern Russian coast (Narva Bay) in the Gulf of Finland to the German coast (Lubmin area), with no spur lines or intermediate landfalls.

The proposed NSP2 route will cover approximately 1,230 km if the combination of the proposed NSP2 route with V1 is selected, and approximately 1,248 km if the combination of the NSP2 route with V2 is selected. The route crosses the TW of Russia and Germany and runs within the EEZs of Finland, Sweden, Denmark and Germany (see Figure 0-3).

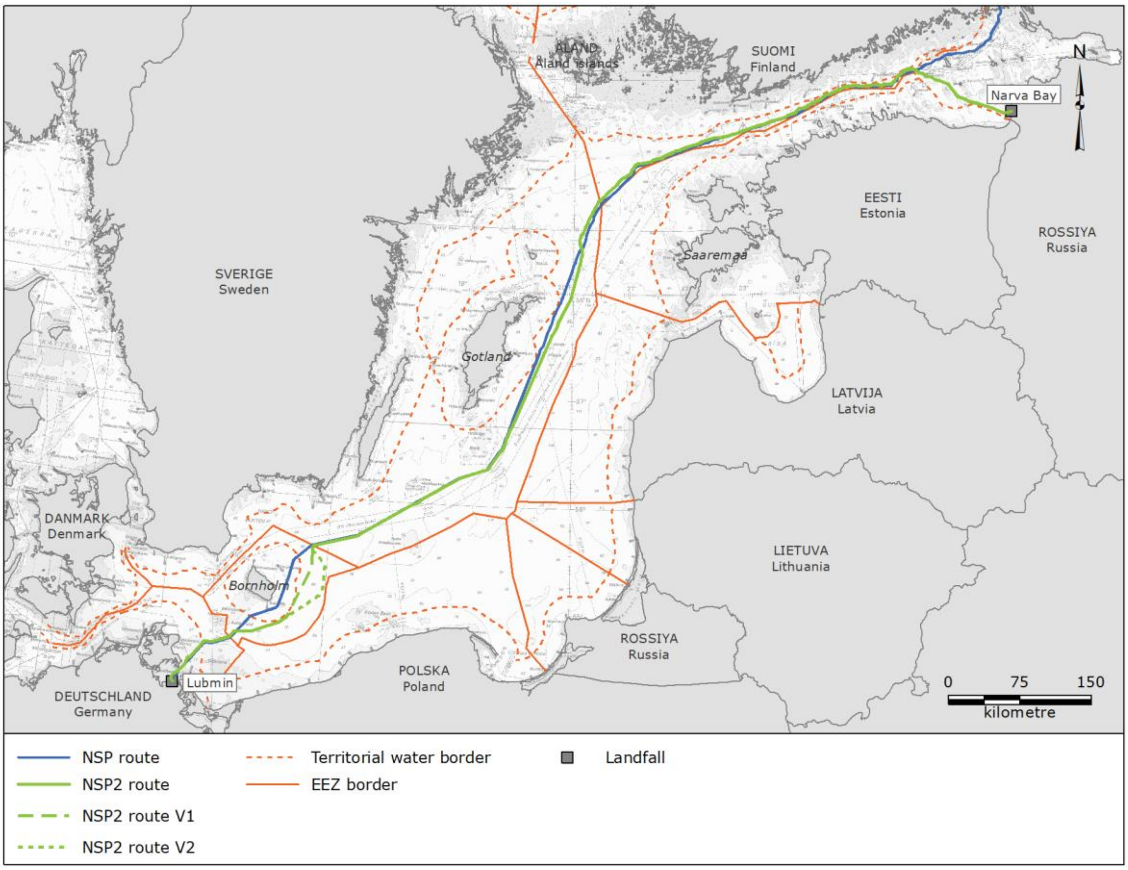


Figure 0-3 Proposed NSP2 route in the Baltic Sea.

In Danish waters, the proposed NSP2 route runs exclusively in the EEZ south and east of Bornholm. The length of the proposed route in Danish waters is approximately 147 km if the combination of the proposed NSP2 route with V1 is selected, and approximately 164 km if the combination of the proposed NSP2 route with V2 is selected. The two NSP2 pipelines (Line A and Line B) will run almost parallel to one another, with a separation distance for the two lines of between 35 m and 155 m.

0.4.3 Construction activities and status

Construction activities in Danish waters include pipe-lay and seabed intervention works. Pipeline installation is expected to last approximately 115 days in total for the two pipelines if the combination of the proposed NSP2 route with V1 is selected, and approximately 125 days if the combination of the proposed NSP2 route with V2 is selected, and the installation is assumed to be sequential, meaning that one pipeline will be installed at a time. Construction activities are scheduled to start in the beginning of 2020, but this may be subject to change during project development.

Pipe-lay will be undertaken using specialised vessels handling the entire welding and pipe-laying process. In the Danish sector, it is expected that a dynamically positioned (DP) pipe-lay vessel will be used. DP vessels do not require anchors and are kept in position by horizontal thrusters that constantly counteract forces from the pipeline, waves, currents and wind.

In some areas, the offshore installation of the pipelines will require additional stabilisation and/or protection against hydrodynamic forces (e.g. waves, currents), which can be achieved by either trenching the pipelines into the seabed or with rock placement. Stabilization is expected over 4 km of the route, and can be achieved either by post-lay trenching or rock placement.

Rock placement is the use of rock pieces to provide support and cover for sections of the pipeline to ensure its long-term integrity. Rock placement will be used in the areas where NSP2 pipelines cross the NSP pipelines, and spot rock placement may also be used to provide additional stability to the pipelines. For cable crossings, a solution with flexible or rigid separation mattresses is envisaged.

Construction activities are presently underway, both onshore at the two landfall areas in Germany and Russia, as well as offshore in German, Swedish, Finnish and Russian waters.

0.4.4 Operational activities

Nord Stream 2 AG will be the owner and operator of NSP2. During normal operation, pressurized natural gas will be continuously introduced at Narva Bay, Russia and taken out at an equal rate at Lubmin, Germany.

An operations concept and security system has been developed to ensure the safe operation of the pipelines. The technical expectation of operation of the infrastructure is at least 50 years.

0.5 EIA methodology

This section provides a summary of the methodology applied in the EIA. The assessment methodology enables characterisation of the potential impacts from planned activities and assessment of their overall significance. Potential impacts from unplanned events are assessed using either a similar methodology or an established risk-based methodology, as appropriate. The resources and receptors that may be impacted by NSP2 are summarised in Table 0-1.

Table 0-1 Resources or receptors susceptible to potential impacts associated with NSP2.

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

Although conventional and chemical munitions are not a resource or receptor, and therefore not included in the list above, munitions were identified during consultation as an issue requiring consideration. Munitions have been assessed in relation to the above-listed resources and receptors, as applicable.

0.5.1 Identifying potential impacts

A systematic approach was applied in the EIA to identify and evaluate the potential impacts that the NSP2 project may have on the physical-chemical, biological and socio-economic environment and to describe mitigation measures to avoid, minimise or reduce any potentially negative impacts to acceptable levels. Throughout the EIA, where appropriate, a worst-case assessment of an impact has been considered to ensure that the conclusions are conservative.

The temporal scope of the assessment has included impacts that could arise during the construction and operational phases of the project. The pre-commissioning and commissioning phases will not impact resources or receptors in Danish waters; as such, they have not been addressed in the EIA. Impacts during decommissioning will depend on the decommissioning method, which will be developed near the end of the operational phase. Therefore, only a high-level assessment of potential impacts during decommissioning was undertaken, which is summarised in section 0.8.

0.5.2 Assessment of potential impacts

The impact assessment methodology has taken into consideration the nature, type and magnitude of a given impact as well as the sensitivity of a given resource or receptor to determine an impact ranking. The magnitude of an impact is defined by its spatial extent, duration and intensity. The sensitivity of receptors/resources to each impact was determined by considering their resilience and ecological and/or socio-economic importance, including protected status.

On this basis, an impact ranking was determined and expressed as a qualitative ranking (see Table 0-2). Impact rankings also accounted for the implementation of mitigation measures built-in to the project to avoid or reduce significant adverse impacts.

Table 0-2 Impact ranking categories for planned activities.

Negligible	Impact that is indistinguishable from the background/natural level of environmental and socio-economic change. Impact is considered "not significant".
Minor	Impact of low magnitude, within standards and/or associated with low or medium importance/sensitivity resources/receptors, or impact of medium magnitude affecting low importance/sensitivity resources/receptors. Impact is 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. The impact may or may not be significant, depending on the context, and further mitigation may be required to avoid or reduce the impact to non-significant levels.
Major	Impact that exceeds acceptable limits and standards and is of high magnitude affecting medium or high importance/sensitivity resources/receptors. Impact is considered "significant".

For the purposes of this EIA, a "significant" impact is one that should be considered by the relevant authority when determining the acceptability of a project.

0.5.3 NSP2 modelling and assumptions

An early task in the EIA process was to determine the characteristics of the physical changes that would arise from NSP2 activities. This was informed by a substantial body of empirical data gathered from the NSP monitoring programme, which spanned both construction and operation, as well as the completion of targeted field surveys specifically for the NSP2 project. In the cases of sediment release, underwater noise, airborne noise and air emissions, the results from NSP monitoring were supplemented with targeted modelling studies. The release of contaminants, including CWA, and nutrients during construction was evaluated based on the results of sediment release modelling and the levels of such substances identified during prior field environmental surveys.

0.6 Assessment of potential impacts

In this section, potential impacts are assessed and described for the entire NSP2 route in Danish waters. The NSP2 route V1 and the NSP2 route V2 are discussed separately only where the impacts differ between these two route variants.

0.6.1 Bathymetry

Modelling has shown that potential changes to water depth caused by the NSP2 project (during the construction and operational phases) would not be significant enough to cause bathymetry-related impacts on local bottom-dwelling communities or the basic physical-chemical conditions for life near the pipelines.

It is therefore assessed that impacts on bathymetry during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.2 Sediment quality

Along the Danish portion of the proposed NSP2 route, the bedrock consists mainly of sandstone and mudstone. Along the proposed NSP2 route, surface sediments mainly consist of mud and sandy mud, Quaternary clay and silt and muddy sand. In the shallowest parts close to the German EEZ, the bottom becomes more sandy.

Modelling indicates that seabed intervention works will lead to sedimentation in a localised area that corresponds to a sediment layer of approximately 1 mm. The predicted levels of sedimentation are not considered sufficient to alter the sediment quality in terms of chemistry, content of contaminants or the natural processes that take place in the sediment. Furthermore, survey results have indicated that intervention works will not expose sediment of a fundamentally different quality, and the physical characteristics of the sediment will not be changed.

Changes in bottom-water dynamics due to the presence of the pipelines and other structures on the seabed can affect sedimentation and erosion patterns. These impacts are assessed to be highly localised and insignificant in relation to the vast bottom habitat area around the proposed NSP2 route.

Sacrificial anodes will be used to protect the pipelines from corrosion, which will result in the release of aluminium, zinc and cadmium. The amounts of metals released from the anodes will be so small that sediment is not expected to be affected above background variations.

It is therefore assessed that impacts on sediment quality during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.3 Hydrography

The predicted sedimentation levels arising from NSP2 construction activities are within the natural range of yearly sedimentation in the Bornholm Basin, and therefore not of a magnitude that would cause any hydrographical changes in the marine environment.

The potential hydrographical effect on deep water flowing into the Baltic Proper was evaluated, and it was concluded that the pipelines will not lead to any significant “blocking effect”.

It is therefore assessed that impacts on hydrography during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.4 Water quality

Construction activities will result in increased levels of sediments in the water column, potentially along with contaminants and/or CWA that were previously present in these sediments. Modelling has shown that sediments will be suspended for a duration of several hours before resettling on the seabed. In the deeper parts of the route, where measured levels of contaminants are highest, the halocline will prevent the upward migration of contaminants to the surface waters, where they may impact pelagic species and seabirds. The impact will thus be temporary and local to the area around the pipelines.

There is also the potential for discharges from project vessels to impact water quality; however, all project vessels will comply with the requirements of applicable international conventions regarding pollution at sea. As such, no impacts from vessel discharges are expected.

Gas flowing through the NSP2 pipelines during operation has the potential to increase the surface temperature of unburied pipeline sections, creating a temperature difference between the pipeline and the surrounding seawater. Natural mixing will ensure that the water temperature reaches equilibrium with the surrounding water within 1 m after crossing the pipeline, and the impact is therefore highly local. Modelling has shown that the transfer of heat from the buried parts of the pipelines to the sediment and the surrounding seawater is insignificant.

Sacrificial anodes will be used to protect the pipelines from corrosion, which will result in the release of aluminium, zinc and cadmium. Elevated levels of anode metal ions in the water column are expected only within a few metres of the anodes, and the levels will be insignificant compared with the existing level of water-borne inflow of metals to the area.

It is therefore assessed that impacts on water quality during construction and operation of NSP2 will be **negligible** and **not significant**, except for impacts associated with the release of sediments and contaminants into the water column, which are assessed to be **minor** and **not significant**.

0.6.5 Climate and air quality

Vessel traffic associated with construction and operation of NSP2 will generate air emissions that have the potential to impact climate and/or air quality. The total release of air pollutants during both project phases has been calculated and corresponds to an amount that will not be significant in comparison with the annual Danish emissions caused by shipping. In addition, all construction and operation activities will occur several kilometres away from inhabited areas, so no onshore air quality impacts are expected.

It is therefore assessed that impacts on climate and air quality during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.6 Plankton

Construction activities will result in increased levels of sediments in the water column, potentially along with contaminants and/or CWA that were previously present in these sediments. Modelling has shown that sediments will be suspended for a duration of several hours before resettling on the seabed. In the deeper parts of the route, where measured levels of contaminants are highest, the halocline will prevent the upward migration of contaminants to the surface waters, where they may impact plankton. The impact will thus be temporary and local to the area around the pipelines.

Further, the previously described release of metals from sacrificial anodes into the water column may impact plankton. This will only occur within a few metres of the anodes, and the levels will be insignificant compared with the existing level of water-borne inflow of metals to the area.

It is therefore assessed that impacts on plankton during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.7 Benthic flora and fauna

Physical disturbance associated with construction activities may result in the disturbance of benthic flora and fauna. The impact would be limited to the footprint of the physical disturbance, which covers a negligible area in comparison with the surrounding habitats that are physically uniform and support similar benthic communities.

Construction activities will result in increased levels of sediments in the water column, potentially along with contaminants and/or CWA that were previously present in these sediments. Modelling has shown that sediments will be suspended for a duration of several hours before resettling on the seabed. Most contaminants and CWA are unlikely to be dissolvable in water and will therefore also resettle on the seabed within hours. The impact will thus be temporary and local to the area around the pipelines.

During operation, the presence of the pipelines and structures on the seabed can potentially create a new hard-bottom substrate (a "reef effect"), where benthic fauna can settle. Mobile animals may then be attracted to the area in search of food and/or shelter. Overall, any changes to the population structure near the pipelines will be limited, given that the pipelines will occupy a negligible part of the total area with a similar habitat in the Baltic Sea.

It is therefore assessed that impacts on benthic flora and fauna during construction and operation of NSP2 will be **negligible** and **not significant**, except for impacts associated with change of habitat, which are assessed to be **minor** and **not significant**.

0.6.8 Fish

Physical disturbance from construction works will be limited to the footprint of the proposed NSP2 route and will not lead to impacts on fish at the population level. The ecosystem is furthermore expected to revert to its pre-impact state within a short time span.

Bottom-dwelling fish, as well as fish eggs and larvae close to the seafloor, can be smothered as sediments that were released into the water column during construction settle back onto the seabed. However, modelling has shown that the rate and amount of sediment resettling on the seabed after construction works would not exceed thresholds that could permanently impact fish at the population level, and the impacts will thus be local and temporary.

Construction activities will result in increased levels of sediments in the water column, potentially along with contaminants and/or CWA that were previously present in these sediments. Suspended sediments can cause avoidance behaviour and injury/death in adult fish and can also reduce the viability of eggs and larvae. Modelling has shown that sediments will be suspended only into the lower 10 m of the water column for a duration of several hours before resettling on the seabed. Furthermore, most contaminants and CWA are unlikely to be dissolvable in water and will therefore also resettle on the seabed within hours. Any impact will thus be temporary and local to the area around the pipelines.

Underwater noise can potentially result in physical injury, behavioural disturbance, and in a worst case, death. Modelling of rock placement, considered the noisiest project activity, has shown that noise levels will not exceed the threshold for permanent hearing loss, although there is a risk of temporary hearing loss very close (within 100 m) to the noise source. Behavioural impacts are considered temporary, as the construction vessels will be continuously moving, and of low intensity, as fish are expected to leave the area as ships approach.

The proposed NSP2 route crosses an important cod spawning area, and the following potential sources of impact during construction have been considered: physical disturbance, release of sediments and contaminants into the water column and generation of underwater noise. On the basis of the assessments performed and described above, no impacts on cod spawning are anticipated.

During operation, the presence of the pipelines and structures on the seabed can potentially create a new hard-bottom substrate (a "reef effect"), which may attract fish in search of food and/or shelter. Overall, any changes to the population structure near the pipelines will be limited, given that the pipelines will occupy a negligible part of the total area with a similar habitat in the Baltic Sea.

It is therefore assessed that impacts on fish during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.9 Marine mammals

Marine mammals commonly found in Danish waters along the proposed NSP2 route include the harbour porpoise and grey seal. Foraging harbour seals may also potentially enter the project area. These species are protected under several international agreements as well as national legislation.

Construction activities will result in increased levels of sediments in the water column, potentially along with contaminants and/or CWA that were previously present in these sediments. Modelling has shown that sediments will be suspended for a duration of several hours before resettling on the seabed, and will not lead to injuries. In the deeper parts of the route, where measured levels of contaminants are highest, the halocline will prevent the upward migration of contaminants, thereby reducing the likelihood of toxicological impacts. The overall impact will thus be temporary and local to the area around the pipelines.

Underwater noise can potentially result in physical injury, hearing loss, behavioural disturbance or masking effects. Modelling of rock placement, considered the noisiest project activity, has shown that noise levels will not exceed the threshold for permanent hearing loss, although there is a risk of temporary hearing loss very close (within 80 m) to the noise source. Behavioural and masking impacts are considered temporary, as the construction vessels will be continuously moving, and of low intensity, as animals are expected to leave the area as ships approach.

During operation, the gas flowing through the pipelines will generate noise. A comparison of modelling results for noise generated by the NSP pipelines with ambient noise measurements in the area indicate that the noise from the NSP2 pipelines will be below ambient levels.

The change of habitat brought about by the presence of the pipelines on the seabed has been assessed not to lead to changes in diversity or abundance of benthic and/or fish species, and is therefore not anticipated to affect marine mammal foraging behaviour.

It is therefore assessed that impacts on marine mammals during construction and operation of NSP2 will be **negligible** and **not significant**, except for behavioural response impacts associated with the generation of underwater noise, which are assessed to be **minor** and **not significant**.

0.6.10 Seabirds

Construction activities will result in increased levels of sediments in the water column, potentially along with contaminants and/or CWA that were previously present in these sediments. Suspended sediments can impact the foraging efficiency of some birds due to increased turbidity or reduced food availability because prey may avoid the affected area. Modelling has shown that sediments will be suspended only into the lower 10 m of the water column and for a duration of several hours before resettling on the seabed. Furthermore, most contaminants and CWA are unlikely to be dissolvable in water and will therefore also resettle on the seabed within hours. Any impact will thus be temporary and local to the area around the pipelines.

Benthic prey for bottom-feeding seabirds can potentially be covered as sediments that were suspended into the water column during construction settle back onto the seabed. However, modelling has shown that the rate and amount of sediment resettling on the seabed after construction works would not be sufficient to affect the ability of seabirds to locate prey.

The physical presence of construction vessels (visual presence and noise) has the potential to disturb seabirds and cause them to temporarily abandon their resting and/or foraging areas. Data indicate that in general, impacts are expected to be limited to a 1-2 km radius around the working area. Any impacts on birds within this radius are considered temporary, as the construction vessels will be continuously moving.

It is therefore assessed that impacts on seabirds during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.11 Protected areas

The proposed NSP2 route does not cross any protected areas within Danish waters. The minimum distance from the proposed NSP2 route to a Ramsar site is more than 29 km from the NSP2 route V1 and more than 35 km from the NSP2 route V2 and to the nearest HELCOM MPA is approximately 18 km, irrespective of the route variant selected.

Impacts on protected areas have been assessed by considering the least resilient species, habitats or ecosystems for which a given protected area has been designated, particularly those associated with the pressures that have been identified as part of the protection, e.g., eutrophication, pollution, introduction of non-indigenous species (NIS), physical disturbance, etc. On this basis, no significant impacts on protected areas were identified.

It is therefore assessed that impacts on protected areas during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.12 Natura 2000

The proposed NSP2 route does not cross any Natura 2000 sites within Danish waters. The nearest Danish Natura 2000 site is N252 Adler Grund and Rønne Banke, which is located approximately 18 km from the proposed NSP2 route at the nearest point, irrespective of the route variant selected.

At N252 Adler Grund and Rønne Banke, there are designated sandbank and reef habitats, but no designated species. The following sources of potential impact have been included in the Natura 2000 screening for these marine habitat types: release of sediments, contaminants and CWA into the water column and subsequent sedimentation (from e.g. post-lay trenching). No significant impacts on protected reef or sandbank habitats were identified.

In conclusion, it is assessed that there will be **no risk of significant impact** on the designated habitat types in Danish Natura 2000 sites during construction and/or operation of NSP2.

0.6.13 Biodiversity

Biodiversity is typically referred to as the "health" of an ecosystem. The Helsinki Commission (HELCOM) has assessed the biodiversity status of the waters around Bornholm as ranging from "Bad" to "Moderate", reflecting an impaired biodiversity status.

Impacts on biodiversity are consistent with the impacts identified for species, habitats and protected areas discussed above. Additionally, based on a review of the potential for in-combination impacts, it is considered that NSP2 will not impact the overall integrity and functioning of habitats, nor the trophic interactions between species. The potential of introducing NIS is limited by the fact that ballast water will only be exchanged outside of the Baltic Sea.

It is therefore assessed that impacts on biodiversity during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.14 Shipping and shipping lanes

During construction, vessels that are not involved in construction activities will not be allowed to enter the safety zones created around construction vessels. The imposition of safety zones will be temporary at any given location as the construction activities progress. Furthermore, the shipping lanes crossed by the proposed NSP2 route generally provide sufficient space and water depth for other ships to plan their journey and safely navigate around possible temporary obstructions.

During operation, safety zones will also be imposed in connection with periodic, vessel-based inspection and maintenance activities. However, given that inspection activities are planned at one- to two-year intervals (or less), impacts are expected to be lower than those anticipated during construction.

It is therefore assessed that impacts on shipping and shipping lanes during construction of NSP2 will be **minor** and **not significant**. Impacts on shipping and shipping lanes during operation of NSP2 will be **negligible** and **not significant**.

0.6.15 Commercial fishery

During construction, fishing vessels will not be allowed to enter the safety zones created around construction vessels. The imposition of safety zones will be temporary at any given location as the construction activities progress. Additionally, supply vessels will bring pipes and other supplies to the pipe-lay vessel. The increased traffic has the potential to damage fishing gear, particularly longlines at the surface of the water column.

During operation, the physical presence of pipelines and structures on the seabed has the potential to impact bottom trawling activities through either protection zones or through damage or loss of gear. The NSP2 pipelines are designed to be resistant to impacts from interaction with fishing gear, and therefore Nord Stream 2 AG will apply for a dispensation to remove the fishery restriction usually enforced around pipelines in Danish waters during the operation of the pipeline. In addition, post-lay trenching and natural embedment of the pipelines will reduce their height above the seabed, thereby reducing the risk of bottom trawling gear becoming stuck.

It is therefore assessed that impacts on commercial fishery during construction of NSP2 will be **negligible** and **not significant**. Impacts on commercial fishery during operation of NSP2 will be **minor** and **not significant**.

0.6.16 Cultural heritage

Pipe-lay, anchor-handling, post-lay trenching and rock placement could damage cultural heritage objects (CHOs) or make them inaccessible for archaeological investigation. To ensure the integrity of CHOs during the construction and operation of NSP2, all targets found during route surveys will be visually inspected. Mitigation measures, as necessary, will be elaborated together with the relevant Danish authorities. Safety zones will be defined around identified CHOs. This approach was effective during NSP construction, with post-lay wreck surveys showing no impacts in Danish waters.

It is therefore assessed that impacts on cultural heritage during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.17 Conventional and chemical munitions

Potential impacts on resources and receptors in connection with conventional and chemical munitions that have been dumped in the Baltic Sea following World Wars I and II have been assessed in the respective assessment sections for each resource or receptor that may be impacted by disturbance of munitions during the construction and operational phases of the project.

0.6.18 People and health

The closest Danish populations to the proposed NSP2 route are on the islands of Bornholm and Ertholmene, which are respectively located approximately 23 km and 30 km (shortest distances) north-west of the NSP2 route V1 and approximately 24 km and 37 km (shortest distances) north-west of the NSP2 route V2.

The noise levels from pipe-lay activities (considered worst-case for airborne noise) are not expected to exceed the World Health Organization (WHO) maximum onshore threshold guideline of 40 decibels (dB). In fact, it is unlikely that the noise will be heard above ambient level.

Pipe-lay will be conducted on a 24-hour basis. During the night-time periods, the pipe-lay vessel will use spotlights. When visibility is good, it is possible to see 19 km or more across the Baltic Sea, and therefore the spotlight is unlikely to be visible from either Bornholm or Ertholmene.

During operation, the potential also exists for airborne noise and light impacts arising from periodic, vessel-based inspection and maintenance activities. However, given that inspection activities are planned at one- to two-year intervals (or less), impacts are expected to be lower than those anticipated during construction.

It is therefore assessed that impacts on people and health during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.19 Tourism and recreational areas

During construction, recreational vessels used for e.g. diving or fishing will not be allowed to enter the safety zones created around construction vessels. The imposition of safety zones will be temporary at any given location as the construction activities progress. Furthermore, construction activities will lead to airborne noise, which may impact the enjoyment of recreational areas. However, given the distances between Bornholm and Ertholmene and the proposed NSP2 route, airborne noise is not expected to reach nuisance levels on the islands at any time.

The water turbidity (i.e., cloudiness) may be increased during construction due to the suspension of sediment into the water column. However, given the use of safety zones around project-related vessels, no recreational activities, including those susceptible to such impacts (i.e. diving), will take place near the areas of highest turbidity. Suspended sediment beyond the safety zone will be at much lower levels and will settle to the seabed within a few hours.

During operation, safety zones around vessels used for periodic inspection and/or maintenance of the pipelines may affect recreational vessels within the immediate vicinity of the pipelines. However, the impact will be less than that during construction due to the low frequency of surveys.

It is therefore assessed that impacts on tourism and recreational areas during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.20 Existing and planned installations

Crossings of existing installations, including cables and the NSP pipeline system, will be implemented using experience from NSP and best practice measures, and in agreement with the respective owners of each installation. This will ensure that a separation is maintained between the NSP2 pipelines and each installation and that the operation of the infrastructure is not affected.

It is therefore assessed that impacts on existing and planned installations during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.21 Raw material extraction sites

The proposed NSP2 route does not cross any areas in Danish waters that are currently being used for the exploration or extraction of natural resources, nor do they cross any areas of potential future extraction. Therefore, no impacts on raw material extraction sites are anticipated during the construction or operational phase.

It is therefore assessed that impacts on raw material extraction sites during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.22 Military practice areas

The NSP2 route V1 and the NSP2 route V2 both cross two areas used for naval shooting exercises by the Danish and Swedish militaries, as well as one submarine exercise area used by the German military. These areas are located east of Bornholm. The Naval District Bornholm and the Danish Navy inform the public when military practice areas are active.

During construction, supply vessels will bring pipes and other supplies to the pipe-lay vessel. The increased vessel traffic to and from the project area can potentially conflict with military practice activities. Nord Stream 2 AG will coordinate with the appropriate authorities to ensure that there will be no conflicts between military activities and construction of NSP2. During operation, the pipelines and related support structures will be present on the seabed, which may conflict with submarine exercises carried out by the German military east of Bornholm. However, on the basis of communication with the German Armed Forces, it has been confirmed that bottoming does not occur in the area to be occupied by the pipelines, and therefore there will be no impact.

It is therefore assessed that impacts on military practice areas during construction and operation of NSP2 will be **negligible** and **not significant**.

0.6.23 Environmental monitoring stations

Long-term trends in physical, chemical and biological variables are being monitored at selected environmental monitoring stations throughout the Baltic Sea. Monitoring stations in the Danish waters around Bornholm include Swedish, Finnish, and HELCOM stations. There are four stations located within 10 km of the proposed NSP2 route; of these, none are located less than 1 km from the NSP2 route V1 and one of them is located less than 1 km from the NSP2 route V2. The station is used by the Finnish authorities for monitoring of physical and chemical parameters as well as benthos.

Modelling indicates that the impacts associated with increased suspended sediments and contaminants, as well as sedimentation on the seabed, will be short-term and limited to the near vicinity of the pipelines. It is therefore assessed that there will be a limited potential for impacts on environmental monitoring stations. In order to exclude any potential impact on historical and future data acquired by long-term monitoring stations, Nord Stream 2 AG will consult with the responsible authority to minimise potential interference. No impacts on environmental monitoring stations are anticipated during the operational phase.

It is therefore assessed that impacts on environmental monitoring stations during construction and operation of NSP2 will be **negligible** and **not significant**.

0.7 Marine strategic planning

Several directives and programmes are in place with the aim of improving the quality of European waters and creating a common framework for marine spatial planning. These include the Marine Strategy Framework Directive (MSFD), Water Framework Directive (WFD) and Baltic Sea Action Plan (BSAP).

An assessment has been undertaken to determine the compliance of NSP2 with these directives and programmes, and shows that NSP2 will not prevent the achievement of the long-term goals, or be contrary to the objectives and initiatives set out in the MSFD, WFD and/or BSAP.

0.8 Decommissioning

NSP2 is designed to operate for at least 50 years. The proposed decommissioning programme will be developed during the latter years of operation to enable consideration of any new or updated legislation and guidance, as well as to utilise good international industry practice and technical knowledge gained over the lifetime of NSP2. The condition of the NSP2 infrastructure may also influence the preferred decommissioning method and relevant mitigation measures.

The preferred option for decommissioning of the offshore NSP2 structures is likely to be leaving *in situ*. Management and mitigation methods for decommissioning will be developed in agreement with the relevant national authorities, in accordance with the legislative requirements at the time of decommissioning and with due consideration of available knowledge and technology.

0.9 Cumulative impacts

In addition to assessing the impact of the NSP2 project on individual resources or receptors (see section 0.6), it is also necessary to consider the potential for NSP2-related impacts to interact with impacts from other existing or planned projects. These other projects may generate their own individually insignificant impacts, but when considered together with the impacts from NSP2, a significant combined or cumulative impact could result.

This section considers the potential for cumulative impacts from the construction and/or operation of NSP2 in conjunction with other planned and existing projects. These other projects have been selected on the basis of location, timing, degree of certainty (for planned projects), and potential for resulting in impacts on the same receptors as NSP2.

0.9.1 Planned projects

The only planned project identified as having the potential to combine with NSP2 and generate cumulative impacts is the Baltic Pipe subsea natural gas pipeline, which could cross the proposed NSP2 route.

The Baltic Pipe project is in the planning stage and anticipates that pre-lay seabed intervention work will begin in November 2020 and the actual installation of the Baltic Pipe is expected to be carried out within the period April – August 2021. The NSP2 pipelines are scheduled to be laid at the start of 2020 in order to facilitate testing and commissioning of the system within the second half of 2020. Therefore, there should be no temporal overlap and therefore no cumulative impacts are foreseen for the construction phases of the two projects. Sources of potential cumulative impacts during operation of the two systems that were assessed included the physical presence of pipelines and structures on the seabed; change of habitat, physical disturbance above water (e.g. from the presence of vessels); the release of metals from anodes and the imposition of safety zones around vessels.

For each source, the assessment concluded that negligible cumulative impacts are expected, due to the localised extent and/or short duration of the impacts for both projects.

Therefore, it is assessed that there would be **negligible** and **not significant** cumulative impacts on all resources and receptors due to interaction between NSP2 and planned projects, and no potential transboundary impacts were identified.

0.9.2 Existing projects

Consideration was also given to the potential for cumulative impacts from interaction of NSP2 with existing projects; namely, existing telecommunication cables and the NSP pipeline.

The assessment concluded that due to the localised extent and low magnitude of the impacts from each project, there would be negligible cumulative impacts on all resources and receptors due to interaction between NSP2 and existing projects, and no potential transboundary impacts were identified.

0.10 Unplanned events and risk assessment

The construction and operation of NSP2 may give rise to hazards that could present risks to the environment, the public/third parties or workers. As such, comprehensive risk assessments have been carried out to understand, mitigate or prepare for possible risks. The identified risks to the environment and public during construction and/or operation of NSP2 that have been assessed in this EIA relate to the following unplanned events:

- Vessel collisions and subsequent oil spill;
- Gas release;
- Unplanned munitions encounter;
- Unplanned maintenance works;
- Wet buckle (construction phase only).

In all phases of the project, Nord Stream 2 AG will only undertake activities for which the associated risk is assessed to be acceptable.

0.11 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 an assessment of potential transboundary impacts be performed when a planned activity may lead to impacts across the boundaries of Parties of the Convention. NSP2 crosses the jurisdictions of several countries and will be constructed in a marine environment, where an impact may be experienced some distance from its source. Therefore, the potential for planned activities in Danish waters to impact resources or receptors in neighbouring countries was assessed in the EIA. The potential for transboundary impacts has been identified for Sweden, Germany and Poland, see Table 0-3. Furthermore, the EIA also assessed the potential for transboundary impacts on regional or global receptors in the Baltic Sea arising from the construction and operation of NSP2 in Danish waters, see Table 0-4.

Table 0-3 Assessment of potential transboundary impacts arising from the construction and operation of NSP2 in Danish waters.

Source of potential impact	Sweden	Germany	Poland
Release of sediments into the water column			
Release of contaminants into the water column			
Release of chemical warfare agents into the water column			
Sedimentation on the seabed			
Generation of underwater noise			
Imposition of safety zones around vessels			
Impacts on protected areas			

Negligible impact   Minor impact

Table 0-4 Assessment of potential transboundary impacts on regional or global receptors in the Baltic Sea arising from the construction and operation of NSP2 in Danish waters.

Potentially impacted regional or global receptors	Potential impact
Altered hydrography	
Air quality and climate	
Fish	
Marine biodiversity	
Shipping and shipping lanes	
Fisheries	
Marine strategic planning	
Natura 2000 sites	

Negligible impact   Minor impact

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 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. Furthermore, the shortest distance from the pipeline to the Danish/Polish EEZ border is approximately 7.0 km for the combination of the proposed NSP2 route with V1 and approximately 3.6 km for the combination of the proposed NSP2 route with V2, and significant impacts are not expected to reach Polish waters. It is therefore generally assessed that the impacts from activities within the Danish EEZ on neighbouring countries will be **negligible to minor** and thus **not significant**. This is in line with the monitoring results obtained during the construction and first years of operation of NSP.

Furthermore, the construction and operation of the NSP2 pipelines within the Danish EEZ will have no significant impact on protected areas, including internationally protected areas (Natura 2000 sites, Ramsar sites). Therefore, the coherence of the Natura 2000 network, including spatial and functional connections, will not be affected.

Lastly, the EIA also evaluated the potential for transboundary impacts from unplanned events, such as an oil spill following a ship collision or a gas leakage. Unplanned events have been subject to a risk assessment (see section 14), which concluded that the likelihood of occurrence is extremely low. The potential for transboundary impacts is also assessed to be **negligible** and **not significant**.

0.12 Mitigation measures

Nord Stream 2 AG is committed to designing, planning and implementing NSP2 with the lowest reasonably practicable impact on the environment. The environmental and social management system (ESMS) for managing planned impacts and emergency response is detailed in section 0.14.

A key objective during the planning and design 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 each phase of the project. These mitigation measures have been identified through consideration of legal requirements, best practice industry standards, applicable international standards, experience from NSP and other infrastructure projects, as well as application of expert judgement.

In developing mitigation measures, the primary goal has been to prevent or reduce identified negative impacts. If it was not possible to avoid an impact (i.e. there is no technically 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 are considered.

Mitigation measures during construction and/or operation of NSP2 have been proposed for the following topics: water quality, non-indigenous species, shipping and shipping lanes, commercial fishery, cultural heritage, conventional and chemical munitions, existing and planned offshore installations, military practice areas, environmental monitoring stations and the management of hazardous materials and wastes.

0.13 Proposed environmental monitoring

The purpose of an environmental and socio-economic monitoring programme is to verify and evaluate the assumptions and environmental impacts described in the EIA. In addition, the data gathered through a monitoring programme may identify the need for further environmental mitigation measures if, contrary to expectations, they indicate unforeseen environmental impacts.

The proposed NSP2 monitoring programme draws on the vast knowledge and experience acquired from the NSP monitoring programme. This concluded that impacts on the marine environment were negligible to minor, not significant and limited to the immediate vicinity of the pipelines. It is anticipated that the NSP2 programme will include monitoring activities before, during and/or after construction, see Table 0-5.

Table 0-5 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
Chemical warfare agents Chemical warfare agents 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 behaviour of construction vessels		X	
NSP2 pipelines footprint Monitoring of the seabed area occupied by the NSP2 pipelines and associated structures and documentation of physical loss for overall habitat types			X
*An expert from the Danish Navy will likely be on board the pipe-lay vessel.			

The precise approach of the final monitoring programme will be elaborated in consultation with the Danish authorities. Environmental and socio-economic monitoring results will be made publicly available.

0.14 Health, Safety, Environmental and Social Management System

A health, safety, environmental and social management system (HSES MS) has been developed by Nord Stream 2 AG to enable identification and management of all relevant HSES risks associated with the project. The HSES MS also covers the management of security where it may impact the safety of personnel and affected communities, the integrity of project assets and the reputation of Nord Stream 2 AG.

The current HSES MS is applicable to the planning and construction phases of NSP2. It will be adjusted once the pipeline system is commissioned so as to manage HSES issues for the operational phase. Throughout all phases of the project, Nord Stream 2 AG will ensure that HSES information is proactively communicated both internally and externally, and that all staff and contractors adhere to the standards and requirements in the HSES MS.

0.15 Summary

In summary, the construction and operation of NSP2 may result in **mainly negligible** to **a few minor** impacts on the environment. No impacts, either individually or in combination, are assessed to be significant.

A summary of the potential impacts on all resources and receptors assessed in the EIA is provided in Table 0-6 (physical-chemical and biological) and Table 0-7 (socio-economic), based on the assessment of potential impacts (see section 0.6).

Table 0-6 Summary of the overall impacts caused by the NSP2 project on 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	Seabirds	Protected areas***	Natura 2000	Biodiversity
Construction phase	Physical disturbance on the seabed													
	Release of sediments into the water column													
	Release of contaminants into the water column													
	Release of chemical warfare agents into the water column													
	Sedimentation on the seabed													
	Generation of underwater noise									**				
	Physical disturbance above water*													
	Emissions of air pollutants and greenhouse gases													
	Introduction of non-indigenous species													
Operational phase	Physical presence of pipelines and structures on the seabed									****				
	Change of habitat													
	Physical disturbance above water*													
	Emissions of air pollutants and greenhouse gases													
	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, airborne noise and light.
** Impact on marine mammals from underwater noise is assessed to be "Negligible" for PTS/TTS and "Minor" for behavioural response and masking.
*** Protected areas include Ramsar sites and HELCOM MPAs.
**** This impact refers to the noise of the gas flowing through the pipeline.

Negligible impact | Minor impact

Table 0-7 Summary of the overall impacts caused by the NSP2 project on socio-economic resources or receptors.

Source of potential impact		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 moni-toring stations
Construction phase	Physical disturbance on the seabed			Negligible			Negligible			
	Release of sediments into the water col-umn					Negligible				Negligible
	Release of contaminants into 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
Operational phase	Physical presence of pipelines and struc-tures on the seabed		Minor	Negligible			Negligible	Negligible	Negligible	
	Physical disturbance above water				Negligible					
	Imposition of safety zones around vessels	Negligible				Negligible				

Negligible impact Minor impact

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 operation in 2011 and 2012. The new pipelines will increase the capacity to Europe via the Baltic Sea route from Russia to Germany.

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

The Nord Stream 2 Pipeline project 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) have been submitted in all five countries. In addition, international consultation has been undertaken according to the Espoo Convention so that all countries possibly affected by the Nord Stream 2 Pipeline project have the opportunity to review the transboundary impacts that the pipelines could potentially have on the environment.

In Denmark, an EIA is an integrated part of the permitting procedure for a pipeline, and must be prepared in accordance with the Danish EIA Act.

This EIA has been prepared specifically for the Danish section 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.

A construction permit application for the base case Nord Stream 2 Pipeline route, including EIAs and Espoo documentation, was sent to the relevant authorities for all involved countries in April 2017. Permits have been granted in Germany, Sweden, Finland and Russia. In Denmark, the NSP2 base case route application is being evaluated by the Minister of Foreign Affairs, as a construction permit for a route in Danish TW can only be granted if the activity is compatible with national foreign, security and defence policy interests, cf. section 3a(2) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters.

As it is not clear when a recommendation by the Minister of Foreign Affairs will be made, Nord Stream 2 AG decided to develop a route outside of Danish TW to the north and west of Bornholm (NW route). The EIA and permit application were submitted to the DEA in August 2018.

Given the recent delimitation of the EEZ borders between Denmark and Poland, Nord Stream 2 AG has now decided to develop a route outside of Danish TW to the south and east of Bornholm and the base case route. It is noted that the positioning of the proposed NSP2 route at the Danish/Swedish and Danish/German EEZ borders is considered fixed, on the basis of environmental and technical reasons together with the issuance of the German and the Swedish permits and the start of pipeline installation in German and Swedish waters.

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 1,230-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, €9.5 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-t 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 in Danish waters at the start of 2020 in order to facilitate testing and commissioning of the system within the second half of 2020.

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, except in Danish waters. 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 is 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 deliver 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 existing infrastructure.

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 health, safety and environmental (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, EIAs 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, EIAs and stakeholder feedback, in order to come to an optimised 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 EIAs. 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 AG discussed the programme proposals for the national environmental impact studies in the five countries (Russia, Finland, Sweden, Denmark and Germany) whose EEZs or TW 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 consequently 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% of global gas production. Five European energy companies, ENGIE, OMV, Shell, Uniper and Wintershall, have committed to provide long-term financing for 50% of the total cost of the project. The financial commitment by the European companies underscores the Nord Stream 2 project’s strategic importance for the European gas market, contributing to competitiveness as well as medium- and long-term energy security, especially against the background of expected declining European production.

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

Based on its stringent procurement policy and international tenders, Nord Stream 2 AG 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), Chelyabinsk/Russia were chosen to deliver approximately 200,000 large-diameter pipes (totalling approximately 2,500 km) with a total weight of roughly 2.2 million tonnes (mio. t). The first pipe deliveries started at the end of September 2016.

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

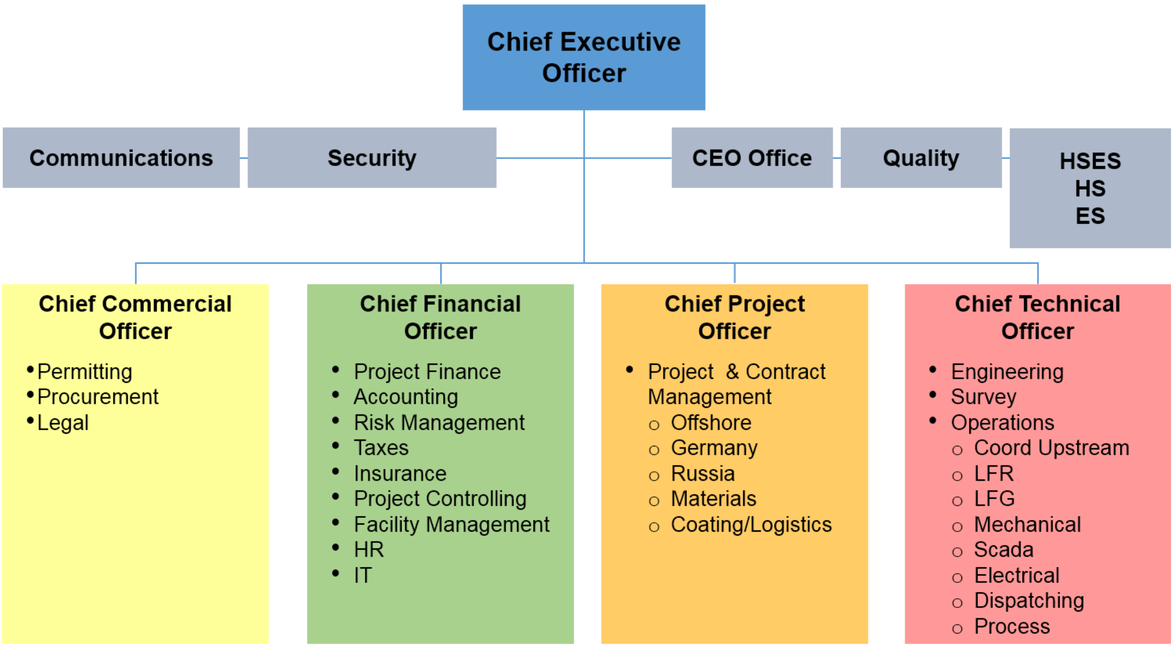
Nord Stream AG has been committed to safety and environmentally-friendly solutions from the very start of the project – through the planning, construction and now operational phases. In addition to a state-of-the-art technical design, Nord Stream AG demonstrated in a very transparent way its competence 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 AG 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 and 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.

The results of previous surveys and the experience gained during the construction and operation of the Nord Stream Pipeline will help 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 AG 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



2.5 NSP2 permit application status

A construction permit application for the base case Nord Stream 2 Pipeline route, including EIAs and Espoo documentation, was sent to the relevant authorities for all involved countries in April 2017. Permits have been granted in Germany, Sweden, Finland and Russia. In Denmark, the NSP2 base case route application is being evaluated by the Minister of Foreign Affairs as a construction permit for a route in Danish TW can only be granted if the activity is compatible with national foreign, security and defence policy interests, cf. section 3a(2) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters.

As it is not clear when a recommendation by the Minister of Foreign Affairs will be made, Nord Stream 2 AG decided to develop a route outside of Danish TW to the north and west of Bornholm (NW route). This routing was selected after the Danish authorities advised in a letter dated November 2017 that the disputed area between Denmark and Poland was not available for the route of the gas pipelines that Nord Stream 2 AG previously had developed /80/. The EIA and permit application were submitted to the DEA in August 2018.

Given the recent delimitation of the EEZ borders between Denmark and Poland, Nord Stream 2 AG has now decided to develop a route outside of Danish TW to the south and east of Bornholm and the base case route. This proposed NSP2 route, the south-eastern route alternative (SE route), is included as a main alternative to the NSP2 base case route. It is noted that the positioning of the proposed NSP2 route at the Danish/Swedish and Danish/German EEZ borders is considered fixed, on the basis of environmental and technical reasons together with the issuance of the German and the Swedish permits and the start of pipeline installation in German and Swedish waters.

3 PROJECT JUSTIFICATION

This section on project justification has been prepared by Nord Stream 2 AG based on a number of external reports.

The section describes the circumstances and reasons for the Nord Stream 2 Pipeline project (NSP2) and argues why it is required to secure the supply of gas to the EU Member States.

Nord Stream 2 AG has commissioned Prognos AG as an independent industry expert to prepare a study on the European gas balance, forecast future gas demand and assess possible sources of demand coverage. In view of the above, Prognos AG, which advises decision-makers from politics, business and society in Europe by providing objective analyses and forecasts, completed the study "Current Status and Perspectives of the European Gas Balance" in January 2017 /1/[1].

The study area of this section is thus the European Union, consisting of 28 Member States (*EU 28*), including the United Kingdom (UK). The expected withdrawal of UK from *EU 28* ("Brexit") would have no significant impact on the natural gas flows between the UK and other *EU 28* Member States as well as Norway, as the UK's natural gas import requirements, and the *EU 28* total imports, would not change /1/. The geographic area will be extended within the following analysis, when required, from an *EU 28* perspective, i.e. non-*EU 28* Member States that are able to or have decided to cover their gas import requirements partially or exclusively from the *EU 28* /1/. This is discussed in detail in the following.

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 must 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 section 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 /1/.

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

In its analysis, Prognos differentiates between target and reference scenarios. Reference scenarios are based on current policies and the enforcement of existing legislation, thereby continuing current trends as a basis of their forecast. Target scenarios, on the other hand, go beyond this and take into account further assumptions, e.g. the development and implementation of technologies or the achievement of political targets (i.e. climate protection goals). Defining a target scenario is based

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[1] The editorial deadline of the Prognos study, a key component of the project justification, was the end of January 2017. The study was published in April 2017. Prognos provided an update at the end of 2017 to revisit the original projections, taking account of 2017 developments in gas demand and production. Prognos concludes that overall, the original projections remain plausible. It is too early in 2018 to already consider 2018 developments.

on a method of working backwards – the required status is set for the future, and then with a reverse approach, the steps for how to reach it are projected backwards.

For a time horizon until 2050, target scenarios typically aim at an all-electric world fuelled by renewable power generation and show strongly declining fossil fuel demand trajectories to achieve politically set climate protection targets, without taking enforceability or likelihood of achievement into account. Basing the demand planning on a reference scenario is good practice for large infrastructure projects in the EU. This can be explained due to an asymmetry of risks: the gravity of disadvantages happening in case the assumptions of a chosen target scenario do not materialise can usually be considered worse than if a reference scenario were used, as is explained below. Building the demand planning on a reference scenario does not mean to neglect ambitious policy objectives (that may or may not be successfully implemented in the future), but rather bases this kind of sensitive planning on more robust scenarios in order to guarantee security of supply, also in case these objectives are not met or only partially met.

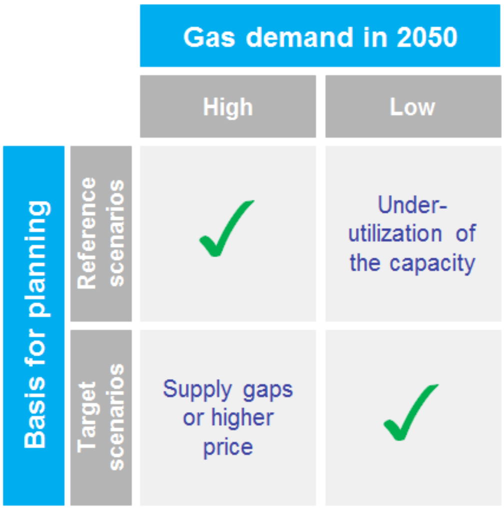

Figure 3-1 Risk asymmetry based on a reference and a target scenario.

The asymmetry of risk with regard to NSP2 is illustrated in the matrix above. If the NSP2 gas demand scenario is based on a reference scenario that projects a relatively higher gas demand compared to a target scenario, but gas demand does not reach the expected level by 2050, the pipeline's capacity will be underutilised and the environmental intervention due to construction will potentially have been unnecessary. However, as the project is privately financed, the costs of this stranded asset will be borne by the companies involved.

On the other hand, if the infrastructure development were based on a target scenario with a relatively low gas demand in the future, but the assumed targets are not met or not entirely met and there is a higher demand for gas than expected, the disadvantageous outcome is more severe. The security of supply is endangered, as the construction of the required infrastructure cannot be provided in time due to the lead time required for such projects. The demand gap would need to be covered by other gas sources, but that would potentially lead to significantly higher prices. In this case, it cannot be guaranteed that the gas demand would be covered.

Therefore, in order to secure gas supply for Europe for the coming decades (in the planning process of energy infrastructure) reference scenarios are the better alternative to be used as a forecast basis in order to ensure security of supply also in case ambitious targets are not met in time.

Prognos AG took into consideration a number of projected scenarios regarding gas demand (see Figure 3-2). The argument for choosing the EU Ref 2016 scenario over other scenarios – including Greenpeace's energy [r]evolution and advanced energy [r]evolution scenarios, IEA's 450, scenarios from ENTSOG, ExxonMobil, Statoil and HIS – is underpinned and explained in detail in the Prognos study /1/.

EU Ref 2016 as the chosen scenario for NSP2 is a widely acknowledged reference scenario and also a comprehensive study on European energy demand, based on accepted methodologies, i.e. the PRIMES model, and published by the EU. EU Ref 2016 still represents a prudent approach also compared to other reference scenarios, as it is situated rather on the lower end of gas demand scenarios.

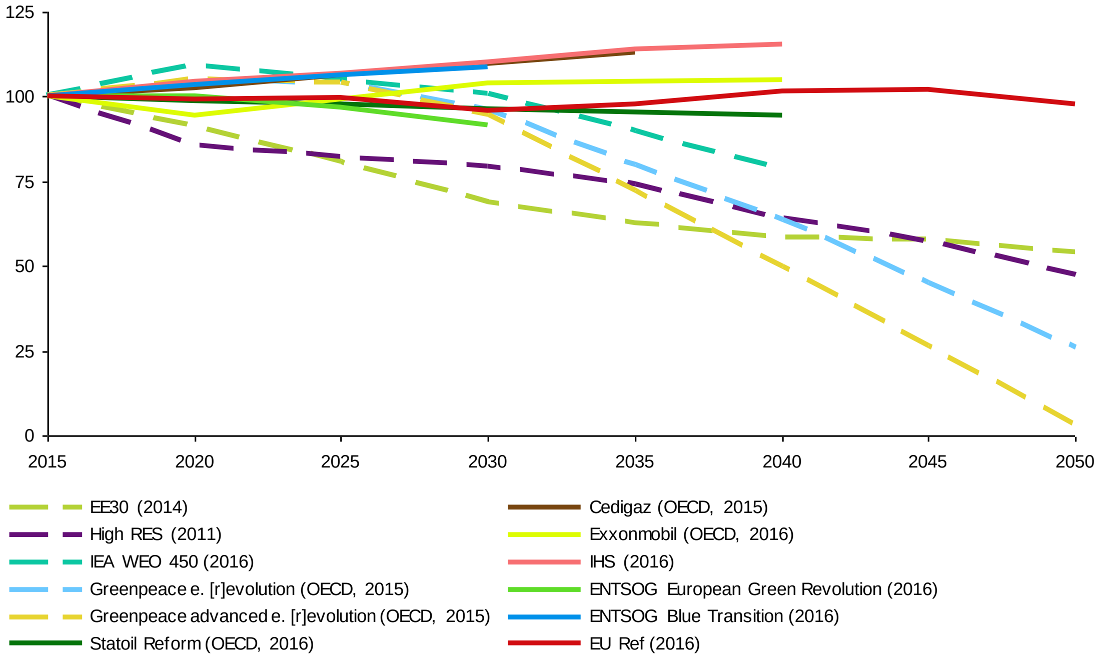

Figure 3-2 Natural gas demand scenarios for EU 28 and OECD Europe [indexed with 2015 = 100] (straight line = reference scenarios; dotted lines = target scenarios).

To summarise, in order to ensure the security of energy supply of the *EU 28* with natural gas, it is reasonable to base the medium- to long-term planning on reference scenarios. Prognos bases its analysis on the *EU Reference Scenario* (2016), as its projections are built on present best practices from a technological and legal perspective, takes into account recent developments as well as potential risks and it is highly transparent. However, Prognos also adjusted the *EU Reference Scenario* to include up-to-date official production outlooks and extended the regional scope 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 dependent on the existing gas network (*EU 28*).

Considering Switzerland and Ukraine, which are expected to import approximately 20 bcm of natural gas per year from the EU internal gas market as of 2020, the *EU 28* demand 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 3-3).

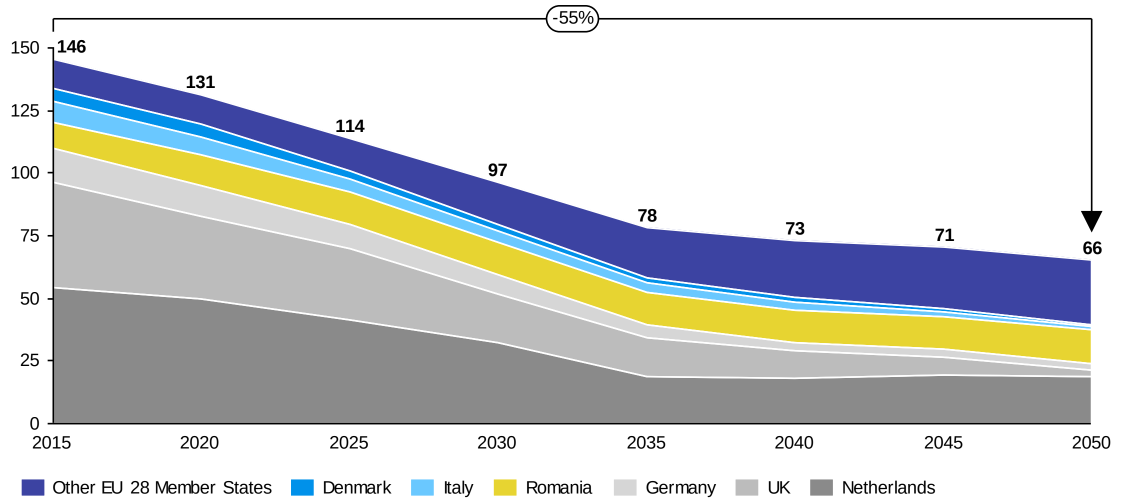

Figure 3-3 EU 28 natural gas production projections according to Prognos based on the EU Reference Scenario 2016 [bcm].

According to Prognos, natural gas production is expected to decrease even more than projected due to recent decisions by the Dutch government to reinforce limitations on 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 3-4).

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 3-4), with the result that additional gas supplies will be necessary to ensure the sustainable supply security of *EU 28*.

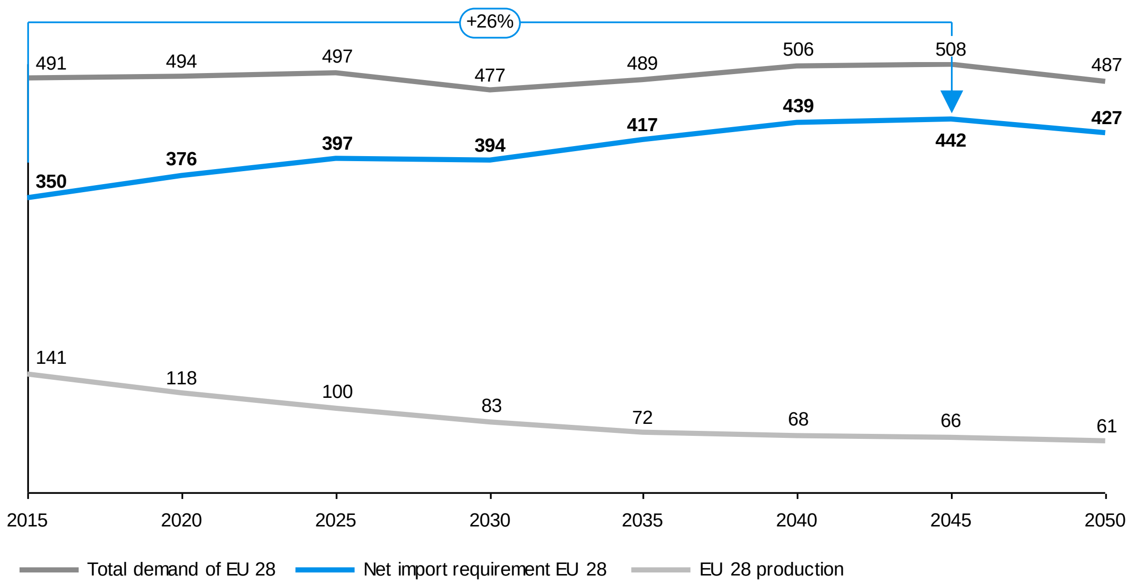

Figure 3-4 Natural gas demand, production and import requirement of EU 28 [bcm].

According to Prognos, without NSP2, 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 alternative supply, the global LNG market, is subject to drastic fluctuations, so that LNG cannot be assumed to reliably cover potential demand gaps. Therefore, the realisation of the project is necessary in order to eliminate uncertainties of supply and 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 (i.e. Norway, see Figure 3-5, Algeria, see Figure 3-6, and Libya), are projected to supply decreasing volumes due to restrictions in future production and/or increases in domestic consumption.

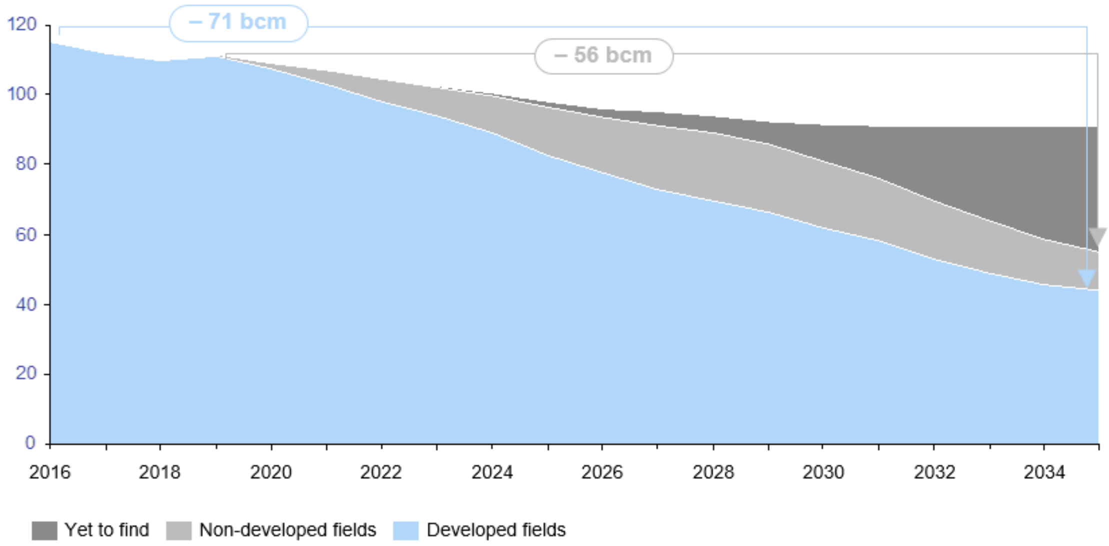

Figure 3-5 Norway: Natural gas production forecast [bcm].

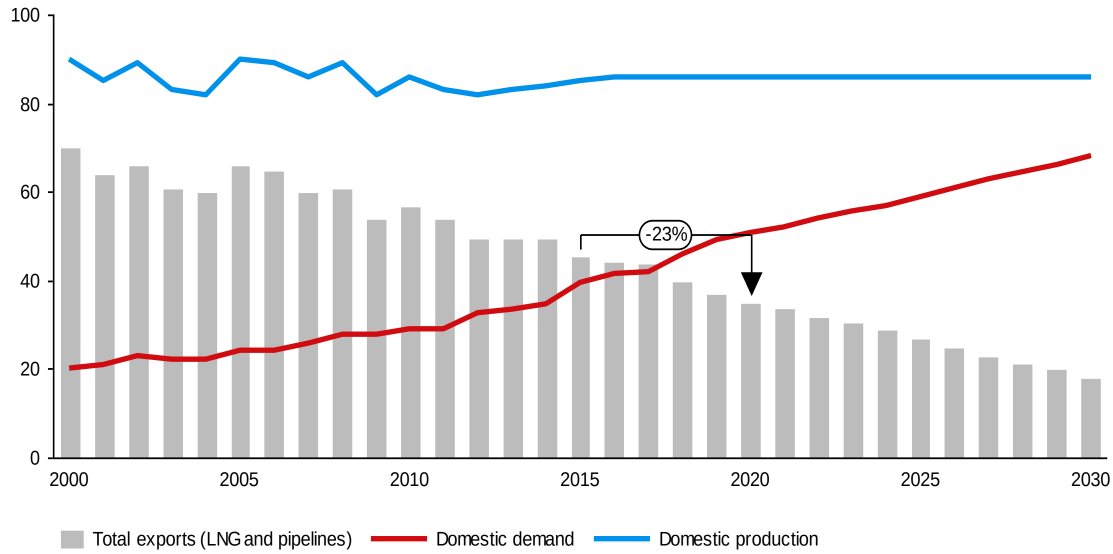

Figure 3-6 Algeria: Natural gas balance forecast [bcm].

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 3-7).

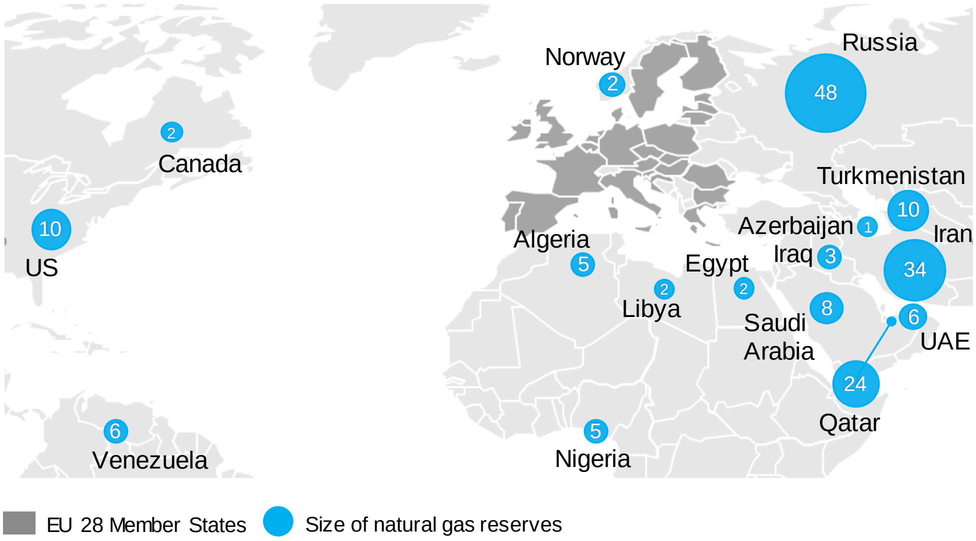

Figure 3-7 Distribution of global natural gas reserves [tcm].

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 (i.e. Estonia, Latvia, Lithuania) and Finland are reliably available. However, for the Central corridor through Ukraine, further transport capacity of only 30 bcm/yr can be considered as sustainably available. This transport capacity is only available if the required refurbishment, which is funded by EBRD (European Bank for Reconstruction and Development) / EIB (European Investment Bank) 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 have not been undertaken in recent years. In fact, the planned investment programme has been consistently underfulfilled by the operator.

The inadequate condition of the system has resulted in an incident rate about 10 times higher than the European average. This situation is 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 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 significantly lower gas consumption by the compressor stations required for transport, and thus to a higher efficiency and consequently lower GHG and other emissions. As a result, the respective demand gaps can be reliably covered by pipeline gas, ensuring future gas supply.

The potential for pipeline gas to be supplied from new source countries (i.e. 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/yr – no additional pipeline gas coming to the EU internal gas market is presently 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 3-8), LNG cannot ensure coverage of natural gas demand. Therefore, reliable medium- and long-term forecasts of the LNG market are hardly feasible.

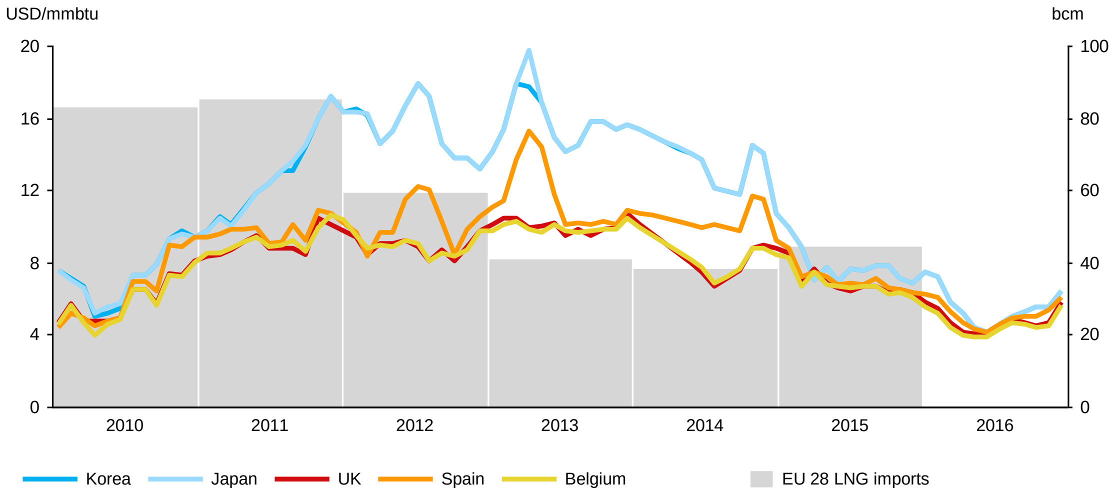

Figure 3-8 Development of regional landed LNG prices [USD/MMBtu] and EU 28 LNG imports [bcm].

In addition, Prognos /1/ and various other available studies /2//3/ assume that LNG demand will exceed supply in the early 2020s, so that sufficient quantities for Europe are not guaranteed, resulting in increased price competition. Natural gas imported as LNG into the EU internal gas market is therefore 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 implementation of the NSP2 project. This import gap will increase from 30 bcm in 2020 to 59 bcm in 2030 and 110 bcm in 2050 (see Figure 3-9). The construction of NSP2 can close this import gap from 2020 onwards. This will increase Russia's sustainable transport capacity towards the EU internal gas market, thereby avoiding the additional reliance on volatile LNG. With its designed annual capacity of 55 bcm per year[2], NSP2 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 complexity of possible forecasts, it cannot be excluded that other studies may generate different results. However, these will not be able to prove that the EU's security of supply can be guaranteed in the future without the implementation of NSP2. On the contrary, there are additional risk factors which can currently lead to an increased threat to the security of supply. The NSP2 pipeline can help to ensure security of supply, particularly in terms of potential transit, supply and demand risks.

[2] In Figure 3-9, a typical utilisation rate of 90% is applied to the designed annual capacity of NSP2 (55 bcm/yr), which leads to average annual volumes of 50 bcm.

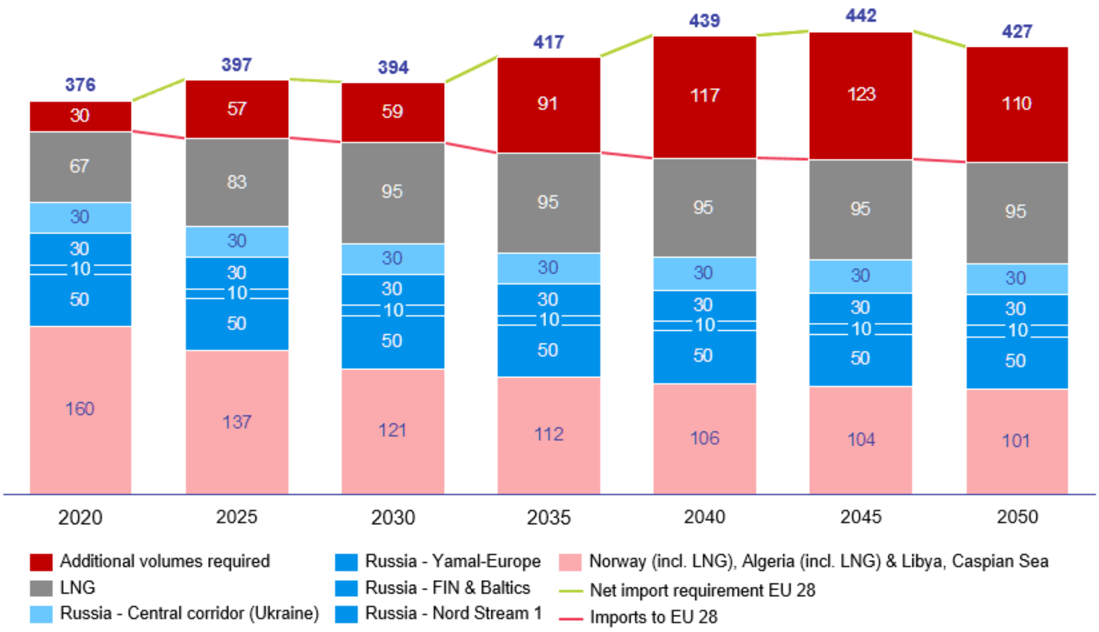

Figure 3-9 EU 28 import gap forecast with average LNG and 30 bcm/yr Ukraine transit (Reference Case) [bcm]. Figures for Russian supplies in the bar chart are arranged in the same order as used in the legend.

The most prominent risk factors are a complete halt of transit through Ukraine on commercial or legal grounds (see Figure 3-10) or low levels of LNG supply due to a tightening global LNG market (see Figure 3-11). 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 *EU 28* security of gas supply (see Figure 3-12).

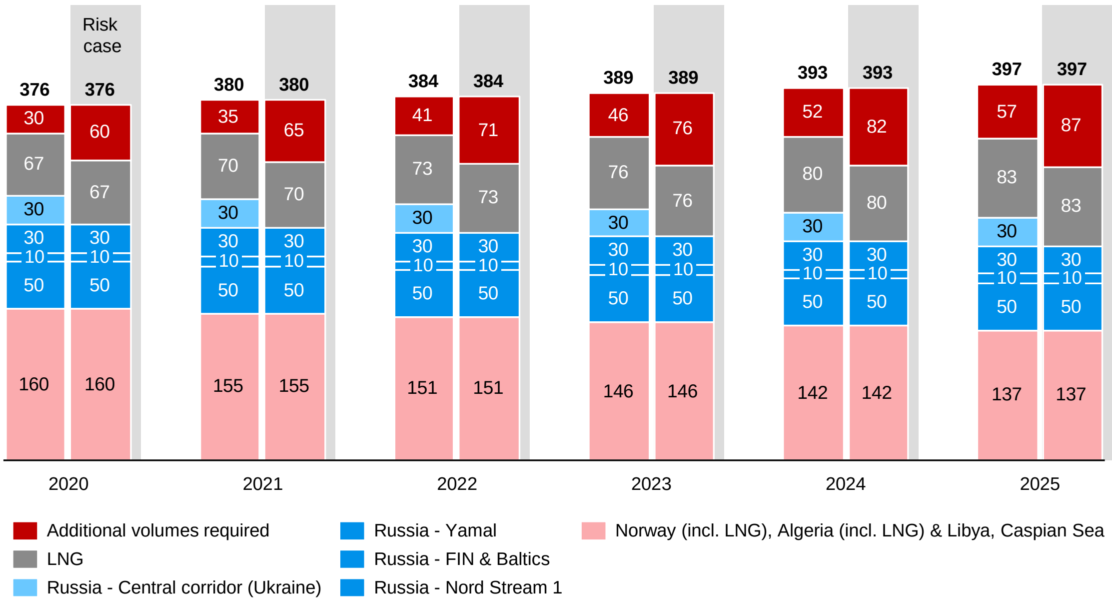

Figure 3-10 Risk case 1 for EU 28: 0 bcm/yr Ukraine transit [bcm].

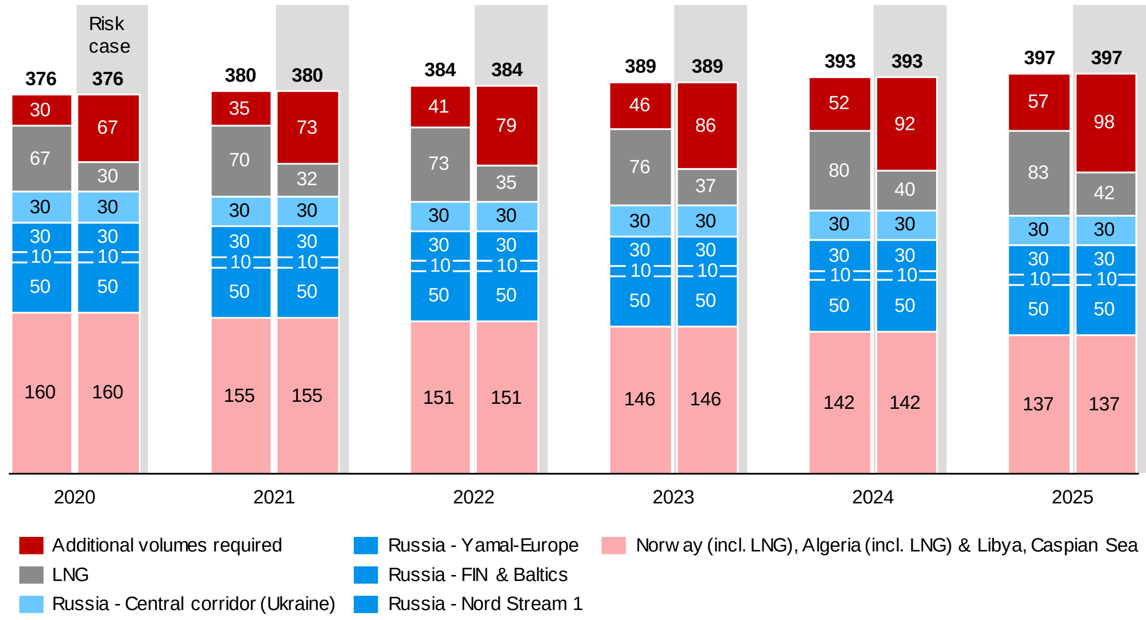

Figure 3-11 Risk case 2 for EU 28: Minimum LNG import by EU 28 [bcm].

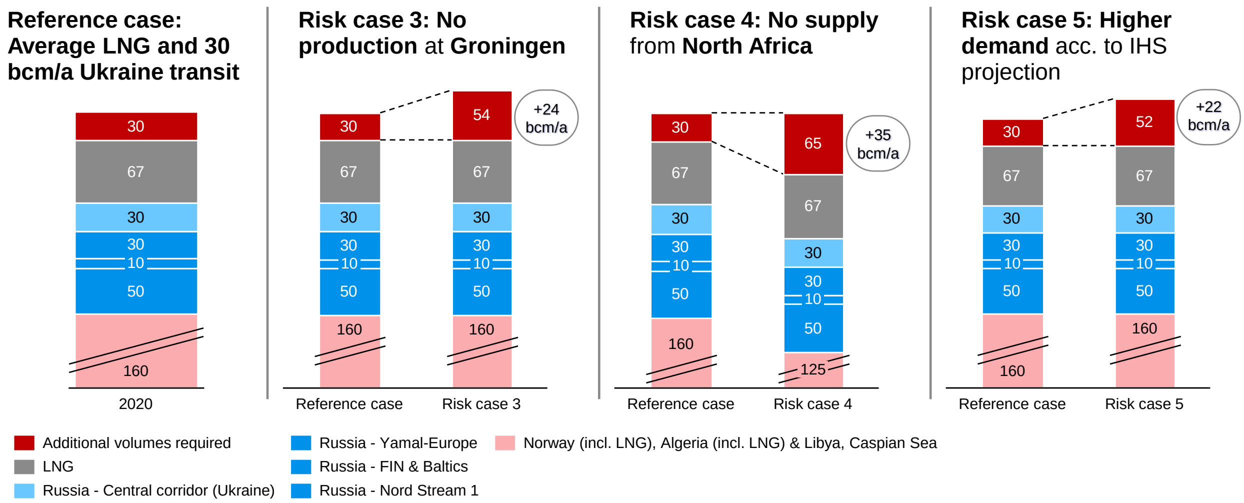

Figure 3-12 Other relevant risk cases for EU 28: No supply from Groningen (NL), North Africa or higher demand for natural gas [bcm].

In addition, NSP2 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, NSP2 will trigger further integration of the EU internal gas market through additional downstream pipeline infrastructure.

Finally, the proposed project contributes to an environmentally 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.

Today, natural gas has the second largest share (~21%) in the energy mix of EU 28 after oil (~34%), but markedly before coal (~17%), nuclear (~14%) and renewables (~13%) /4/. The increase in renewable production in the past years has mainly led to a reduction in the use of coal.

Being the least-emitting fossil fuel of greenhouse gases (GHGs) and other pollutants (e.g. particulate matter), natural gas can replace fossil fuels in burner, internal combustion and turbine processes, including those being used for power generation. In contrast, renewables are predominantly used for power generation thus far.

According to Prognos, reaching the vision of an all-electric economy in Europe by 2050, which can be seen as the gold standard for the current target scenarios, seems to be quite challenging. As long as full integration of renewables has not been achieved (and, for instance, the electricity storage issue remains open), renewables will need to be supplemented by conventional power production capacity to ensure the reliability of power supply and grid stability.

The power plants providing this supplementary function should preferably be fired by natural gas, as it is the best alternative among the fossil fuels. Besides being the lowest carbon emitting fuel, gas is also the first choice when it comes to making best use of the remaining carbon budget in an enhanced low-carbon energy strategy. There is also an already existing infrastructure for transport and storage within *EU 28*, which facilitates the security of energy supply at relatively low costs. In order to replace phased out nuclear power plants and coal/lignite plants, natural gas will need to play an important role in power generation. Gas also has an important potential to reduce inner-urban pollution in terms of particulate matter. Several other studies have also concluded that out of all fossil fuels, gas will play the most important role in the future in complementing energy from renewables and securing energy supply /5//6/.

To summarise, natural gas is a fuel with various applications in the heating, power generation, industry and transport sector of the *EU 28* (see Figure 3-13). Being the fossil fuel with the least GHG and other emissions resulting from combustion – 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 the 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 the 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 jeopardising the overall security of energy supply.

This is why when targeting the Paris Agreement and EU climate goals, taking all potential risks into consideration, a prudent trajectory includes the use of gas as a bridging fuel in order to secure energy supply.

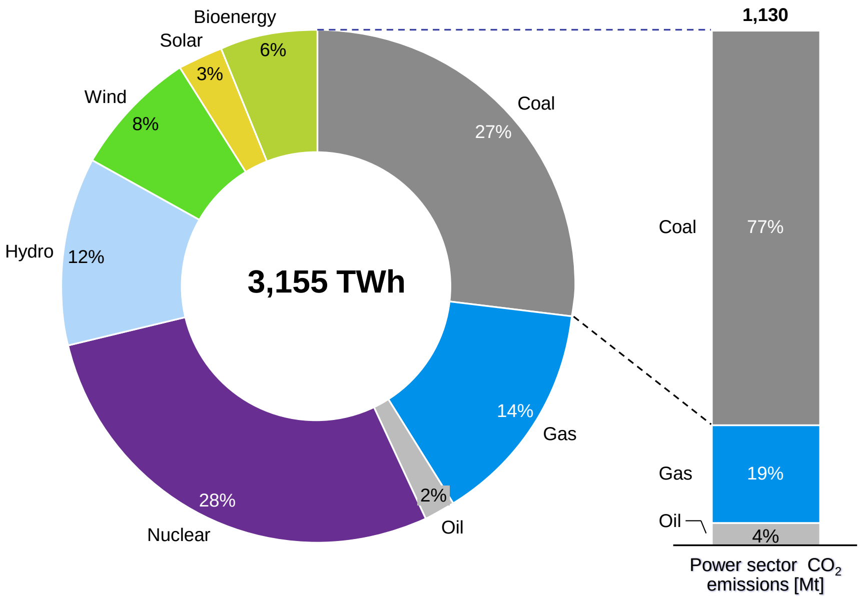

Figure 3-13 Electricity mix 2014 in EU 28 by energy source [TWh, %] and corresponding CO_2 emissions [Mt, %].

Also, from an environmental perspective, NSP2 – 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 3-14) – has significant advantages in terms of environmental and climate impacts.

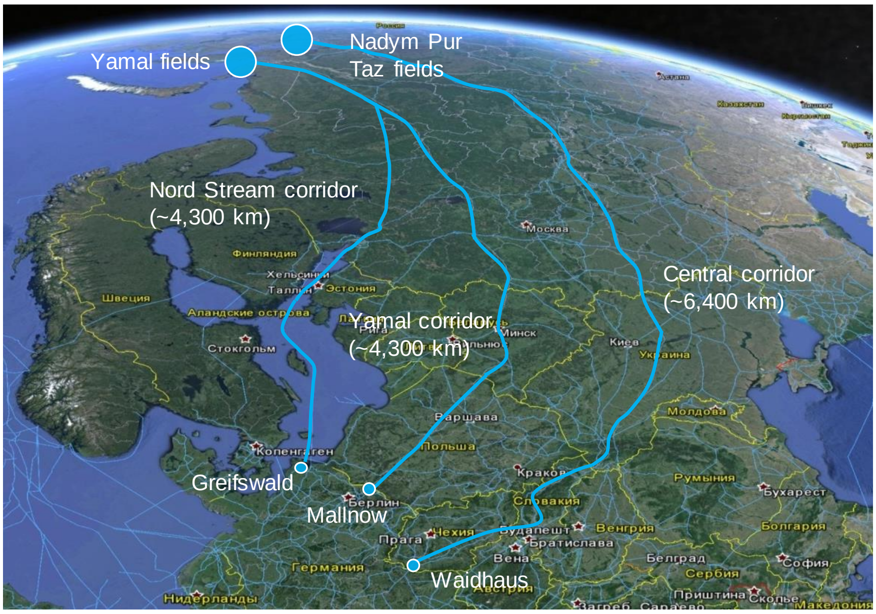

Figure 3-14 Schematic overview of Russian gas fields and pipelines to the EU.

The proposed NSP2 route offers advantages about GHG emissions and cost of production. Comprehensive route considerations have been undertaken in the past to connect the Siberian gas fields to Europe, starting with the North Transgas project in 1995 to the development of NSP and subsequently also NSP2. The previously assessed alternatives form the basis of the routing that is currently being considered for NSP2.

During the planning of NSP, requests to consider an onshore alignment were put forward by the stakeholders during the permitting process. In the project's response to this, it was apparent that onshore pipelines would entail additional environmental and socio-economic effects in comparison with an offshore project. Additional challenges for onshore pipeline development include human settlements, roads, railways, canals, rivers, surface landforms, agricultural land, site reinstatement and cultural heritage sites.

Furthermore, overland pipelines require additional infrastructure sites, such as compressor stations approximately every 200 km to maintain pressure for gas transport flow, which would require significant land and energy usage while emitting noise and emissions to air. Transmission is also less efficient compared with offshore pipelines. Experience with NSP confirmed that impacts were localised and demonstrated that offshore pipelines are the most advantageous approach with respect to all considered aspects, including environmental, cost, supply capacity and security. For these reasons, there has been no further consideration of an onshore alternative.

The NSP/NSP2 route is the most beneficial also when compared to LNG supply options (i.e. Algeria, Australia, Qatar and the US), not only when compared to the Yamal-Europe and the Central corridor.

Among the potential sources of gas supply able to significantly contribute to closing the *EU 28* import gap, Russian gas supplied via the NSP/NSP2 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 through the Yamal-Europe is at least 46% greater, and that of LNG alternatives at least 131% greater (see Figure 3-15).

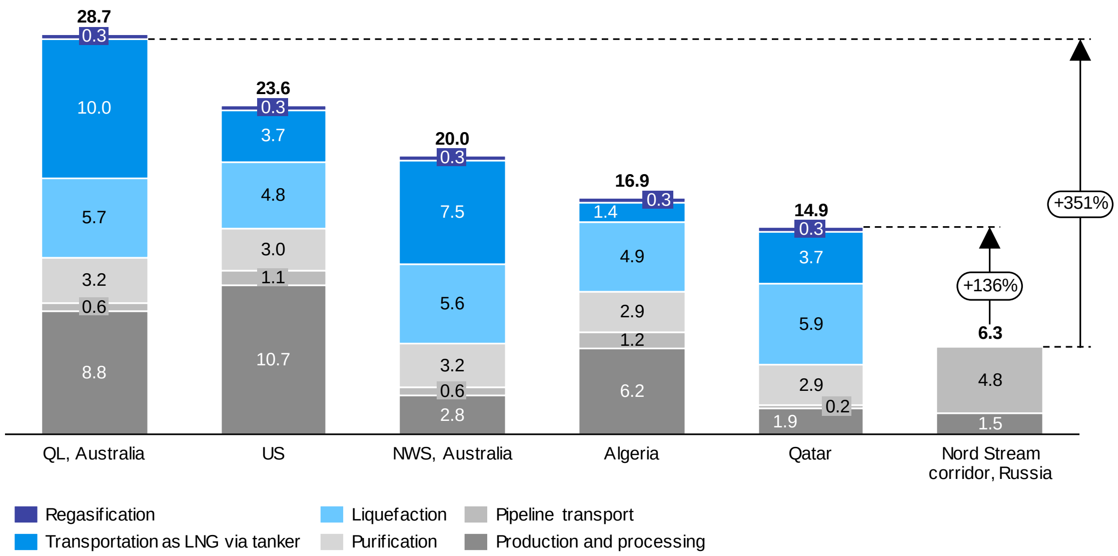

Figure 3-15 Carbon footprint of Russian pipeline gas coming to EU 28 via the Nord Stream corridor and from different sources via LNG [gCO_2e/MJ].

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 NSP2 transport system 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 section provides an account of the legal framework for the EIA procedure and public participation under Danish law. To this end, the section 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 the laying of pipelines and the marine environment. International environmental requirements must therefore be observed in the preparation 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 for NSP2, the EIA procedure and the main environmental requirements are also described in section 4.3.

Nord Stream 2 AG's approach for ensuring public participation in the construction and operation of NSP2 is described in section 4.4.

4.1 Legal framework under Danish law

4.1.1 Legal basis for construction of NSP2

Construction of pipelines on the Danish continental shelf for the transportation of hydrocarbons requires a permit pursuant to section 4(1) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters (*lov om kontinentalsoklen og visse rørledningsanlæg på søterritoriet*) /7/ and section 2(1), cf. section 1 of the Administrative Order on Pipeline Installations (*bekendtgørelse om visse rørledningsanlæg på søterritoriet og kontinentalsoklen*) /8/.

Pursuant to the Administrative Order on the Tasks and Responsibilities of the Danish Energy Agency (*bekendtgørelse om Energistyrelsens opgaver og beføjelser)* /9/, it is the Danish Energy Agency (DEA) that considers an application for a permit to construct pipelines for transportation of hydrocarbons on the Danish continental shelf. Further, it is the DEA that issues the permit on behalf of the Minister of Energy, Utilities and Climate.

A permit for the construction of pipelines for transportation of hydrocarbons in Danish TW can only be granted if the activity is compatible with national foreign, security and defence policy interests, cf. section 3a(2) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters. However, this requirement only applies in the Danish TW, and thus does not apply to a permit for the construction of the proposed NSP2 route (SE route), as the pipelines will be constructed on the Danish continental shelf/EEZ area only.

Permits for the construction of pipelines like the NSP2 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 EIA report, see section 4.1.2 below. Further, if a risk of significant effect on international nature conservation areas (Natura 2000 sites) cannot be excluded in a Natura 2000 screening, a permit can only be granted on the basis of an appropriate assessment of the project's impacts on Natura 2000 sites, taking into account the conservation objectives of the sites concerned.

In addition thereto, as the NSP2 project may potentially have a significant impact on the environment of another state, the procedure under the Espoo Convention applies (Espoo procedure), see section 4.1.3 below.

The DEA's decision to grant the construction permit for NSP2 is thus based on the permit application, the EIA report, including the transboundary impact assessment (see section 14), any additional information and the results of the national consultation and the consultations on transboundary environmental impacts that are carried out.

The permit may lay down specific terms taking into consideration the exploration of the continental shelf, exploitation of its natural resources, prevention and reduction of pollution from pipelines and the possibility of performing repair work on existing pipelines and cables, cf. section 4(2) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters. The Administrative Order on Pipeline Installations, section 4, lists which terms a permit, for instance, may be subject to.

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

The permit decision may be appealed to the Danish Energy Board of Appeal (*Energiklagenævnet*) within four weeks from the issuance of the permit. A permit may not be utilised before the grievance period has expired.

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 EIA report pursuant to the EIA Act (*miljøvurderingsloven*) /11/. Hence, this national Danish EIA report has been prepared for the proposed NSP2 route, and is submitted to the DEA. A scoping process is not required for the proposed NSP2 route.

A permit granted pursuant to section 4(1) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters supersedes the EIA permit otherwise required pursuant to section 25 of the EIA Act, cf. section 10, no. 5 of the Administrative Order on the coordination of environmental assessments and digital self-service, etc. for plans, programmes and concrete projects covered by the EIA Act (*bekendtgørelse om samordning af miljøvurderinger og digital selvbetjening m.v. for planer, programmer og konkrete projekter omfattet af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM)*) /13/.

The DEA is the competent authority to consider the EIA report for the proposed NSP2 route, cf. section 17(4), no. 1 of the EIA Act.

The requirements for the minimum content of the EIA report in accordance with the EIA Directive are outlined in section 20(2) and Annex 7 of the EIA Act /11/, and include, *inter alia*, a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment.

The information to be provided about the project in the EIA report must in an appropriate manner identify, describe and assess the direct and indirect significant effects of the project on the following factors: population and human health; biodiversity, with particular attention to species and habitats protected under the Habitats Directive and Birds Directive; land, soil, water, air and climate; material assets, cultural heritage and the landscape; and the interaction between said factors.

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[3] NSP2 will not be connected to the Danish natural gas system. Therefore, NSP2 is not subject to the provisions of the Danish Natural Gas Supply Act (Consolidated Act no. 1127 of 5 September 2018, as subsequently amended), cf. section 2(4) of the Act.

The description of the likely significant effects on the abovementioned factors should cover the 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. This description should take into account the environmental protection objectives established at the EU or Member State level that are relevant to the project.

If construction or operation of NSP2 may give rise to significant effects on a Natura 2000 site, an appropriate assessment of the project's impact on the site, taking the conservation objectives for that site into consideration, would be required under section 4a of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters and the Administrative Order on Impact Assessment Offshore (*bekendtgørelse om konsekvensvurdering vedrørende internationale naturbeskyttelsesområder og beskyttelse af visse arter ved forundersøgelser, efterforskning og indvinding af kulbrinter, lagring i undergrunden, rørledninger, m.v. offshore*) /12/. The legal framework in regard to Natura 2000 sites is described further in section 4.2.3.

Pursuant to section 35 of the EIA Act, the DEA must consult the affected authorities and the public on the EIA report, including the permit application, before the permit decision is made. The DEA can set appropriate deadlines for consultations with the affected authorities. With respect to the public consultation, a deadline of a minimum of eight weeks is required. Nord Stream 2 AG's approach for ensuring public participation in the construction and operation of NSP2 is described in section 4.4.

When the DEA has made its decision on whether to grant a permit to NSP2, the DEA must immediately provide the public and involved authorities with information about this decision.

The public generally has access to environmental information held by the authorities, including the DEA, pursuant to the Environmental Information Act (*lov om aktindsigt i miljøoplysninger*) /14/, further described in section 4.2.2.

4.1.3 Legal basis for Espoo procedure and public participation

As the proposed NSP2 route may potentially have a significant transboundary impact on the environment of another state, the procedure under the Espoo Convention applies (Espoo procedure), as implemented in section 38 of the EIA Act, further described in section 4.3.2.1.

Due to the transboundary aspects of NSP2, a transboundary EIA report (Espoo report) has previously been prepared for the entire project /74/. This EIA report includes an additional transboundary impact assessment (see section 14) specific to the proposed NSP2 route in Danish waters. The DEA must inform the Minister for the Environment and Food on the purpose of conducting a consultation on transboundary environmental impacts in accordance with section 38 of the EIA Act (Espoo consultation), and the DEA is not allowed to make a final permit decision before the Minister for the Environment and Food has given his consent hereto. The Ministry of the Environment and Food and the DEPA is the Focal Point for Administrative Matters regarding the Espoo Convention.

When the DEA has made its decision on whether to grant a permit to NSP2, any states consulted must be informed.

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 of the directives.

Legal basis for procedure and public participation

4.2.1 EIA Directive

The EIA Directive /16/ requires that public and private projects that are likely to have significant effects on the environment are assessed on the basis of an EIA before permits are granted.

Pursuant to the EIA Directive, as implemented in the EIA Act /11/, see section 4.1.2 above, permits for the construction of pipelines for the transportation of gas, oil or chemicals and with a diameter exceeding 800 mm and a length of more than 40 km may only be granted on the basis of an EIA. As the dimensions of NSP2 exceed these specifications, an EIA in accordance with the above-mentioned regulation is required.

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

The Environmental Information Directive /17/ and the Public Participation Directive /18/ were adopted by the EU to ensure compliance with the requirements of 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.

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

Provisions for public participation in environmental decision-making are also found in the EIA Directive /16/.

In Denmark, the Environmental Information Directive and Public Participation Directive are implemented, *inter alia*, in the Environmental Information Act /14/.

The Environmental Information Act applies to all public authorities[4], including the DEA, which must generally make environmental information (as defined in s. 3 of the Act) available to the public upon request. This may include information submitted to the DEA by NSP2.

Under section 24(2) of the EIA Act /11/, the DEA must, after having reviewed the EIA report, submit it for consultation with the affected authorities and the public pursuant to the rules on consultation in sections 35 and 38 of the EIA Act.

Public participation in relation to NSP2 is described in section 4.4.

Legal basis for main environmental requirements

4.2.3 Habitats Directive

The Habitats Directive /19/ 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.

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[4] Authorities etc., which fall within the scope of s. 1 of the Public Administration Act (*forvaltningsloven*) (Consolidated Act no. 433 of 22 April 2014, as subsequently amended). The Environmental Information 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.

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 network also includes special protection areas classified pursuant to the Birds Directive /20/.

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

The Habitats Directive is implemented in Danish Law through a number of orders (or regulatory instruments), including, *inter alia,* the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters /7/ and the Administrative Order on Impact Assessment Offshore /12/.

The Danish Natura 2000 sites have been designated in accordance with the Administrative Order on Designation and Management of International Nature Conservation Areas and the Protection of Certain Species (*bekendtgørelse om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter*) /21/, which also sets out rules for the management of the sites.

Pursuant to the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters /7/, the Administrative Order on Impact Assessment Offshore /12/, for a project that is likely to significantly affect a Natura 2000 site, i.e. a designated international nature protection area (SACs, SPAs and Ramsar sites) within or outside Danish territory, the project shall, *inter alia*, present an impact assessment of its 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. A construction permit can be issued if the project does not adversely affect the integrity of a Natura 2000 site, or if weighty societal considerations, including of a social or economic nature, make it imperative to implement the project because no alternative solutions exist /7//19/.

The requirements for the impact assessment in accordance with Article 6 of the Habitats Directive are outlined in the Administrative Order on Impact Assessment Offshore /12/.

Annex IV of the Habitats Directive includes strictly protected species, for which the establishment and implementation of a strict protection regime is required within the whole territory of Member States. The requirements for the assessment of the impact on strictly protected species in accordance with Article 12 of the Habitats Directive are outlined in section 8 of the Administrative Order on Impact Assessment Offshore /12/.

4.2.4 Birds Directive

The Birds Directive /20/ aims to conserve all wild birds in the EU by setting out rules for their protection, management and control. EU Member States must take actions to maintain or restore populations of endangered species to a level that 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 have been included in the Natura 2000 network.

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

The Birds Directive is implemented in Danish law through, *inter alia,* the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters /7/ and the Administrative Order on Impact Assessment Offshore /12/.

4.2.5 Marine Strategy Framework Directive

The Marine Strategy Framework Directive /22/ (MSFD) aims to achieve "good environmental status" ("GES") of EU marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The MSFD takes the obligations of the EU and EU Member States under UNCLOS into account. When applying or interpreting the MSFD, UNCLOS must thus be considered.

Originally, the EU Commission has issued a set of detailed criteria and indicators in 2010 to help Member States implement the MSFD /23/. These criteria and indicators were repealed in 2017, when the EU Commission issued revised criteria and methodological standards on GES of marine waters, as well as specifications and standardised methods for monitoring and assessment /24/.

The MSFD is implemented in Danish law through the Marine Strategy Act (*lov om havstrategi*) /25/. The Marine Strategy Act provides the overall framework for the strategies that should be prepared under the Directive in order to ensure that GES is achieved or maintained in Danish waters. Under the Act, the Minister for Environment and Food has authority to develop and implement the individual parts of the marine strategies.

In accordance with the MSFD and the Marine Strategy Act, in 2012 the Danish authorities prepared an overall marine strategy for Danish waters for 2012-2018, including the Baltic Sea and the waters around Bornholm (the "Danish Marine Strategy"). The Danish Marine Strategy applies to all Danish waters, including the seabed and the subsoil, in the TW and EEZ. However, the Danish Marine Strategy does not apply to Danish waters one nautical mile from the baseline, to the extent such waters are covered by the Water Planning Act (*lov om vandplanlægning*) /31/ and measures under an adopted Natura 2000 pursuant to the Environmental Objectives Act (*miljømålsloven*) /30/. The first part of the draft second volume of the Danish Marine Strategy, which covers the years 2018-2024, was in public consultation from November 29, 2018 to February 21, 2019 /26/. After the consultation deadline, the Ministry of Environment and Food makes a decision on the first part of the Danish Marine Strategy vol. II, which thereby replaces the Danish Marine Strategy vol. I from 2012.

The Danish Marine Strategy involves an assessment of GES in Danish waters with a definition of GES at regional levels based on the 11 qualitative descriptors for determining GES in Annex 1 of the MSFD.

Further, the Danish Marine Strategy involves an integrated assessment and classification of the environmental status of Danish waters, based on the Baltic Marine Environment Protection Commission (also known as the Helsinki Commission or HELCOM) HOLAS assessment (see section 10). 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 /27/.

Following the Danish Marine Strategy, the Minister for the Environment and Food adopted a programme of measures for the Kattegat Sea in 2016, and six areas have been designated in the Kattegat /28/.

The Danish Marine Strategy vol. I was supplemented in 2017 with a programme of measures containing existing initiatives and 20 new initiatives to achieve the environmental targets for the Danish marine environment. Of relevance to NSP2, one of the new 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 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 involve stakeholders in its work before it comes with its recommendations. The working group is expected to report its results in 2019. According to the draft Danish Marine Strategy vol. II (proposed environmental target 6.9), the need for additional protected areas or other initiatives in the Baltic Sea and the North Sea is assessed.

The MSFD in relation to NSP2 is addressed in section 10.

4.2.6 Water Framework Directive

The Water Framework Directive (WFD) 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 /29/. The WFD sets out clear deadlines for each of the requirements under the Directive up to 2027, including achieving the environmental objectives of good ecological status and good chemical status of surface waters, including coastal waters, as defined by the baseline plus one nautical mile; the objective of good chemical status for territorial waters (12-nm area); as well as the objectives of good quantitative status and good chemical status for groundwater.

The WFD is implemented in Denmark by the Act on Environmental Objectives /30/ and the Act on Water Planning /31/.

The proposed NSP2 route will not cross the Danish TW, i.e. the routing is outside the 12-nm delimitation. An assessment in relation to the WFD is undertaken in section 10.

4.2.7 Maritime Spatial Planning Directive

The Maritime Spatial Planning Directive creates a common framework for maritime spatial planning in Europe /32/. While each EU country will be free to plan its own maritime activities, local, regional and national planning in shared seas is 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 /33/.

In January 2017, the DMA began preparing a maritime spatial plan for Denmark. The work is expected to continue until March 2021, when the maritime spatial plan for Denmark enters into force. According to the DMA, a draft maritime spatial plan will be subject to a strategic environmental assessment and be submitted for public consultation for six months. There is currently no draft maritime spatial plan published. On this basis, no detailed consideration can be given to a maritime spatial plan for Denmark in this EIA. Furthermore, there are no rules in Danish planning law that establish a requirement for the bundling of infrastructure.

4.3 International legal framework

4.3.1 Legal basis for constructing NSP2 under international law

The United Nations Convention on the Law of the Sea (UNCLOS) defines the rights and responsibilities of nations in their use of the world's oceans by 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 /34//35/.

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 into Danish law by several regulations, including, *inter alia*, the Act on the Protection of the Marine Environment (*lov om beskyttelse af havmiljøet*) /36/ and the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters /7/, and was fully incorporated into Danish law in 2005 /37/.

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. In short: UNCLOS gives a state the right to lay down pipelines on the continental shelf of a coastal state, but consideration must be given to, *inter alia*, due respect for the environment.

The sovereignty of Denmark extends to its TW in accordance with UNCLOS Article 2. The rights of Denmark over its continental shelf follow from UNCLOS Article 77, under which Denmark has sovereign rights for the purpose of exploring the continental shelf and exploiting its natural resources.

The Danish continental shelf is defined in accordance with UNCLOS Article 76 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 nm 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 /38/.

The EEZ for Denmark is defined in accordance with UNCLOS Article 57, and comprises areas beyond and adjacent to the TW extending seaward to a distance of 200 nm from the applicable coastal baselines /39//40/.

The outer limit of Denmark's TW is demarcated by the applicable lines drawn so that the distance from any point on these lines to the nearest point on the baseline is 12 nm measured in accordance with UNCLOS Article 3 and 4 /41/.

Under UNCLOS Article 79, all states are entitled to lay down pipelines on the continental shelf of a coastal state. The right to lay pipelines under UNCLOS Article 79 also applies in the EEZ, cf. UNCLOS Article 58. The coastal state may not impede the laying or maintenance of pipelines, but 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 under UNCLOS Article 79.

Hence, UNCLOS establishes the right to lay down pipelines on the Danish continental shelf in accordance with the provisions in UNCLOS.

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

4.3.2.1 Espoo Convention

The Espoo Convention /42/ sets out the obligations for public authorities of Parties to the Convention 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 /43/, and through implementation of the EIA and SEA Directives /45/.

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 I, section 8 comprises large-diameter pipelines for transportation of oil, gas and other chemicals. Hence, the Danish authorities must 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 transboundary context.

In Denmark, the DEPA, on behalf of the Ministry of the Environment and Food, administers 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[5]. See further in section 4.1.2.

The potential transboundary significant adverse impacts of the proposed NSP2 route on the environment are assessed in section 14 in accordance with the Espoo Convention.

4.3.2.2 Aarhus Convention

The Aarhus Convention /44/ 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 the national, regional or local level) will contribute to ensuring these rights 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 /17/ and the Public Participation Directive /18/. Provisions for public participation in environmental decision-making are furthermore found in a number of other environmental directives, such as the SEA Directive /45/ and the EIA Directive /16/.

The Aarhus Convention was implemented into Danish law in 2000 as Amendments to Certain Environmental Acts /46/, including amendments to the Continental Shelf Act and Certain Pipeline Installations in the Territorial Waters /7/, 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 EIA Act /11/.

Public participation in connection with NSP2 is addressed in section 4.4.

4.3.3 Legal basis for main environmental requirements under international law

4.3.3.1 UNCLOS

UNCLOS /34//35/ underlines that states have an obligation to adopt necessary measures for the effective protection of the marine environment from harmful effects that may arise from activities in the seabed, ocean floor and subsoil thereof, beyond the limits of national jurisdiction. This includes, *inter alia*, measures to prevent interference with the ecological balance of the marine environment, and particular attention must be paid to the need for protection from the harmful effects

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

of activities such as drilling, dredging, excavation, disposal of waste, and the construction, operation and maintenance of installations, pipelines and other devices related to such activities.

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

The requirements under UNCLOS are incorporated into Danish law, see section 4.1.

4.3.3.2 London Convention and Protocol

The London Convention /47/ 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" (see Annex I). The dumping of wastes on the "reverse list" requires a permit. The DEPA under the Ministry for the Environment and Food is the granting authority of such a permit.

The requirements under the London Convention and Protocol are implemented in the Act on Protection of Marine Environment, and further fully incorporated into Danish law /48/.

The Act on Protection of Marine Environment /36/ applies, *inter alia*, to pipelines for the transportation of hydrocarbons produced outside Danish territory within Danish TW 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 of 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) /49/, entered into force on 2 October 1983[6].

MARPOL 73/78 and its six technical Annexes address pollution from ships by oil, noxious liquid substances carried in bulk, harmful substances carried by sea in packaged form, sewage, garbage and the prevention of air pollution from ships. Under the Convention, a "ship" means a vessel of any type whatsoever operating in the marine environment, including hydrofoil boats, air-cushion vehicles, submersibles, floating craft and fixed or floating platforms.

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 "SO_x Emission Control Area" under MARPOL 73/78, and therefore contains specific requirements for the prevention of air pollution from ships within the Baltic Sea (MARPOL 73/78 Annex VI).

MARPOL 73/78 is incorporated into Danish law through the Act on Protection of the Marine Environment (Marine Protection Act) /48/ and several administrative orders issued pursuant to the Act /50//51//52/.

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 into Danish law apply to all project vessels, including the stricter requirements for MARPOL

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

73/78 Special Areas and SO_x Emission Control Areas, as the ship operations will be carried out in the Baltic Sea.

Prevention of pollution by oil is regulated in Annex I of MARPOL 73/78 as incorporated into section 11 of the Act on Protection of the Marine Environment /48/, whereby any discharge of oil into the Danish sea territory is prohibited. Further, any discharge of oil in the Danish EEZ or outside Danish sea territory may only take place in compliance with the requirements under the Order on Disposal of Oil from Ships /52/.

Prevention of pollution by sewage from ships is regulated in Annex IV of MARPOL 73/78, section 20 of the Act on Protection of the Marine Environment /48/ and the Order on Disposal of Sewage from Ships and Platforms outside Danish Territorial Waters and in the Baltic Sea Area /50/.

Regulations for the prevention of pollution by garbage from ships are contained in Annex V of MARPOL 73/78. "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 that are defined or listed in other Annexes to MARPOL 73/78. The Act on Protection of the Marine Environment 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 nm from the nearest land /48/.

Annex VI of MARPOL 73/78 regulates the 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 (SO_x Emission Control Area) including, *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 /53/ and the Order on Categorisation, Classification, Transport and Disposal of Noxious Liquid Substances Carried in Bulk issued pursuant to the Act on Protection of the Marine Environment /54/.

Pollution from ships in relation to NSP2 is addressed in sections 13 and 15.

4.3.3.4 Ballast Water Management Convention

The Ballast Water Management Convention /55/ 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, as well as 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 in addition to accidental or other exceptional discharges of ballast water.

The Convention was adopted by the International Maritime Organization (IMO) in 2004, and Denmark ratified it in 2012. The Convention entered 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 with NSP2 activities.

4.3.3.5 Convention on Wetlands of International Importance (Ramsar Convention)

The Ramsar Convention /56/ 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 was fully incorporated into Danish law in 1978 /57/.

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

- 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 are addressed in section 9.11.

4.3.3.6 Convention on Biological Diversity

The Convention on Biological Diversity (CBD) /58/ entered into force in 1993. The 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, as well as 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 /59/, and the CBD commitments are reflected in the EU's 2020 Biodiversity Strategy and regulations implemented pursuant to the strategy /60/.

At the EU level, biodiversity is protected by several laws, including the Birds Directive and the Habitats Directive. Further, the regulation on Invasive Alien Species /61/ and Access to Genetic Resources /62/ bring EU law in line with international obligations under the 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 WFD and MSFD, which require the achievement of GES for water ecosystems by 2025 and marine ecosystems by 2020, respectively. Biodiversity indicators have been developed to monitor, assess and report on progress towards the EU Biodiversity Strategy's target. Data and information on EU biodiversity indicators and related EU targets are available at the Biodiversity Information System for Europe /63/.

The CBD applies to NSP2 under Danish law through the Administrative Order on Biological Diversity, as subsequently amended /64/.

4.3.3.7 Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) /65/ 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 the EU level by both the Habitats Directive /19/ and the Birds Directive /20/ and by the Order on Conservation of European Wildlife and Natural Habitats /66/.

The relevance of said rules for the Danish section of NSP2 is addressed in sections 9.10, 9.11, 9.12 and 9.13.

4.3.3.8 Helsinki Convention

The Baltic Sea is protected by the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention) /67/. The first Helsinki Convention was signed in 1974 and entered into force in 1980. The Convention was since revised in 1992, and the 1992 Helsinki Convention entered into force on 17 January 2000.

The EU, Denmark and other Baltic Sea region countries[7] have ratified the Helsinki Convention, which covers the whole of the Baltic Sea area, including inland waters as well as the water of the sea itself and the seabed. The Convention was incorporated into Danish law in 2011 /68/. 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, with HELCOM as its governing body. HELCOM makes recommendations on measures to address certain pollution sources or areas of concern, which are to be implemented by the contracting parties through national legislation. HELCOM also follows up on the implementation of the Helsinki Convention and HELCOM's recommendations. HELCOM also provides the cooperation structure that aims to protect the marine environment of the Baltic Sea. The MSFD requires that EU Member States use existing 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 Sea, cf. Ministerial Declaration from the HELCOM Moscow Ministerial Meeting held on 20 May 2010.

The Baltic Sea Action Plan (BSAP) /69/ forms the 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 GES status by use of indicators and associated quantitative boundaries for specific elements of the marine ecosystem. The BSAP is regularly updated in ministerial meetings and most recently by the Ministerial Declaration from the HELCOM Brussels Ministerial Meeting on 6 March 2018. HELCOM and its members have decided to update and reconduct the BSAP after 2021. The BSAP will be updated in three phases from mid-2018 to 2021.

According to HELCOM Recommendation 15/5 as superseded by 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 for harmful human activities through different actions. The Danish HELCOM MPAs are identical to the Danish Natura 2000 sites. The Natura 2000 network protects natural habitats and species deemed important at the EU level (see section 4.2.3), whereas the HELCOM MPA network aims to protect marine and coastal habitats and species specific to the Baltic Sea.

The obligations under the Helsinki Convention, including the HELCOM recommendations and the goals and objectives of the HELCOM BSAP, must be taken into account in the EIA for NSP2. 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 Convention on Migratory Species

The Convention on the Conservation of Migratory Species of Wild Animals (CMS) /70/, also referred to as the Bonn Convention, is an intergovernmental treaty concluded under the United Nations Environment Programme. The CMS aims to conserve terrestrial, aquatic and avian migratory species throughout their ranges.

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

Migratory species that need or would significantly benefit from international cooperation are listed in Appendix II of the CMS. For this reason, the 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, a number of agreements and memoranda of understanding have been signed. Agreements under the auspices of the CMS aim to conserve a number of marine, terrestrial and avian species.

The CMS entered into force in Denmark in 1983 and was fully incorporated into Danish law in 1986 /71/. The requirements under the CMS further apply to NSP2 through the implementation of the Convention at the 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 in 1991. ASCOBANS was incorporated into Danish law in 1994 /72/.

The relevance of said rules in relation to the Danish section of NSP2 is addressed in section 7.10 and an assessment is presented in section 9.9.

4.4 NSP2 public participation

In accordance with the EIA Act /12/, the EIA Directive /16/ and the Aarhus Convention /44/, the authorities must enable public participation in environmental decision-making.

To this end, the DEA must publish information concerning the application, the EIA report and the draft permit on the Agency’s website and allow at least eight weeks for public consultation. Public participation may also involve stakeholder meetings and public presentations of technical material.

During the public consultation, the affected public as well as 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, including 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.

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.

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.

Stakeholder feedback will be systematically collected, reviewed and included in a database to enable tracking and monitoring of follow-up actions that may be required, in order to ensure that issues are properly addressed.

During the 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, stakeholder engagement process and results, compliance with ESMS and overall performance.

5 ALTERNATIVES

The study of route options in Danish waters is naturally built on previous planning and experience as well as in dialogue with the Danish authorities and data obtained by Nord Stream 2 AG from Nord Stream AG, supplemented with new route surveys and seabed investigations, e.g. technical surveys and environmental surveys, see sections 6 and 7, respectively. Furthermore, the experience from installation of the existing Nord Stream pipelines (NSP) has served as 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

In general, three criteria have been considered when selecting viable route alternatives for the NSP2 pipelines.

The first criterion involves environmental aspects and focuses 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 is also considered.

The second criterion includes socio-economic factors to minimise any interference with shipping, fishing, dredging, the military, tourism and existing cables and wind turbines. Likewise, no impacts on 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. This includes considerations concerning 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 associated disruptions, as well as reducing the technical complexity of the operation to keep the use of resources low have been considered.

A pipeline routing that considers engineering design as well as the biological, physical-chemical and socio-economic environment is one of the most important criteria in avoiding or minimising impacts. See section 15 for further information on mitigation measures.

Nord Stream 2 AG has implemented several measures (where reasonably feasible) with respect to route optimisation. Environmental and social considerations that are embedded in the process of identifying an optimal pipeline route include:

- The presence of protected and environmentally sensitive areas, including fishing banks and nursery and spawning areas;

- Maritime safety and shipping lanes;
- The presence of conventional and chemical munitions;
- Commercial fishery patterns and intensity;
- Existing and future infrastructure;
- Parallel routing to the NSP pipelines so that the combined footprint of the two pipeline systems is minimised;
- The presence of raw material extraction areas.
- The presence of military practice areas;
- Minimisation of overall pipeline length.

Routing considerations also include avoiding sea bottom conditions that could give rise to freespans or larger requirements for seabed intervention works (including trenching and rock placement), which could potentially have environmental impacts.

Of specific concern in the waters around Bornholm is the avoidance of chemical munitions and their degradation products as well as the proximity to conventional munitions. 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. Experience from NSP has thus shown that whilst the presence of both conventional and chemical munitions on the seabed continues to pose a hazard in the Baltic Sea region, the potential risk can be safely managed. 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 is conducting equivalent surveys and activities to manage associated risks. As with NSP, munitions screening surveys have been performed to establish the location of conventional and chemical munitions that could constitute a danger for the pipeline or the environment during pipeline installation works.

Maritime cultural heritage is protected by legislation, and national authorities have developed procedures to avoid impacts on cultural heritage from construction projects. Specific surveys allow Nord Stream 2 AG to precisely locate cultural heritage sites and to locally reroute, in close consultation with national authorities, to avoid potential impact.

Based on the experience gained from NSP 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 possible route corridors as a basis for further planning.

Based on the above considerations, experience and existing data, the route originally applied for (the base case route) is shown in Figure 5-1. A construction permit application for the base case route, including environmental impact assessments /73/ as well as Espoo documentation /74/, was sent to the relevant authorities for all involved countries in 2017. Since January 2018, the decision on the base case route has been pending a recommendation from the Minister for Foreign Affairs on whether a construction permit for a route in Danish TW is compatible with national foreign, security and defence policy interests, cf. section 3a(2) of the Act on the Continental Shelf and Certain Pipeline Installations in the Territorial Waters. It is not clear when a recommendation by the Minister for Foreign Affairs will be given. Consequently, Nord Stream 2 AG decided to develop a route in the Danish EEZ outside of Danish TW. In November 2017, the DEA confirmed that the Danish EEZ south of Bornholm between Denmark and Poland was not available for the laying of pipelines due to the unclarified EEZ border between the two states /80/.

A route to the north and west of Bornholm (NW route) was evaluated and was applied for by a separate permit application in August 2018. The NW route was assessed as feasible and viable based on environmental and socio-economic challenges and potential impacts. The authorities' permitting procedure of the NW route is nearing its finalisation. Permits for NSP2 have been granted in Germany, Sweden, Finland and Russia and more than 800 km of the pipelines (Lines A and B) have been installed as of early April 2019.

On 1 November 2018, the Danish Ministry of Foreign Affairs and the Polish Ministry of Foreign Affairs announced that Denmark and Poland had agreed on a maritime boundary that, once it enters into force, will delimit the continental shelves and the EEZs of the two countries in the Baltic Sea, south of Bornholm /81//82/. Denmark and Poland signed a treaty on the EEZ border delimitation between Demark and Poland south of Bornholm on 19 November 2018, which enters into force 30 days after the parties have notified each other in writing that the necessary procedures for bringing the treaty into force have been finalised /83/.

On 26 March 2019, the DEA made the decision to request Nord Stream 2 AG to submit an environmental impact assessment with a permit application for a route in the Danish continental shelf/EEZ area south of Bornholm. The DEA has based its decision on that a route south of Bornholm is a better route for NSP2 in Danish waters than the NW route /84/.

The NSP2 route proposed in this EIA, the south-eastern route alternative (SE route), is included in Figure 5-1 as an alternative to the base case route and the NW route in Danish waters. The eastern part of the SE route in Danish waters splits into two potential route variants, the SE route V1 and the SE route V2, respectively. Both SE route variants are described and assessed in this EIA on the same level.

On the basis of environmental and technical considerations, and given the fact that permits for NSP2 have been issued in all of the other jurisdictions, including in Sweden and Germany, both the southern fix point of the SE route and the northern fix points of the SE route V1 and the SE route V2 correspond to the fix points for the base case route and the NW route. In Sweden, one of the NSP2 pipelines has been installed 6 km from the Danish/Swedish EEZ border, and in Germany, both NSP2 pipelines have been installed 16.5 km from the Danish/German EEZ border. Nord Stream 2 AG is planning to start pipe-lay in the Danish EEZ in Q1 of 2020.

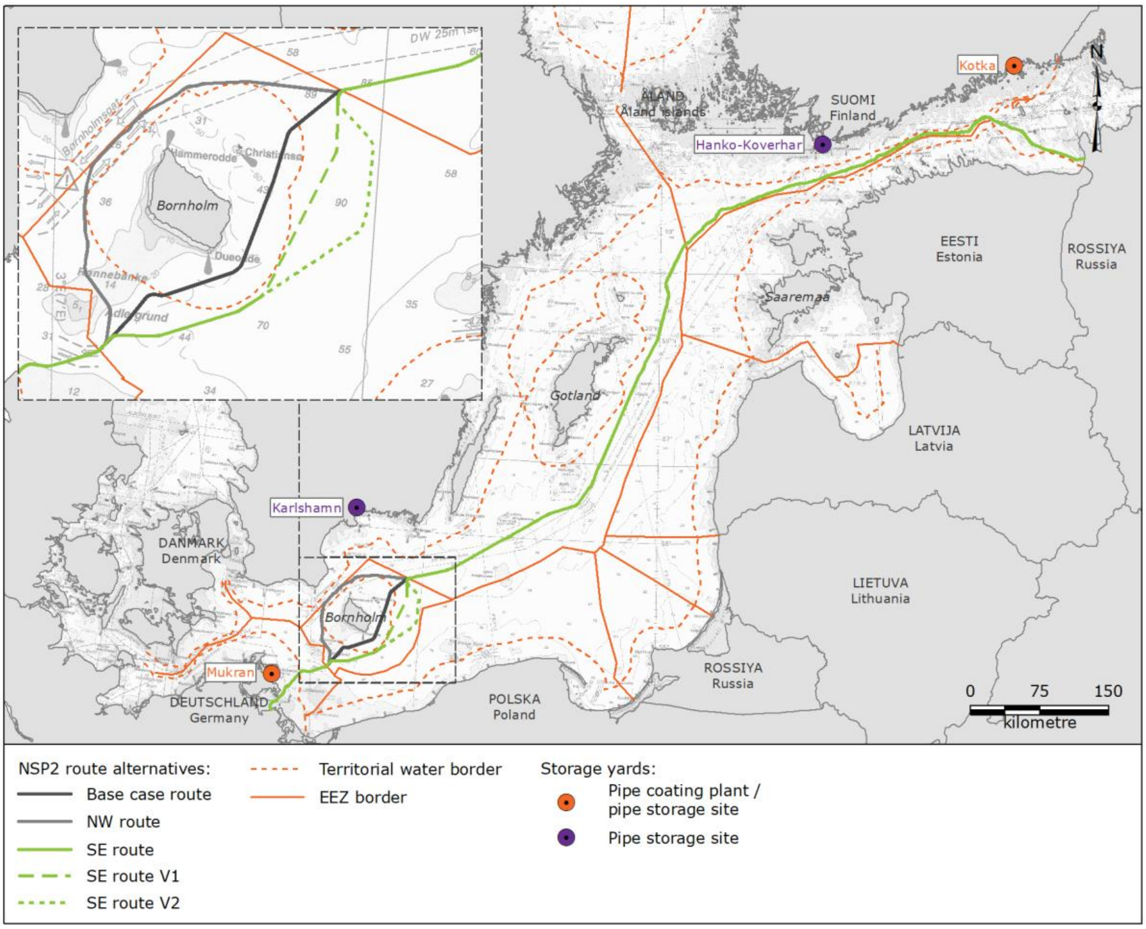


Figure 5-1 Route corridor options developed for the NSP2 project.

5.2 The NSP route

Nord Stream 2 AG considers the experience from the route selection process for NSP important for the selection of an optimal route for the NSP2 project. This is due to the high similarity of the two projects both being gas transportation pipelines running through the Baltic Sea and since the routing of the NSP2 pipelines will be faced with many of the same challenges when going through Danish waters. Therefore, a short presentation of the route selection process for NSP is given in this section.

In the period 2005 to 2009, Nord Stream AG identified, studied and conducted field investigations in several different route corridors in Danish waters around Bornholm before selecting the preferred S-route for the project. This included routes to the north of Bornholm in the Danish TW and EEZ as well as routes to the south and east of Bornholm in the TW and EEZ, as illustrated in Figure 5-2.

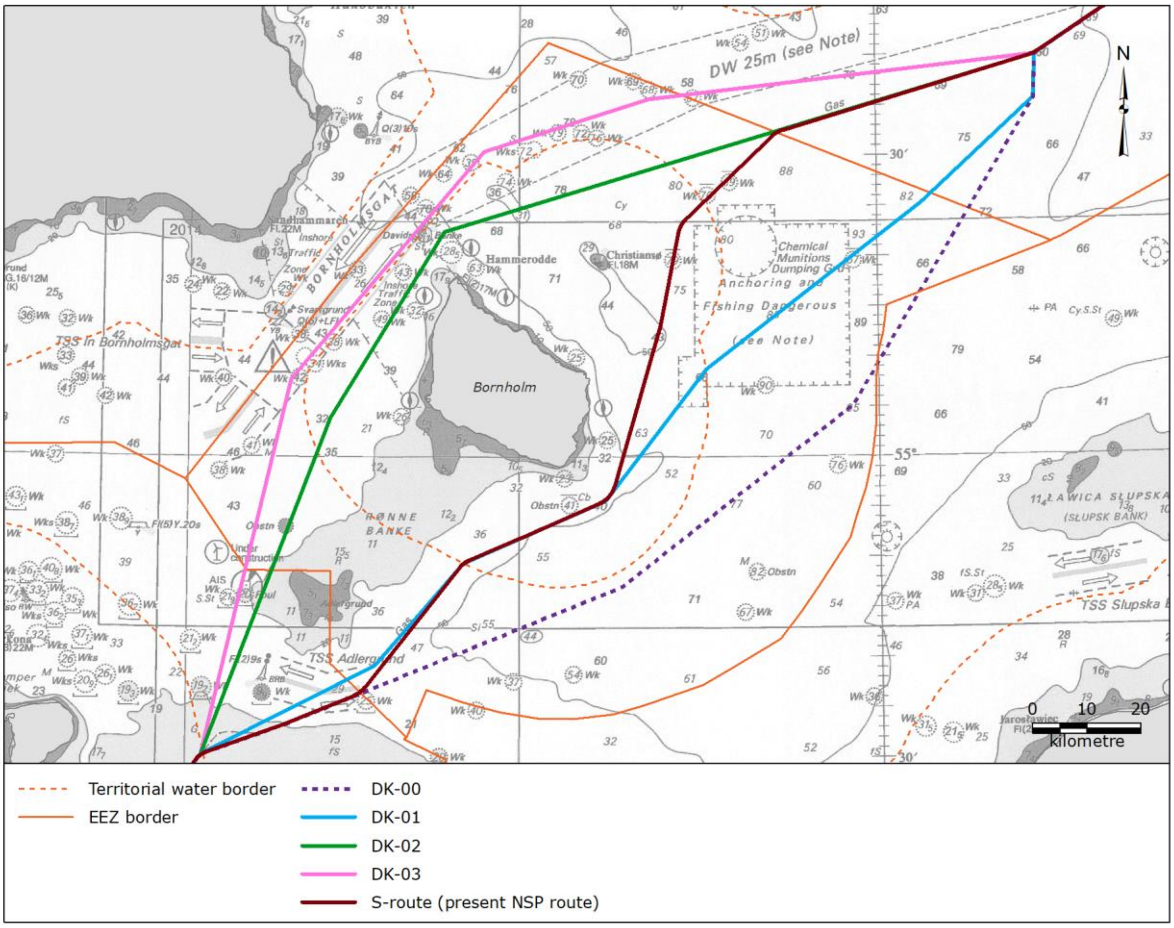


Figure 5-2 Different pipeline routes investigated from 2005 to 2009 for the Nord Stream project.

The route selection was challenged by several factors, such as the EEZ border between Poland and Denmark not yet being settled and intensive maritime traffic with several traffic separation schemes. Furthermore, the route needed to consider a European important commercial fishery area (bottom trawling) in particular east of Bornholm, as well as the location of a World War II (WWII) chemical munitions dumping ground, which limited the possibilities for seabed intervention works in an area close to the Swedish EEZ border.

When Nord Stream AG first approached the Danish authorities concerning NSP in 2006, route DK-00 outside of Danish TW and to the east and south of Bornholm was the preferred route /75/. This route is very similar to the SE route presented in this EIA. The DK-00 route had been surveyed in mid-2005 and served as the basis for the conceptual engineering at that stage of the project. The route was presented in the notification documentation sent out for consultation on transboundary environmental impacts according to the Espoo Convention in November 2006 /76//77/. However, comments received during the consultation on transboundary environmental impacts in the beginning of 2007 pointed out that the route was located in an area where maritime borders had not been agreed between Denmark and Poland, and therefore jurisdiction in the area was claimed by both countries /78/. As stated in the information provided by the then Minister for Climate and Energy to the European Affairs Committee of the Danish Parliament in November 2009, the Danish authorities hereafter informed Nord Stream AG that the area of the proposed pipeline route was not available for the project /79/. At the request of the Danish authorities, Nord Stream AG therefore abandoned this route option and started investigating other alternatives.

In November 2009, one month after the granting of the permit for NSP, the European Affairs Committee of the Danish Parliament raised questions to the then Minister for Climate and Energy concerning the construction permit for NSP. The Minister was asked to account for – among other things – the possibilities of influencing the routing of NSP. The question was answered in a memo dated 2 December 2009, which was prepared by the DEA /79/. In the memo prepared by the DEA, the following is stated in relation to the requirements for the NSP route:

"In the case of Nord Stream, the company has worked with four route options in the area around Bornholm: Two north and west of Bornholm and two south and east of Bornholm.

At the time, in 2006, when the company approached the Danish authorities, the company's preferred route was south and east of Bornholm, and it was this route which was presented in the project description, and sent out in public hearing in November 2006 in all countries around the Baltic Sea. Poland objected to this route since it crosses a sea territory to which the border line between Poland and Denmark had not yet been settled by mutual agreement, and which both countries claim as theirs. This border dispute has previously been attempted settled, and the Nord Stream project gave cause for a meeting between the authorities of the two countries where this could once again be discussed. A solution was not found and subsequently Nord Stream AG was informed that this area was not an option for the pipeline.

Nord Stream then investigated a route north and west of Bornholm. The investigations resulted in both the Swedish and the Danish maritime authorities expressing their concern about a route so close to the heavily trafficked shipping lane between Bornholm and Sweden. This route would furthermore involve substantial seabed intervention works and would be close to Natura 2000 areas (specially designated nature protection areas). The Danish authorities therefore believed that an investigation should be made to whether an optimization, both in terms of environment and safety, could be made by choosing a route east and south of Bornholm, but this time closer to Bornholm and outside the disputed area between Denmark and Poland.

The Energy Agency hereafter instructed Nord Stream to investigate a route corresponding to the now permitted S-route east and south of Bornholm. This route is partly inside, partly outside Danish territorial waters. The instruction was given based on the so-called ALARP principle. ALARP means As Low As Reasonably Practicable, and is used in connection with offshore projects to lower risks. The Energy Agency was, after consultation with the other involved authorities, of the opinion that this route would be the best one, both from an environmental and a safety perspective.

The biggest challenges in Danish waters were dumped chemical munitions and fishery. In the sea around Bornholm, and in particular after WWII, large amounts of conventional and chemical munitions were dumped. The Navy Operational Command Denmark (SOK) on Bornholm is in charge of managing fished munitions and are experts in this field. SOK was, based on their knowledge of the conditions, not concerned about installing the pipeline in this area, which is outside the actual dumping area but within the risk zone where fishermen are instructed to carry special equipment on board.

In this area there is furthermore significant bottom trawling. It was important for the Danish authorities that the fishermen of Bornholm could continue this fishery.

Nord Stream was requested to investigate this pipeline route. Three objects were found, which turned out to be chemical munitions. No conventional munitions were found. More than 100 sediment and water samples were taken and analysed by accredited and independent institutes. The conclusion was that a light contamination from chemical munitions was found in the samples, but that the pipeline installation would not change this condition.

The pipeline route crosses important trawling areas. The Danish authorities required Nord Stream to install the pipelines in such a way that fishery was not obstructed. This has led Nord Stream, in collaboration with fishery organisations, to develop a new type of trawl board that enables fishery to take place unhindered across the pipelines. The new trawl gives at least as good catch as the previous trawl, it is gentler towards the environment and at the same time saves fishing vessel fuel. Nord Stream has made an agreement with the fishery organisations that Nord Stream pays for the new trawl equipment.

Based on an overall assessment, it is the opinion of the involved Danish authorities that the permitted route is the optimal one in Danish waters of the Baltic Sea at Bornholm, and that this route has been found after investigating other possible routes in the area."

Based on the memo from the DEA as reported above, Nord Stream 2 AG understood that the route selection process for NSP was performed in close collaboration with the Danish authorities and that the advice and evaluations of the authorities in relation to the route selection were followed by Nord Stream AG. Furthermore, it is noted that NSP has been built and operated without limitation to fishery and has proven to have no significant environmental impacts.

Building on this experience and advice from the authorities, the NSP2 base case route (see Figure 5-1) was aligned with the route corridor for NSP in Danish waters.

5.3 Evaluation and comparison of the route alternatives for NSP2

Many of the challenges faced during the route selection process for NSP apply to the route selection for NSP2 as well and are thus considered to be relevant for the NSP2 project. The EEZ border between Poland and Denmark south of Bornholm was not settled at the time of the route planning for NSP, the NSP2 base case route nor the NSP2 NW route. Other challenges included the general ship traffic pattern, which has not been subject to significant changes since 2009. Furthermore, there have been no changes to the area of restrictions on anchoring and fishing due to the potential presence of chemical munitions or CWA, and, in general, the bottom fishery pattern has not been subject to significant changes during this period.

Apart from the now resolved delimitation of the EEZ border between Poland and Denmark, the challenges above remain valid and are highly relevant to the route selection process for NSP2. Figure 5-3 shows the considered route alternatives for NSP2; namely, the base case route, NW route and SE route (which will join with either the SE route V1 or the SE route V2). As described above, the SE route and its respective route variants connect to the original fix points of the NSP2 base case route and the NW route at the Swedish/Danish EEZ border and the German/Danish EEZ border.

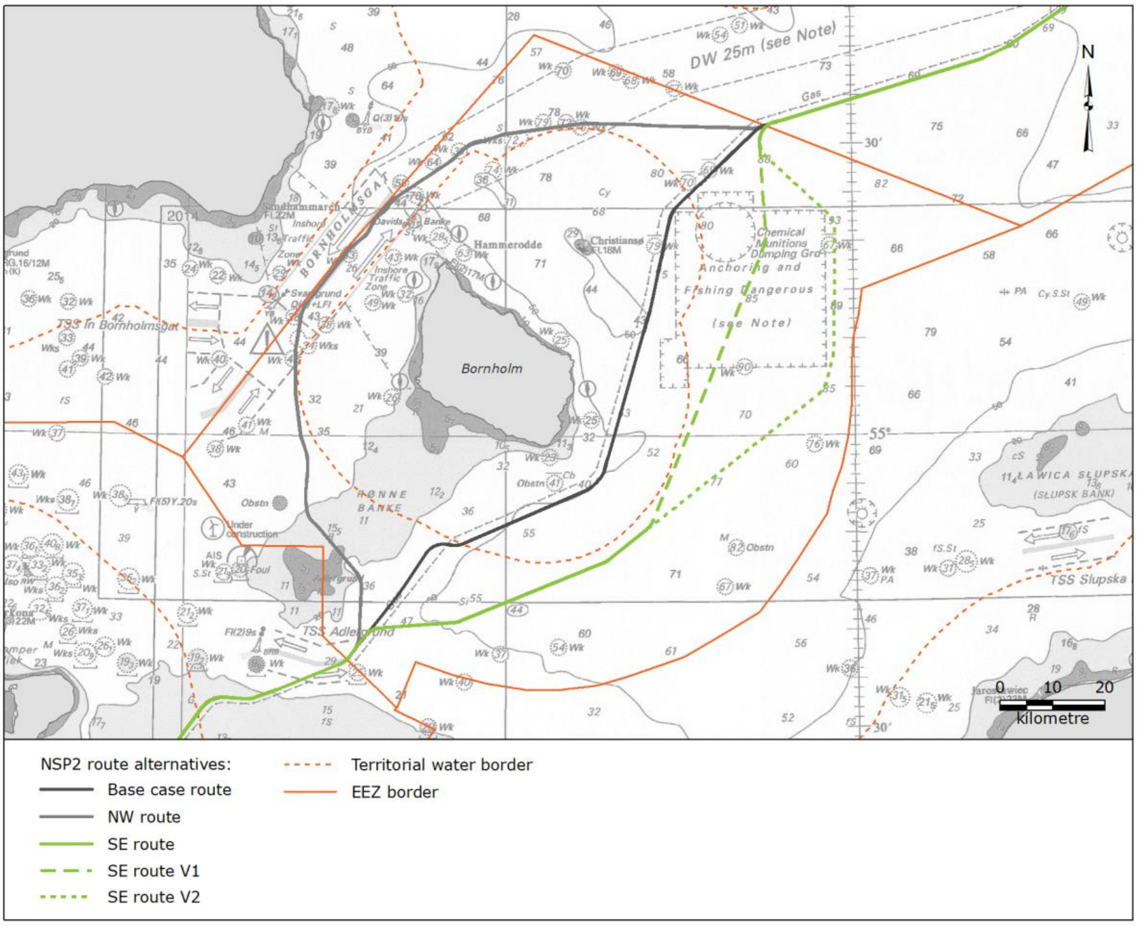


Figure 5-3 The NSP2 base case route, NW route SE route, SE route V1 and SE route V2.

The following environmental and socio-economic criteria shown in Table 5-1 below have been assessed for the combination of the SE route with V1 and the combination of the SE route with V2. The results of the assessment of the combination of the SE route with V1 and the combination of the SE route with V2 are then compared to the environmental and socio-economic impacts evaluated for the reasonable alternatives that have been identified and studied by Nord Stream 2 AG; the base case route and the NW route. In the evaluations, all criteria are considered important for the choice of the pipeline route in Danish waters and therefore no weighting of parameters has been applied.

Table 5-1 Environmental and socio-economic aspects considered in the comparative alternatives assessment.

Aspect	Environmental and socio-economic criteria
Biological environment	• Avoidance and minimization of impact (direct or indirect from pipe-lay and/or seabed intervention works) on protected and environmentally sensitive areas, including fishing banks and nursery and spawning areas
Maritime safety	• Minimise interaction with shipping lanes
Munitions risk	• Avoidance of munitions • Avoidance of chemical warfare agents (CWA)
Fishery	• Minimise hindrance to fishery (bottom trawling)
Maritime spatial planning	• Grouping of infrastructure in a common corridor (marine spatial planning): parallel routing to the Nord Stream pipeline system so that the combined footprint of the two pipeline systems is minimised • Avoidance of crossing of / proximity to existing and future infrastructure
Raw material extraction sites	• Avoidance of extraction areas
Military practice areas	• Avoidance of military practice areas
Pipeline length	• Minimise pipeline length

Based on the relative comparison, the combination of the SE route with V1 and the combination of the SE route with V2 have each been rated within each aspect listed above as either better, slightly better, comparable, slightly worse or worse compared to the NSP2 reference routes; i.e. base case route and NW route. The combination of the SE route with V1 is generally considered to result in comparable environmental impacts as the combination of the SE route with V2, though with slightly elevated CWA risk. Key distinctions between the two route alignments are described in the sections below where relevant to the evaluations.

5.3.1 Biological environment and extent of intervention works

Impacts on the marine biological environment are expected to result from construction 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, the presence of the pipelines and supporting structures on the seabed may potentially impact the biological environment by constituting a change in seabed environment.

It is assumed that impacts from the vessel operations and pipe-lay activity will be similar along the base case route, the combination of the SE route with V1 and the combination of the SE route with V2, as they are in a similar biological environment. Differences in potential impacts on the biological environment along the routes may arise from the extent of intervention works required for installation of the pipelines and the levels of contaminants, including metals, organic compounds and CWA in the seabed sediment along the different routes. Figure 5-4 below shows the protected areas in Danish waters, including Natura 2000 sites, HELCOM Marine Protected Areas (MPAs) and Ramsar sites.

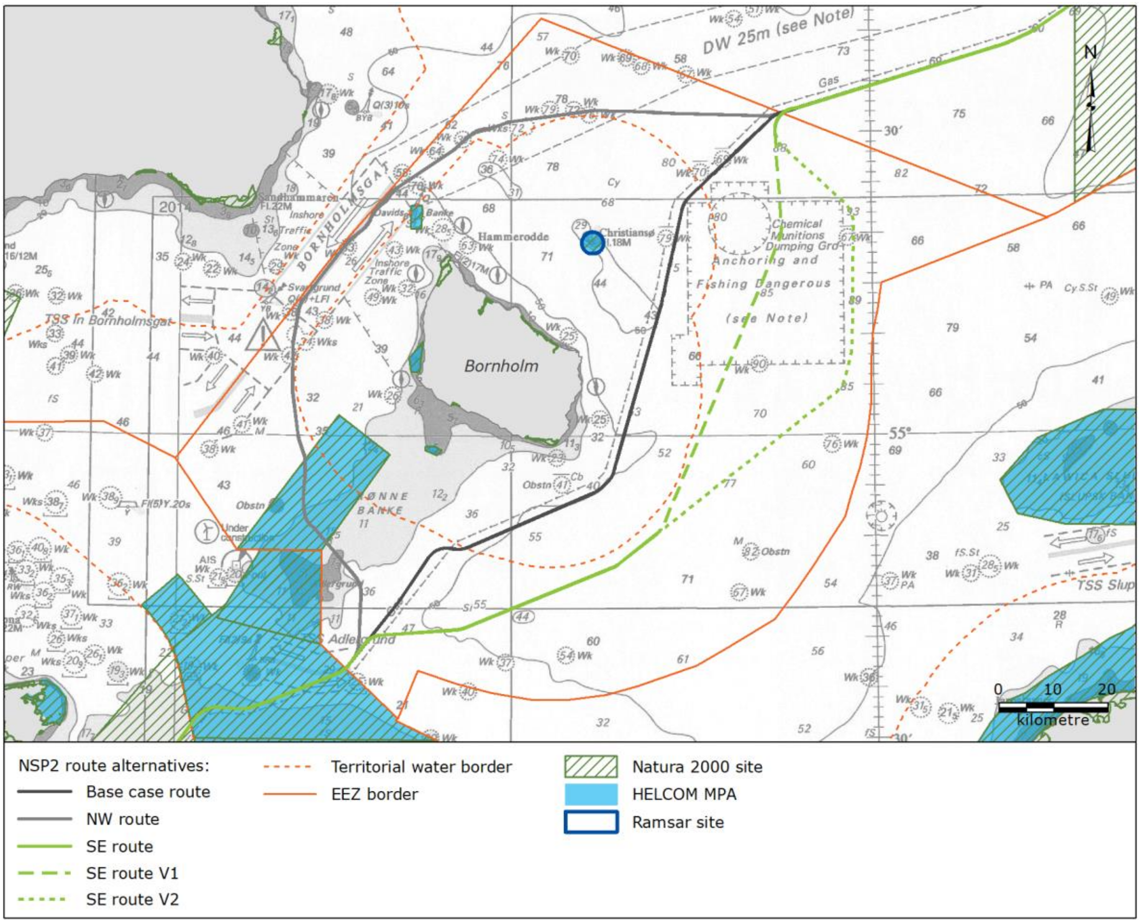


Figure 5-4 Protected areas and route alternatives.

The combination of the SE route with V1 and the combination of the SE route with V2 are expected to require slightly less intervention works compared to the base case route since longer sections of these routes are situated in deep water with muddy sediment where post-lay trenching or rock placement is not expected to be necessary, see Figure 5-5. Furthermore, longer sections of the combination of the SE route with V1 and the combination of the SE route with V2 are situated at water depths of 60-90 m, in the anoxic zone with no or little benthic marine life. The potential for environmental impact is therefore considered slightly lower for the combination of the SE route with V1 and the combination of the SE route variant with V2 compared to the base case route.

The NW route is expected to require slightly more intervention works compared to the combination of the SE route with V1 and the combination of the SE route with V2 due to the need for more preparatory work for further cable crossings, freespan corrections at the TSS Bornholmsgat and potential post-lay trenching and/or rock placement in shallower waters across the Rønne Banke area, see Figure 5-5. The potential for environmental impact is therefore considered higher for the NW route compared to the combination of the SE route with V1 and the combination of the SE route with V2.

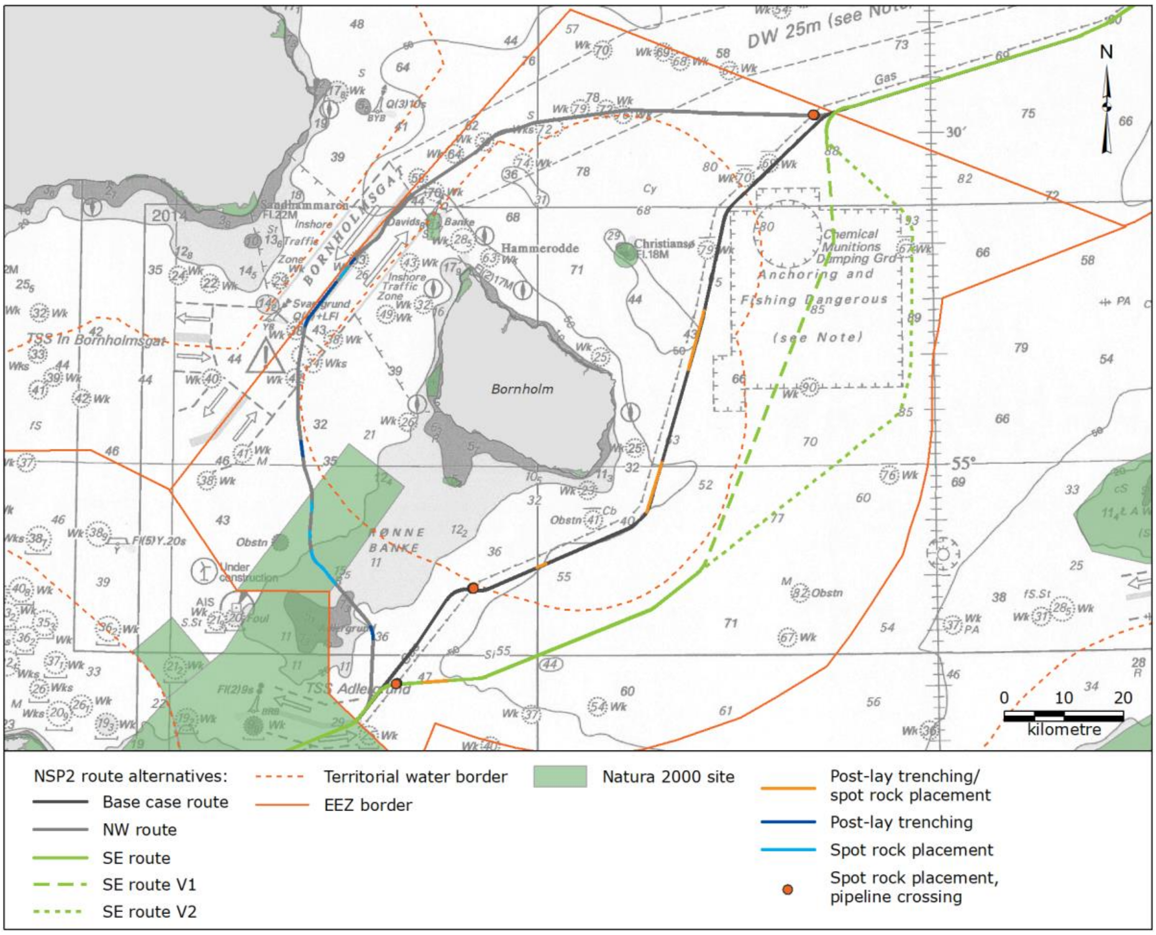


Figure 5-5 Intervention works, Natura 2000 sites and route alternatives.

Three Natura 2000 sites, three HELCOM MPAs, two Important Bird and Biodiversity Areas (IBAs) and one Ramsar site are located near the proposed route alternatives in Danish waters. The base case route, the combination of the SE route with V1 and the combination of the SE route with V2 do not cross any protected areas in Danish waters. The NW route crosses a Natura 2000 site, discussed further below.

The shortest distance to the nearest Natura 2000 site from both potential alignments of the SE route (Adler Grund and Rønne Banke) is approx. 18 km, while there is approx. 13 km to nearest Natura 2000 site (Ertholmene) for the base case route. Adler Grund and Rønne Banke is designated as a Natura 2000 site on the basis of the habitat types "reef" and "sandbank". Ertholmene is designated as a Natura 2000 site on the basis of the habitat type "reef" and the species grey seal, guillemot and razorbill. It has been assessed that there is no risk of significant impacts on the designated habitats and on the integrity of the Natura 2000 sites from either the base case route, the combination of the SE route with V1 or the combination of the SE route with V2. The NW route crosses the Natura 2000 site Adler Grund and Rønne Banke for approximately 15 km. It is assessed in the Appropriate Assessment included in the EIA for the NW route that there will be no risk of adverse impact on the designated habitat types in this Natura 2000 site.

In conclusion, in relation to impacts on the biological environment, the combination of the SE route with V1 and the combination of the SE route with V2 are each considered slightly better when compared with the base case route, and better when compared with the NW route, given the limited amount of intervention works needed and distance from protected nature areas.

Potential impacts during the operational phase arising from the presence of the pipelines and support structures are comparable for all routes and are assessed not to be significant.

The comparison of routes in relation to the biological environment is summarised in Table 5-2.

Table 5-2 Comparison summary for the routes in relation to the biological environment.

Route	Comparison summary	Route preference
Base case	Post-lay trenching and/or rock placement is expected to a limited extent at the NSP crossing and at three other potential sections along the route. This may result in increased levels of suspended sediments and underwater noise. However, the potential impacts on the biological environment associated with the intervention works are expected to be negligible. The impact level is therefore considered low.	Reference
NW	The NW route will require preparatory work for several cable crossings, freespan corrections at the TSS and potential post-lay trenching and/or rock placement in shallower waters across the Rønne Banke area. The NW route additionally crosses the Natura 2000 site Adler Grund and Rønne Banke for approximately 15 km, within which intervention works may be required. It is assessed that there will be no risk of adverse impact on the integrity of the designated habitat types in this Natura 2000 site.	Reference
SE*	Post-lay trenching and/or rock placement is expected to a limited extent at the NSP crossing and at one other potential section along the route. However, the potential impacts on the biological environment associated with the intervention works are expected to be negligible. A large section of the route will be placed at water depths of 60-90 m, in the anoxic zone with no or little marine life. Since the combination of the SE route with either V1 or V2 requires less seabed intervention works and is positioned farther away from protected areas, both SE route alternatives are assessed to be slightly better than the base case route.	Slightly better than base case
	The SE route requires a minor extent of intervention works, and does not cross any protected areas. Therefore, the combination of the SE route with either V1 or V2 is considered better than the NW route, which requires a relatively greater extent of intervention works, also inside a Natura 2000 site.	Better than NW

* These conclusions apply to both the combination of the SE route with V1 and the combination of the SE route with V2.

5.3.2 Maritime safety

The Bornholmsgat is located north of Bornholm. It is the main entrance to/exit from the Baltic Sea for ship traffic and is one of the most trafficked areas in the Baltic Sea. Figure 5-6 shows the ship traffic pattern (intensity) in the Danish waters around Bornholm, based on Automatic Identification System (AIS) registrations in 2014, along with the route alternatives for the NSP2 project. The figure demonstrates that the majority of ships follow predesignated routes that are in accordance with existing traffic separation schemes (TSS), see section 7.15.

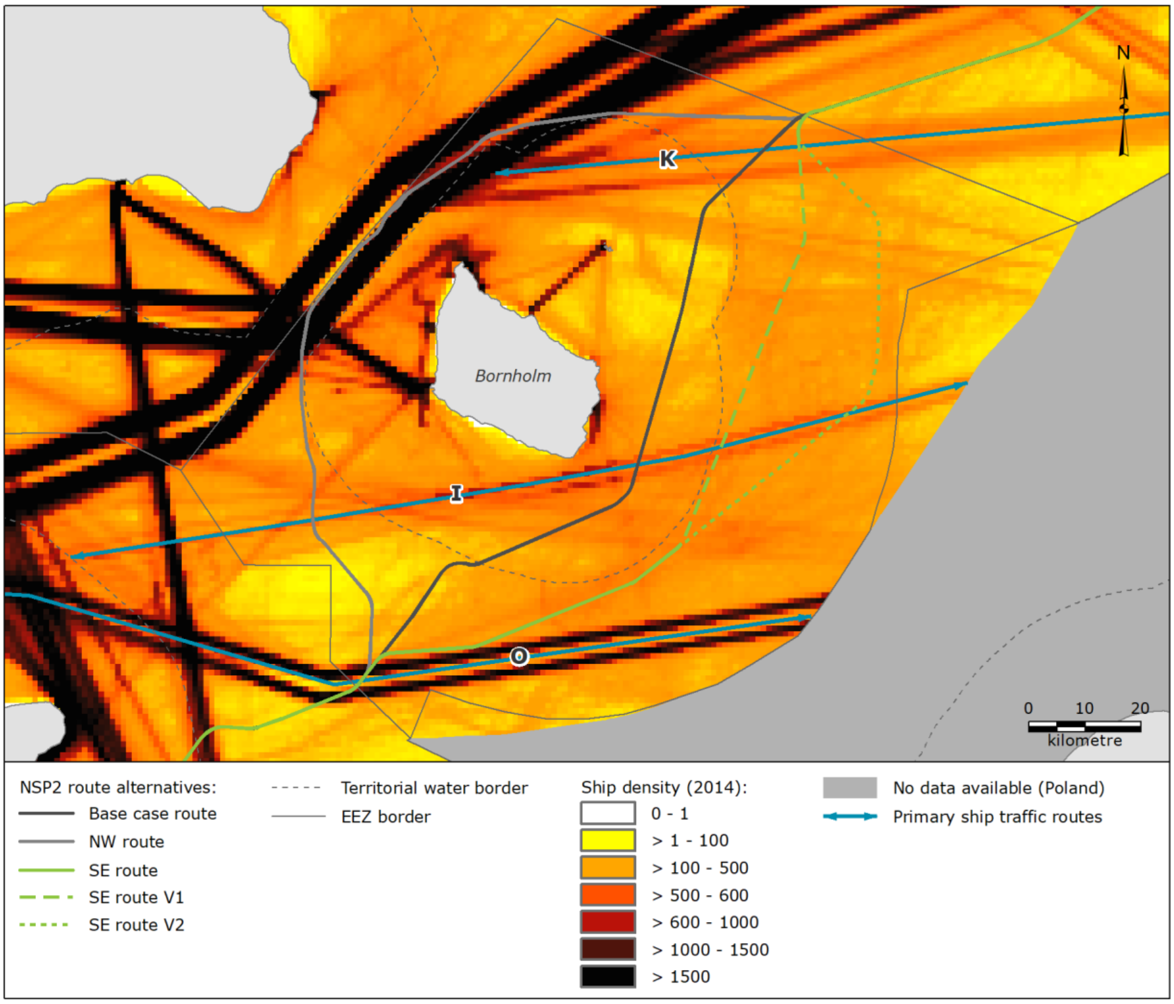


Figure 5-6 Alternative routes for the NSP2 project, shown with ship traffic density.

The NSP2 project, for all route alternatives, may have an impact on maritime safety mainly during the construction phase in the high-traffic areas due to the presence of slow-moving or stationary construction vessels with limited ability to manoeuvre. Upon agreement with the relevant authorities, a safety zone will be implemented in the order of 1 nm around the pipe-lay vessel, and 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 journeys around the safety zone. The safety zone will be communicated through Notices to Mariners. Furthermore, during the operational phase, the presence of the pipeline system may involve potential indirect risks on ship traffic and other maritime activities, e.g. by means of changed behaviour in case of emergency anchoring events.

In general, ship traffic is less intense in the waters south and east of Bornholm, through which the base case route, the combination of the SE route with V1 and the combination of the SE route with V2 pass. All routes cross the TSS Adlergrund, which has about 7,000 ship passages per year, near the Danish-German EEZ border. In this area, safety exclusion zones will be imposed around slow-moving construction vessels, which will lead to a minor restriction on the west-bound traffic in the shipping lane within Danish waters.

With regard to the NW route, a large part of the section in Danish waters (approx. 80 km) is located within the TSS Bornholmsgat/deep water route, which experiences approx. 50,000 ship passages per year. Construction of the pipeline system in this area is viable; however, it necessitates further mitigation measures (during both the construction and operational phases) than would be the case for either the combination of the SE route with V1 or the combination of the SE route with V2. In addition to the above mentioned safety zone, the mitigation measures include the instalment of a temporary, local notification system to inform ships approaching the pipe-lay vessel. This system can be set up with a local vessel that calls to other vessels. Such a temporary system was established during the construction of NSP, where a person local to the area was used to ensure efficient communication with other vessels. It should be noted that the construction works will be temporary in any given area and pipe-lay will progress at a rate of up to 3 km/day, and that during the EIA consultation phase for the NW route, the Danish Maritime Authority did not raise any concerns regarding potential impacts in the TSS Bornholmsgat.

The combination of the SE route with V1 would entail the crossing of the same primary ship traffic routes as would the base case route and the combination of the SE route with V2. However, one of the primary ship traffic routes, Route I, would be crossed at a point approximately 15 km to the east of the base case route and approximately 25 km to the west of the combination of the SE route with V2, see Figure 5-6. The ship traffic along Route I is expected to be the same at any point along the route. The SE route is positioned closer to one of the primary ship traffic routes, Route O (i.e., within approx. 1 km), than the base case route, see Figure 5-6. This is not considered problematic as there are no formal criteria for the distance between a pipeline parallel to a shipping lane and the shipping lane. Furthermore, ships travelling along the part of Route O that is parallel to the SE route are not bound by any TSS, meaning that ships are permitted to leave Route O and thereby avoid being affected by temporary safety exclusion zones. There is no significant difference with respect to maritime safety between the SE route V1 and the SE route V2 and the two SE route options are therefore evaluated to be comparable in this regard.

In relation to maritime safety, both SE route alternatives are therefore considered to be comparable to the base case route, and better compared to the NW route, as reflected in Table 5-3.

Table 5-3 Comparison summary for the routes in relation to maritime safety.

Route	Comparison summary	Route preference
Base case	The main traffic separation scheme Bornholmsgat, with 50,000 ship movements per year, is not impacted. Only ship traffic routes where the ship traffic intensity is relatively low are crossed. The TSS Adlergrund is crossed, but the duration of the construction activities is short and the relatively low intensity of ship traffic, with only 9-10 west-bound ships per day, moves in a one-directional lane. Crossing TSS Adlergrund is common to all considered route alternatives. The impact level is therefore considered low.	Reference
NW	The main traffic separation scheme Bornholmsgat will be directly impacted by the construction activities for this route. The route crosses the TSS diagonally twice and is located inside the TSS for approx. 80 km. Mitigation measures include the imposition of a safety zone around work vessels, establishment of a temporary VTS and use of a guard ship.	Reference
SE*	The route crosses the same ship traffic routes as the NSP2 base case route, although the SE route is positioned closer to one of the primary ship traffic routes, Route O (i.e., within approx. 1 km), than the base case route. This is not considered problematic as ships are permitted to leave Route O and thereby avoid being affected by temporary safety exclusion zones. Therefore, the combination of the SE route with either V1 or V2 represents a comparable alternative compared to the base case route in relation to maritime safety in Danish waters. The main traffic separation scheme Bornholmsgat, with 50,000 ship movements per year, is not impacted. Only ship traffic routes where the ship traffic intensity is relatively low are crossed. As stated above, the proximity of the SE route to Route O is not considered to represent a concern. Therefore, the combination of the SE route with either V1 or V2 represents a better alternative compared to the NW route in relation to maritime safety in Danish waters.	Comparable to base case Better than NW

* These conclusions apply to both the combination of the SE route with V1 and the combination of the SE route with V2.

5.3.3 Munitions risk

Chemical warfare agent risk area

Chemical munitions are munitions containing CWA, whose toxic properties were designed to kill, injure or incapacitate humans. In 1925, the use of chemical munitions was declared illegal in the Third Geneva Convention. Chemical munitions were not used during World War II, but both the Allied and German forces stockpiled large quantities of them. After the war, the Bornholm Basin and the Gotland Deep were selected as dumping sites for chemical munitions.

The main site in Danish waters used for chemical munitions disposal was the southern part of the Bornholm Deep. It is estimated that chemical warfare materials containing 11,000 t 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 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 very possible that dumping vessels 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 in Figure 5-7 as the area where bottom trawling, anchoring and seabed intervention works are discouraged, see also section 7.18.

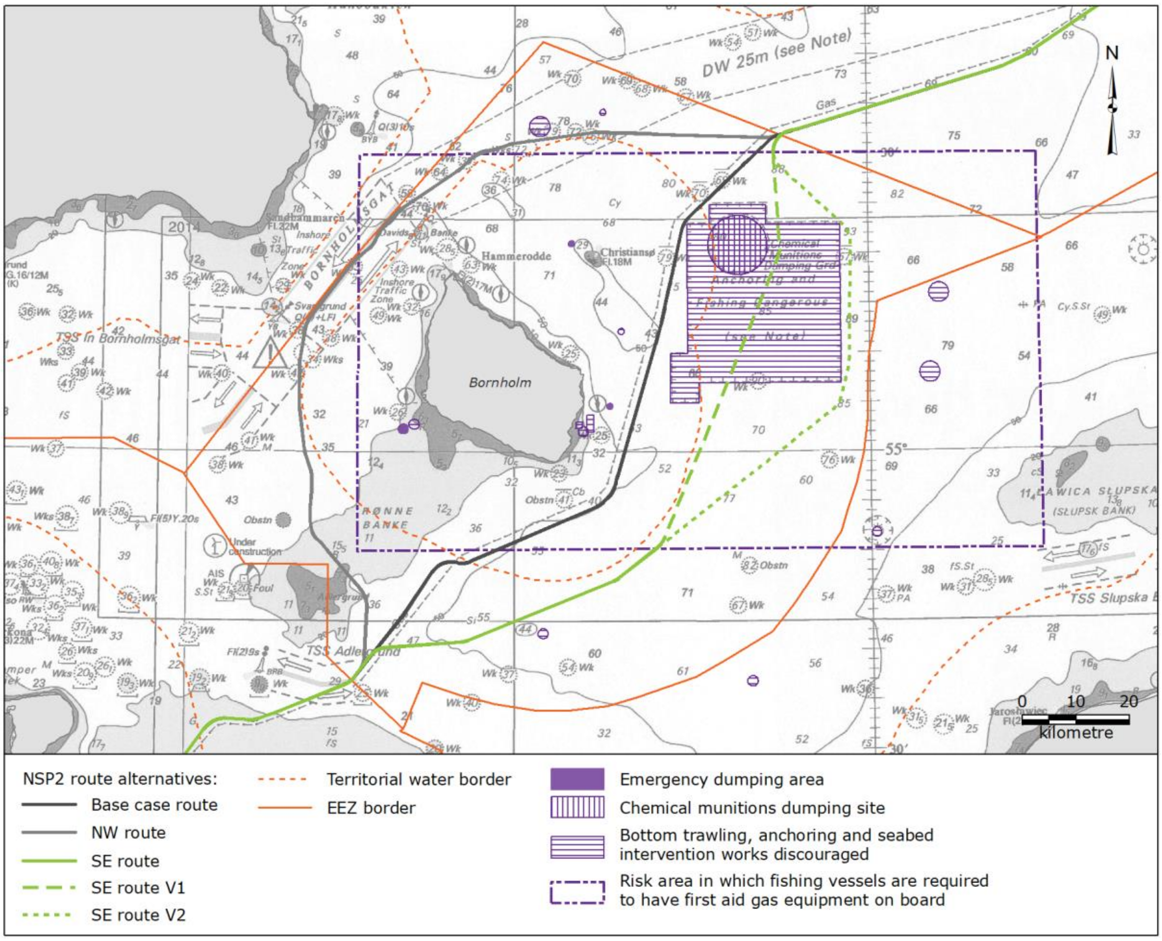


Figure 5-7 CWA area and route alternatives.

Detailed investigations of the presence of CWA along the base case route, the SE route and the two variants SE route V1 and SE route V2 /73/ completed as part of the route development of the NSP2 project (see section 7.1.1.1) showed that the findings of CWA are scattered and highly variable along all surveyed transects, but in general, the levels of CWA are highest within and to the west of the restricted area.

None of the considered routes cross the area noted as a chemical munitions dumping site. The NW route is, however, assessed based on survey results to constitute a lower CWA-related risk than the base case route, the combination of the SE route with V1 or the combination of the SE route with V2, since it is located further away from the area used for chemical munitions disposal.

The SE route V1 crosses the area where bottom trawling, anchoring and seabed intervention works are discouraged. Given the increased risk of encountering CWA in this area, the combination of the SE route with V1 is considered a slightly worse alternative in this regard compared to the base case route, the SE route V2 and the NW route.

In relation to CWA-related risks based on the baseline survey results, the base case route is slightly worse than the combination of the SE route with V2, and the NW route is considered a better alternative.

The comparison of route alternatives relative to CWA risk is summarised in Table 5-4.

Table 5-4 Comparison summary for the routes in relation to CWA areas.

Route	Comparison summary	Route preference
Base case	The route has been planned to avoid crossing the area where anchoring and trawling are discouraged due to the potential presence of chemical munitions and CWA. Installation of the pipelines is envisaged with a dynamically positioned (DP) pipe-lay vessel. Therefore, the risk of exposing the environment to CWA is reduced.	Reference
NW	The frequency and expected concentration of CWA in the sediment along the NW route are lower since the route is at its closest point at least 10 km away from the restricted area. Therefore, the risk of exposing the environment to CWA is reduced.	Reference
SE	The SE route V2 has been planned, as was the base case route, to avoid crossing the area where anchoring and trawling are discouraged due to the potential presence of chemical munitions and CWA. As presented in the above description, the combination of the SE route with V1 is considered a slightly worse alternative compared to the combination of the SE route with V2 as regards CWA risk, given that the SE route V1 crosses the CWA risk area. Less CWA is found along the combination of the SE route with V1 compared to the base case route. Thus, the combination of the SE route with V1 is considered slightly better than the base case route. Compared to the NW route, the combination of the SE route with V2 is associated with a higher potential for environmental impact due to its shorter distance from the CWA-contaminated area. However, the smaller amount of seabed interventions and hence sediment disturbance along the combination of the SE route with V2 to some degree compensates for this.	Slightly worse than base case for the combination of the SE route with V1 Slightly better than base case for the combination of the SE route with V2 Slightly worse than NW for the combination of the SE route with V1 Slightly worse than NW for the combination of the SE route with V2

Conventional munitions risk

Based on the detailed survey results, both the base case route and the NW route can be safely installed without the necessity for the clearance of conventional munitions. Reporting of the munitions screening survey (UXO) along the SE route and the SE route V2 have identified a line of ground mines (in the order of 800 kg) which traverses the SE route V2 pipeline corridor. At the time of this assessment, the required remedial actions have not been fully developed. Such actions under consideration include one or a combination of the following:

- Rerouting; a potential reroute has been surveyed and is being assessed by engineering.
- Relocation of individual munitions to a permanent storage location on the seabed outside the influence of the pipeline corridor, which is yet to be agreed with the competent Danish authority.

The routing has been adapted to safely accommodate all other found munitions along the SE route, SE route V1 and SE route V2, i.e. a minimum offset distance to the pipelines.

The comparison of route alternatives relative to conventional munitions risk is summarised in Table 5-5.

Table 5-5 Comparison summary for the routes in relation to conventional munitions risk.

Route	Comparison summary	Route preference
Base case	No clearance of conventional munitions required to safely install the pipelines.	Reference
NW	No clearance of conventional munitions required to safely install the pipelines.	Reference
SE	Due to the presence of conventional munitions along the SE route V2, additional remedial actions such as rerouting or relocation of the munitions will be required. Therefore, the combination of the SE route with V2 is assessed to be slightly worse compared to the base case route and the NW route. No conventional munitions requiring any actions have been identified along the SE route V1. Therefore, the combination of the SE route with V1 is assessed to be comparable to the base case route and the NW route.	Comparable with base case for the combination of the SE route with V1 Slightly worse than base case for the combination of the SE route with V2 Comparable with NW for the combination of the SE route with V1 Slightly worse than NW for the combination of the SE route with V2

5.3.4 Fishery

The spatial distribution and density of bottom trawling activities in Danish waters by Danish fishermen has been mapped based on vessel monitoring system (VMS) data, see Figure 5-8. Bottom trawling 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/north-east of Bornholm, see section 7.16.

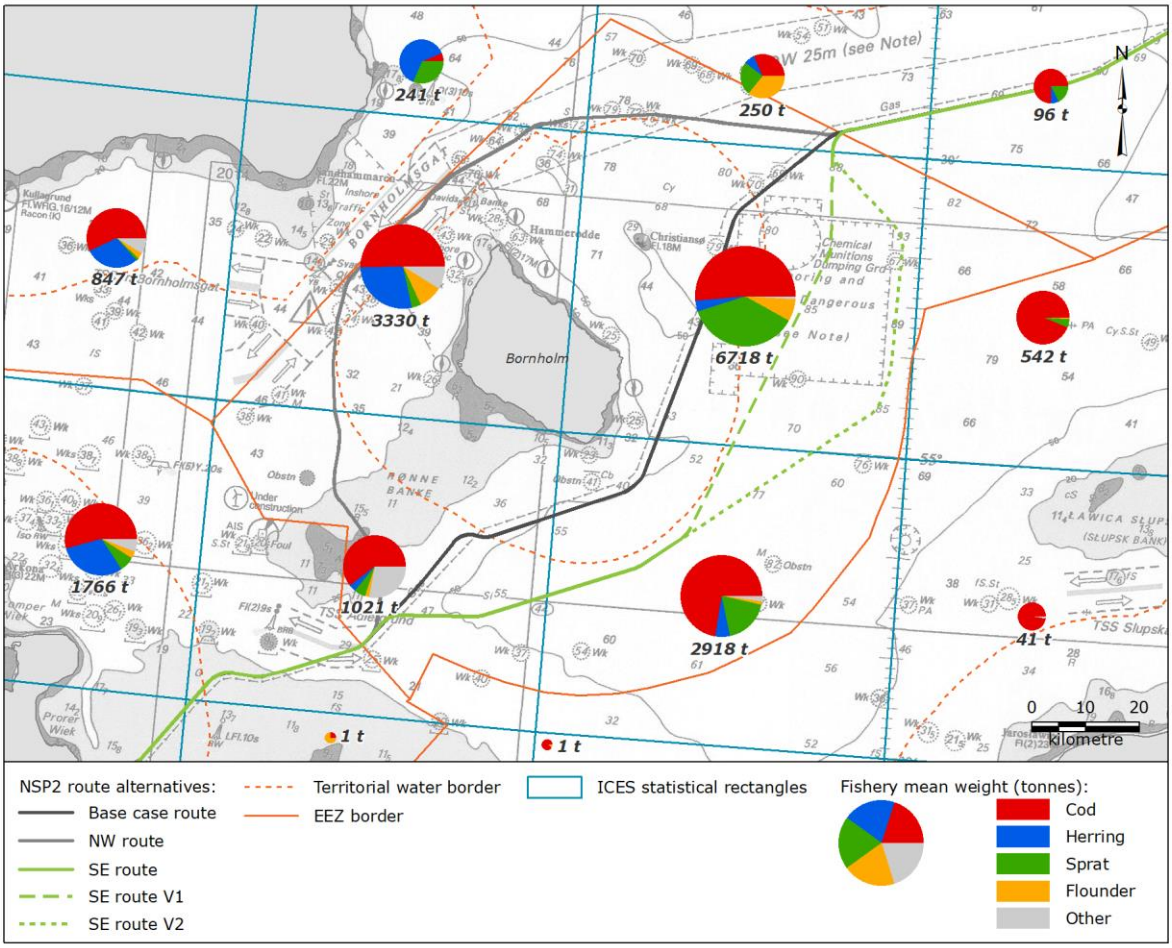


Figure 5-8 Fishery mean weight (tonnes) and route alternatives.

Impacts on commercial fishery may occur due to navigational restrictions around construction vessels during the construction phase and the presence of the pipeline system on the seabed during the operational phase. The pipe-lay activities are expected to be similar along the different route options where fishing areas are crossed by the pipelines. The anticipated lay rate with a DP vessel will be approximately 3 km/day, while an anchored pipe-lay vessel would have a lay rate of approximately 1-2 km/day. Therefore, the duration of the fishery restriction at any given location will be very limited. However, the need for seabed intervention works along the different route options vary, with the need for more intervention works along the base case route and the NW route. The duration of seabed intervention works correlates with the duration of a fishery restriction at each given location where intervention works are carried out.

In general, the base case route does not cross any areas with high intensity of bottom trawling in Danish waters. Furthermore, this route runs parallel to NSP and the distance between the existing pipelines and the proposed pipelines would be approximately 1,200 m. This is considered sufficient for the fishing vessels to trawl and turn between the two pipeline systems, and would therefore have less impact on fishing operations.

The NW route crosses an area of intense bottom trawl fishery to the north-west of Bornholm, and both the combination of the SE route with V1 and the combination of the SE route with V2 cross areas of intense bottom trawl fishery to the south-east of Bornholm. The catch volumes for the base case route and both SE route alternatives are greater than for the NW route; consequently, the potential for impact is considered slightly higher for these route options, both during construction, due to the temporary navigation restrictions around the construction vessels, and during operation, due to the presence of the pipeline system on the seabed. The SE route alternatives and the base case route are therefore considered slightly worse route alternatives compared to the NW route.

The SE route V1 crosses the same ICES rectangles as the SE route V2. As such, bottom trawl fishery intensity is roughly similar in the area of the SE route V1 compared with the SE route V2, and the two route options are therefore considered comparable.

In relation to commercial fishery, the base case route is therefore considered to be more preferable since the bottom trawling fishery is less intense along this route, as reflected in Table 5-6.

Table 5-6 Comparison summary for the routes in relation to fishery.

Route	Comparison summary	Route preference
Base case	The route is outside of areas with a high intensity of fishery activities and the impact level is therefore considered low. The route represents the preferable route in Danish waters in relation to fishery.	Reference
NW	The route crosses an area with a high intensity of fishery activities, and intervention works are planned in the area.	Reference
SE*	The route crosses an area with a high intensity of fishery activities. The impact level is considered slightly higher for this route compared to the base case route since catch volumes are higher along the SE route, SE route V1 and SE route V2. The combination of the SE route with V1 or V2 represents a slightly worse alternative compared to the base case route in relation to fishery in Danish waters. The combination of the SE route with V1, the combination of the SE route with V2 and NW route cross areas of high fishery intensity. However, both SE route alternatives have longer stretches within the ICES rectangles with high catch volumes/value, and they are therefore assessed to be slightly worse than the NW route.	Slightly worse than base case Slightly worse than NW

* These conclusions apply to both the combination of the SE route with V1 and the combination of the SE route with V2.

5.3.5 Maritime spatial planning

Spatial planning

Act no. 615 of 8 June 2016 on maritime spatial planning, as subsequently amended, entered into force on 1 July 2016. The act implements the EU Directive on establishing a framework for maritime spatial planning (Directive 2014/89/EU). Under the act, the Minister for Industry, Business and Financial Affairs is authorised to issue an overall plan for Danish marine areas. At this stage, such a plan has not been issued or submitted for consultation, and there are at present no available draft maritime spatial plans to be taken into consideration for the area crossed by the NSP2 route options.

In relation to maritime spatial planning, it is anticipated that the base case route will be the better route, since this route will occupy the smallest area on the seabed if NSP and NSP2 are considered together. The potential for future impacts on maritime spatial planning is therefore considered higher for the combination of the SE route with V1 and the combination of the SE route with V2 compared to the base case route. As the NW route also runs separate from the base case route within Danish waters, it is considered to be comparable to both SE route alternatives in relation to current and potential future impacts on maritime spatial planning. It is noted, however, that no approved or draft maritime spatial plans have been introduced at present (as mentioned above) and there are furthermore no rules in Danish planning law that establish a requirement for the bundling of infrastructure.

Infrastructure
There are several existing and planned installations in Danish waters around the different NSP2 route options, see section 7.21. Most of the installations crossing the evaluated pipeline routes consist of various cables, but existing and planned pipelines are also present, see Figure 5-9.

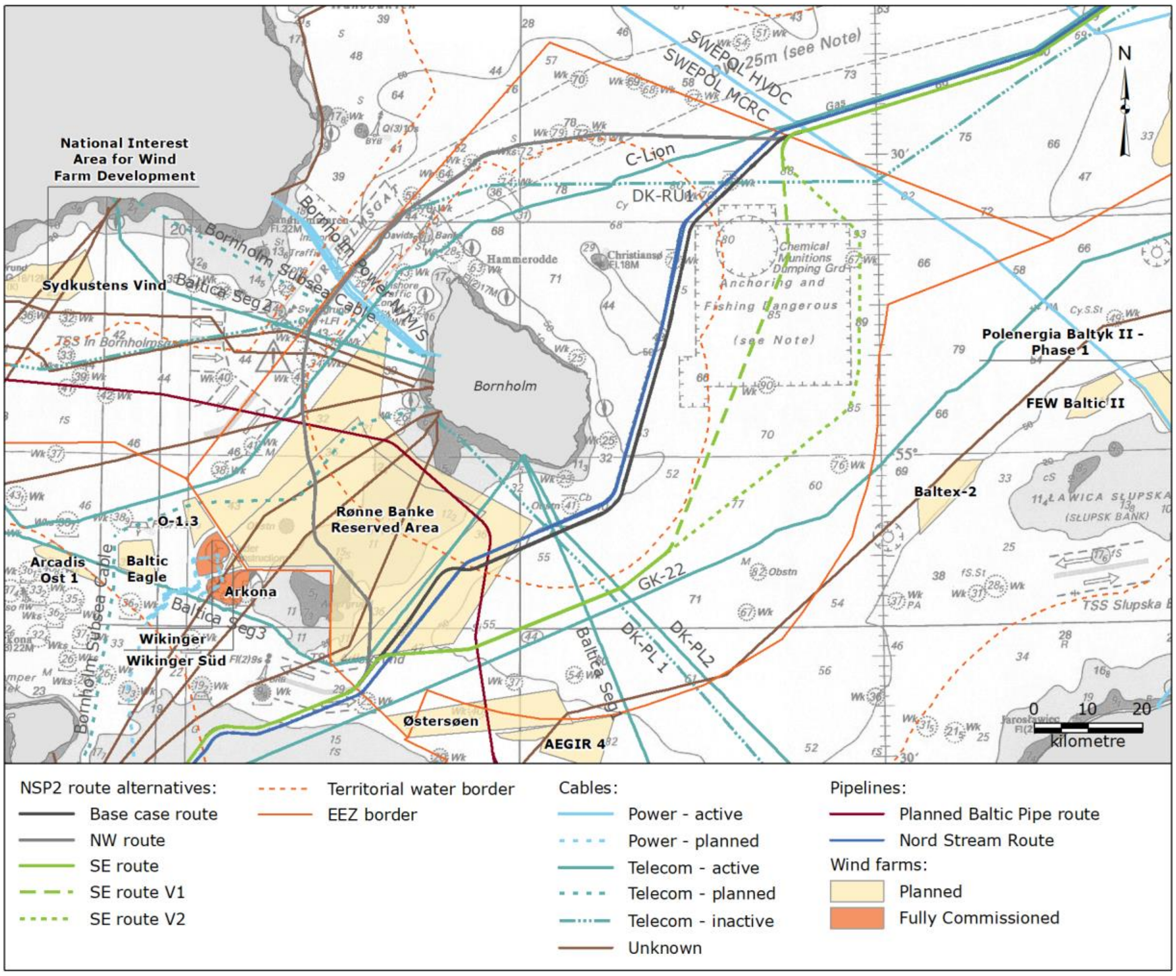


Figure 5-9 Maritime spatial planning and route alternatives.

The combination of the SE route with V1 and the combination of the SE route with V2 would include the same crossings of active infrastructure (two active power/telecom cables and one pipeline (NSP), see Figure 5-9) as the base case route. Both SE route alternatives would additionally cross two inactive telecom cables, whereas the base case route crosses only one inactive telecom cable. Therefore, the route alternatives comprise a similar level of preparatory intervention works.

The NW route would include more infrastructure crossings (seven active power/telecom cables and one pipeline (NSP)); consequently, a slightly higher level of preparatory intervention works is needed compared to the combination of the SE route with V1 or the combination of the SE route with V2.

The SE route V1 would entail the crossing of the same infrastructure as the SE route V2, and the two variants are therefore evaluated to be comparable in relation to maritime spatial planning in Danish waters.

Construction activities have the potential to result in impacts on localised areas of existing pipelines and cables crossing the different route alternatives (e.g. damage). At crossings, the presence of the NSP2 pipelines and support structures during the operational phase has the potential to hinder the ability to repair the existing cables and pipelines. This may have financial implications for the operators/owners of the cables/pipelines. However, where the NSP2 pipelines cross existing infrastructure such as cables and pipelines, Nord Stream 2 AG will agree on designs for safe crossing with the owners of the installations and implement the agreed design.

As shown in Figure 5-9, the SE route, SE route V1 and SE route V2 do not cross any mapped areas of potential future offshore wind farms, including the Rønne Banke Reserved Area in Danish waters. The base case route and the NW route do cross the Rønne Banke Reserved Area, but it should be noted that this does not preclude the construction of other infrastructure in the area and the crossing is therefore not reflected in the assessment of route alternatives.

The comparison of routes in relation to maritime spatial planning is summarised in Table 5-7.

Table 5-7 Comparison summary for the routes in relation to maritime spatial planning.

Route	Comparison summary	Route preference
Base case	The base case route will occupy a smaller area when assessing the NSP pipelines and the NSP2 pipelines together. Furthermore, the number of cable crossings is minimised with this route, as only two active cables are to be crossed. The route is therefore considered to represent the preferable route in Danish waters in relation to maritime spatial planning.	Reference
NW	The NW route will occupy a larger area when assessing the NSP and the NSP2 pipelines together. Further, it will require the crossing of seven active cables, with each crossing requiring preparatory intervention works with a risk of potential impacts.	Reference
SE*	The combination of the SE route with either V1 or V2 will occupy a larger area when assessing the existing NSP and the NSP2 pipelines together. Further, it will include one additional crossing of an inactive cable and thereby slightly more preparatory intervention works with a risk of potential impacts. The route is therefore considered to represent a worse route alternative compared to the base case route. Both the combination of the SE route with either V1 or V2 and NW route are not located alongside the existing NSP route, and therefore neither route follows the principle of infrastructure bundling. The NW route requires a greater number of cable crossings and as such more preparatory intervention works than the combination of the SE route with either V1 or V2. The combination of the SE route with either V1 or V2 is therefore considered to represent a slightly better route alternative compared to the NW route.	Worse than base case Slightly better than NW

* These conclusions apply to both the combination of the SE route with V1 and the combination of the SE route with V2.

5.3.6 Raw material extraction sites

Baltic Sea sediments may contain valuable raw materials, especially for construction purposes. In Danish waters, 20 areas are designated for extraction of raw materials (eight areas for current raw material extraction and 12 areas reserved for potential future raw material extraction). The areas are mainly located south-west of Bornholm at Rønne Banke, as illustrated in Figure 5-10.

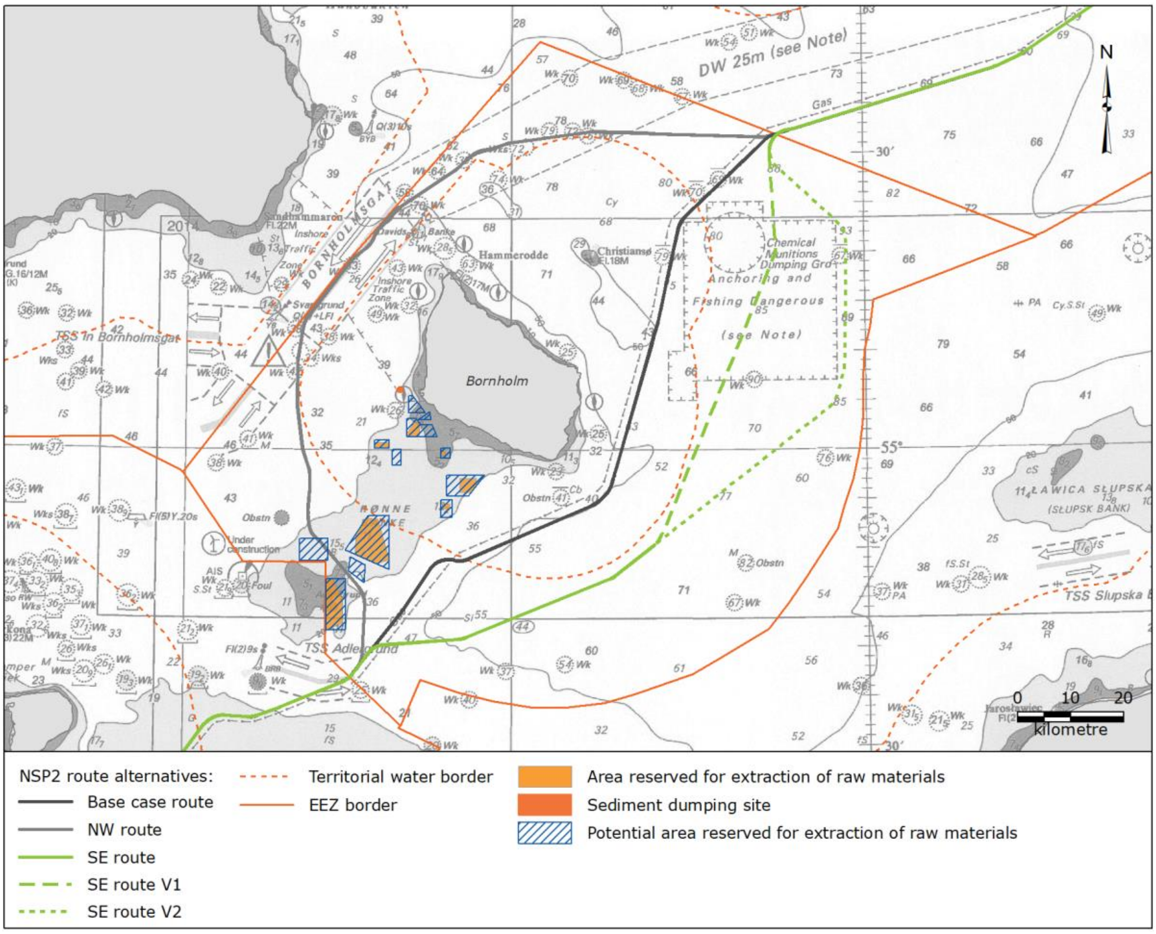


Figure 5-10 Raw material extraction and route alternatives.

As shown in the figure, the base case route, the combination of the SE route with V1 and the combination of the SE route with V2 do not cross any of the areas designated for extraction of raw materials, nor the area for sediment dumping. The NW route does not cross any areas currently reserved for extraction of raw materials; however, the NW route would cross area 564-C, a potential area reserved for extraction of raw materials, for a distance of approximately 3.1 km. It is noted that the DEPA has indicated that it is unlikely to designate this area for future resource extraction, due to its location within the Natura 2000 site “Adler Grund og Rønne Banke.”

The comparison of routes in relation to raw material extraction areas is summarised in Table 5-8.

Table 5-8 Comparison summary for the routes in relation to raw material extraction.

Route	Comparison summary	Route preference
Base case	The base case route does not cross any areas with current or potential future reservations for extraction of raw materials.	Reference
NW	The NW route crosses area 564-C, an area with potential future reservations for extraction of raw materials. However, the area is located within a Natura 2000 area and there are no present reservations for area 564-C.	Reference
SE*	The combination of the SE route with V1 and the combination of the SE route with V2 do not cross any areas with current or potential future reservations for extraction of raw materials. Therefore, the SE routes are considered to represent comparable route alternatives in comparison to the base case route. Although the NW route crosses one area of potential future resource extraction, available information suggests that it is unlikely to be designated for such activity in the future, given its location within a Natura 2000 area. Therefore, the combination of the SE route with either V1 or V2 is considered to represent a comparable route alternative in comparison to the NW route.	Comparable to base case Comparable to NW

* These conclusions apply to both the combination of the SE route with V1 and the combination of the SE route with V2.

5.3.7 Military practice areas

Military practice areas of various types are located in the Baltic Sea. Military practice areas may be restricted in regard to navigation and other access rights. Permanent restriction of access to areas used for military purposes may be applied by countries within their TW. Several military practice areas are located in Danish waters, see Figure 5-11. Construction of the pipelines might interfere with military practice activities in these areas.

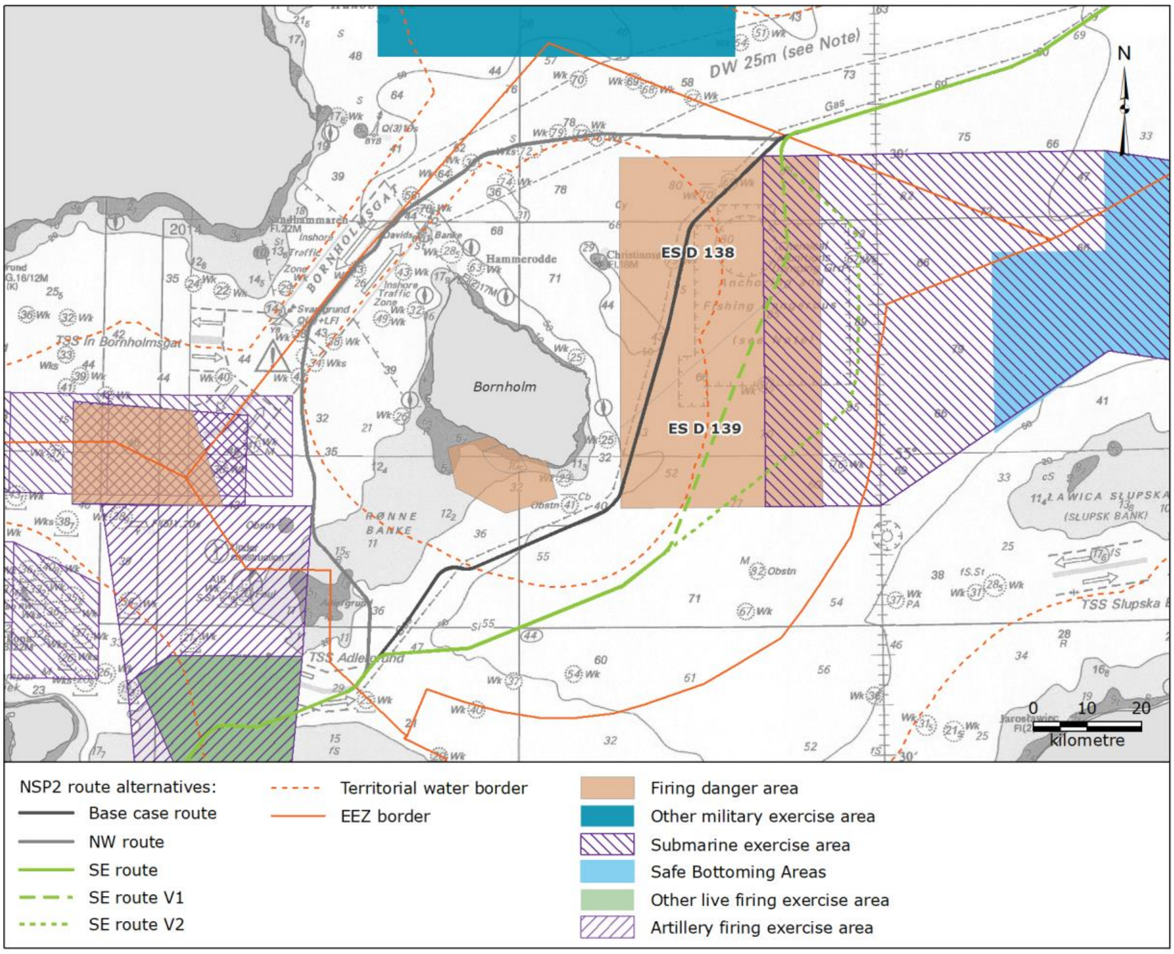


Figure 5-11 Military practice areas and route alternatives.

On behalf of the Danish Navy, the Joint Operations Centre is responsible for activities in the firing areas in Danish waters. See section 7.23 for a description of relevant areas.

Submarine exercise areas used by the German military are located to the east and west of Bornholm. Furthermore, two Safe Bottoming Areas are located in the eastern-most part of the Danish EEZ. The relevant German military authorities have been contacted in relation to the preparation of the EIA for the base case route and the data they provided have been used to update the locations of the areas accordingly.

The base case route crosses the firing danger areas ES D 138 and ES D 139 located north-east and east of Bornholm, respectively. The SE route V1 and the SE route V2 also cross these areas. In addition, both the SE route V1 and the SE route V2 cross a submarine exercise area to the east of Bornholm used by the German Armed Forces. The NW route does not cross any military practice areas.

No concerns were received from the Danish Navy during the EIA consultation phase for the base case route as regards the military firing danger area. Furthermore, the German Armed Forces have stated that there would generally be no objections against laying the pipeline through the mapped submarine areas to be crossed by the SE route V1 and the SE route V2.

Given that the SE route V1 and the SE route V2 cross the same military practice areas, the two route options are evaluated to be comparable in this regard.

The comparison of routes in relation to military practice areas is summarised in Table 5-9.

Table 5-9 Comparison summary for the routes in relation to military practice areas.

Route	Comparison summary	Route preference
Base case	No concerns in relation to military practice areas were received from the Danish Navy during the EIA consultation phase for the base case route. The impact level is therefore considered low and the route represents the preferable route in Danish waters.	Reference
NW	No military practice areas are crossed by the NW route. The impact level is therefore considered low.	Reference
SE*	The SE route V1 and the SE route V2 cross the same two firing danger areas crossed by the base case route, and based on the conclusions from the base case EIA, the impact level is considered low. The SE route V1 and the SE route V2 also cross a submarine exercise area. The overall impact level for the combination of the SE route with either V1 or V2 is considered low, but slightly higher compared to the base case route due to the crossing of the submarine exercise area, which may entail further coordination with the military authorities. The combination of the SE route with either V1 or V2 crosses several military practice areas, as described above. The overall impact level is considered low, but nevertheless higher compared to the NW route, which does not cross any military practice areas.	Slightly worse than base case Worse than NW

* These conclusions apply to both the combination of the SE route with V1 and the combination of the SE route with V2.

5.3.8 Pipeline length

The comparison of the pipeline route lengths is summarised in Table 5-10.

Table 5-10 Comparison summary of the pipeline route lengths.

Route	Comparison summary	Route preference
Base case	139 km length in Danish sector per pipeline.	Reference
NW	174 km length in Danish sector per pipeline.	Reference
SE	The length of the combination of the SE route with V1 is 147 km, i.e. 8 km longer than the base case route (6% longer) and is thus considered slightly worse than the base case route. The length of the combination of the SE route with V2 is 164 km, i.e. 25 km longer compared to the base case route (18% longer) and is thus considered worse than the base case route. The combination of the SE route with V1 is 27 km shorter than the NW route (16% shorter) and is thus considered better than the NW route. The combination of the SE route with V2 is 10 km shorter compared to the NW route (6% shorter) and is thus considered slightly better than NW route.	Slightly worse than base case for the combination of the SE route with V1 Worse than base case for the combination of the SE route with V2 Better than NW for the combination of the SE route with V1 Slightly better than NW for the combination of the SE route with V2

5.3.9 Summary

A main route alternative, the SE route, with two potential route variants, the SE route V1 and the SE route V2, has been evaluated as a feasible alternative compared to the base case route and the NW route. The combination of the SE route with V1 and the combination of the SE route with V2 both represent feasible route alignments for NSP2The following aspects have been scrutinised as part of the evaluation:

- Biological environment;
- Extent of intervention works;

- Maritime safety;
- CWA risk;
- Conventional munition risk;
- Fishery;
- Maritime spatial planning;
- Raw material extraction sites;
- Military practice areas;
- Pipeline length.

For each aspect, the combination of the SE route with V1 and the combination of the SE route with V2 have been compared to the base case route and the NW route alternatives, each representing reference routes. The combination of the SE route with V1 and the combination of the SE route with V2 have thus been rated as either better, slightly better, comparable, slightly worse or worse compared to the base case route and the NW route, as reflected in Table 5-11 and Table 5-12, respectively. The four route alternatives are feasible and justifiable from the perspective of environmental and socio-economic impacts.

Table 5-11 Summary of the evaluation of the combination of the SE route with V1 in comparison with the base case and NW route alternatives.

Relevant biological and socio-economic aspects	SE route evaluation in comparison with route alternatives	
	Base case route	NW route
Biological environment and extent of intervention works	Slightly better	Better
Maritime safety	Comparable	Better
Chemical warfare agent risk	Slightly worse	Slightly worse
Conventional munition risk	Comparable	Comparable
Fishery	Slightly worse	Slightly worse
Maritime spatial planning	Worse	Slightly better
Raw material extraction sites	Comparable	Comparable
Military practice areas	Slightly worse	Worse
Pipeline length	Slightly worse	Better

Table 5-12 Summary of the evaluation of the combination of the SE route with V2 in comparison with the base case and NW route alternatives.

Relevant biological and socio-economic aspects	SE route evaluation in comparison with route alternatives	
	Base case route	NW route
Biological environment and extent of intervention works	Slightly better	Better
Maritime safety	Comparable	Better
Chemical warfare agent risk	Slightly better	Slightly worse
Conventional munition risk	Slightly worse	Slightly worse
Fishery	Slightly worse	Slightly worse
Maritime spatial planning	Worse	Slightly better
Raw material extraction sites	Comparable	Comparable
Military practice areas	Slightly worse	Worse
Pipeline length	Worse	Slightly better

Overall, the evaluation of the combination of the SE route with the SE route V1 in comparison to the base case route shows that the combination of the SE route with V1 is considered *better* or *slightly better* with respect to aspects such as the biological environment and extent of intervention works, but as *worse* or *slightly worse* with respect to aspects such as CWA risk, fishery, maritime spatial planning, military practice areas and pipeline length. The evaluation of the combination of the SE route with the SE route V1 in comparison to the NW route shows that the combination of the SE route with V1 is considered *better* or *slightly better* with respect to aspects such as biological environment, extent of intervention works, maritime safety, maritime spatial planning and pipeline length, but as *worse* or *slightly worse* with respect to aspects such as CWA risk, fishery and military practice areas.

Overall, the evaluation of the combination of the SE route with the SE route V2 in comparison to the base case route shows that the combination of the SE route with V2 is considered *better* or *slightly better* with respect to aspects such as the biological environment, extent of intervention works and CWA risk, but as *worse* or *slightly worse* with respect to aspects such as conventional munition risk, fishery, maritime spatial planning, military practice areas and pipeline length. The evaluation of the combination of the SE route with the SE route V2 in comparison to the NW route shows that the combination of the SE route with V2 is considered *better* or *slightly better* with respect to aspects such as biological environment, extent of intervention works, maritime safety, maritime spatial planning and pipeline length, but as *worse* or *slightly worse* with respect to aspects such as CWA risk, conventional munition risk, fishery and military practice areas.

The significance of the variance between the four considered route alternatives is limited, as has been shown above.

The combination of the SE route with the SE route V1 and the combination of the SE route with the SE route V2 are evaluated in the present EIA as two equally proposed routes for NSP2. It is noted that the potential impacts caused by the construction and operation of NSP2 along the SE route, the SE route V1 and the SE route V2 are generally assessed to be short-term and local, as described in this EIA. Mitigation measures will be applied, and the impacts are assessed to be minor and generally limited to the pipeline corridor. The combination of the SE route with V1 and the combination of the SE route with V2 are therefore considered viable alternatives to the base case route and the NW route.

The assessments conducted as part of this EIA report have therefore been performed for the construction and operation of a pipeline system following the combination of the SE route (referred to as the “NSP2 route” or “proposed NSP2 route” in this EIA) with either the SE route V1 (referred to as the “NSP2 route V1” in this EIA) or the SE route V2 (referred to as the “NSP2 route V2” in this EIA).

5.4 No-action alternative

An EIA 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 NSP2 is not constructed and operated in Danish waters. Non-implementation would mean that there would be no environmental or social impacts from the project in Denmark, neither adverse nor positive. However, Nord Stream 2 AG has already installed more than 800 km of the pipelines (Line A and Line B) in Germany, Sweden and Finland and construction works have progressed at the Russian and German landfalls. If not used, adverse environmental impacts may occur in the corresponding countries (e.g. if the installed pipelines would need to be removed).

The impacts of the 0-alternative therefore can be confined to the natural changes from the baseline. As the construction of the NSP2 pipeline system (SE route) in Danish waters is planned to last for approximately 115 days for the two pipelines if the combination of the SE route with V1 is selected, or approximately 125 days for the two pipelines if the combination of the SE route with V2 is selected, this timeframe is used to define the period for natural changes in the environment from the baseline. During this very short time period, 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 to 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 emphasised 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 NSP, including the extensive monitoring carried out in connection with the 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 and the public interest benefit for gas supply (see section 3), will not occur if the project is not realised.

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 with the construction and operation of NSP2 in Denmark. In general, the scope of the Danish national EIA report is confined to those project activities that occur offshore in Danish waters.

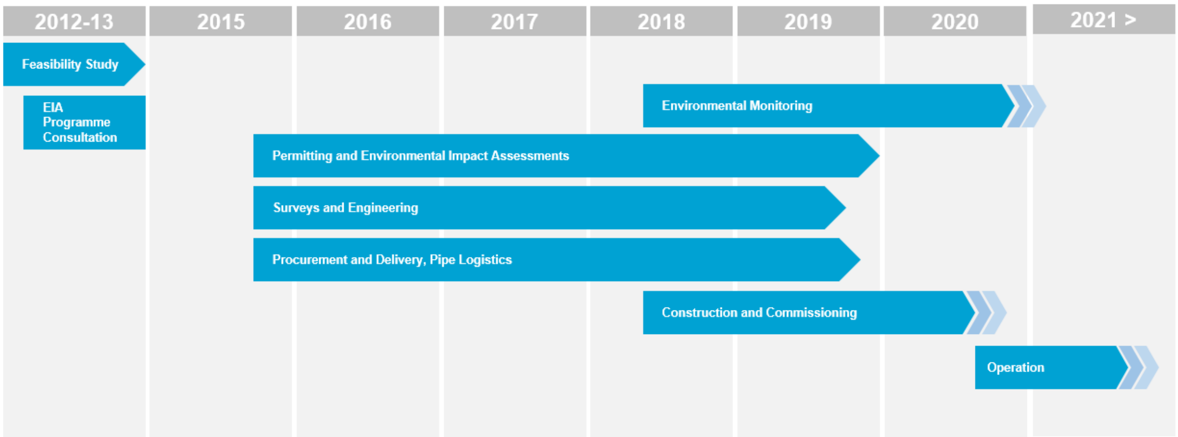


Figure 6-1 General project schedule.

In the sections below, the onshore activities are also 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 and associated 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, see Figure 6-2.

The entire pipeline route will cover a distance of approximately 1,230 km if the combination of the NSP2 route with V1 is selected, or approximately 1,248 km if the combination of the NSP2 route with V2 is selected. The proposed pipeline route crosses the TW of Russia and Germany and runs within the EEZs of Finland, Sweden, Denmark and Germany. The NSP2 pipelines run parallel to the existing NSP system for most of the route in Finland, Sweden and Germany. On the basis of environmental and technical considerations, and given the fact that permits for NSP2 have been issued in all other jurisdictions, including in Sweden and Germany, the proposed NSP2 route and its respective route variants, V1 and V2, connect to the original fix points of the NSP2 base case route at the Danish/German EEZ border and at the Danish/Swedish EEZ border. Figure 6-2 provides an overview of the proposed routing of NSP2.

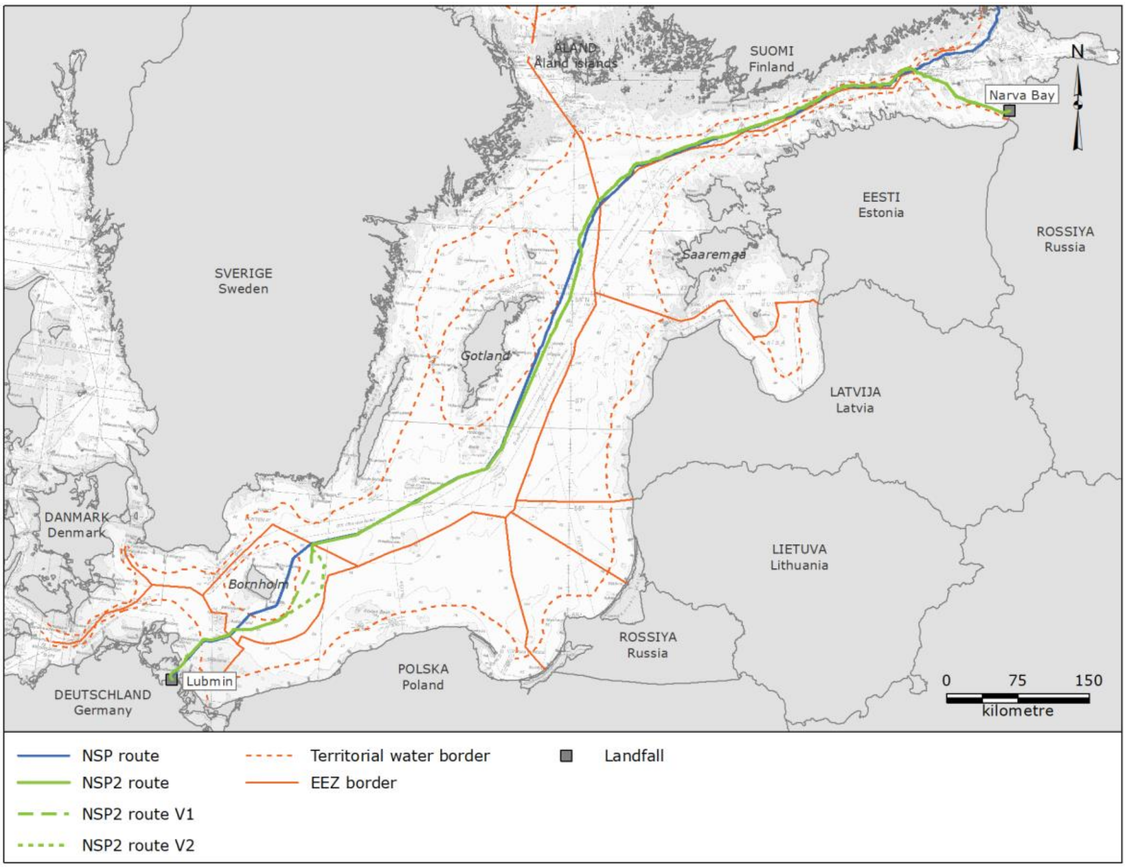


Figure 6-2 Proposed NSP2 route in the Baltic Sea.

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 exclusively in the EEZ south and east of Bornholm, see Figure 6-3. South of Bornholm, the proposed NSP2 route crosses the NSP pipelines and continues to Germany following next to the NSP route. The length of the proposed NSP2 route in Danish waters is approximately 147 km if the combination of the NSP2 route with V1 is selected, or approximately 164 km if the combination of the NSP2 route with V2 is selected.

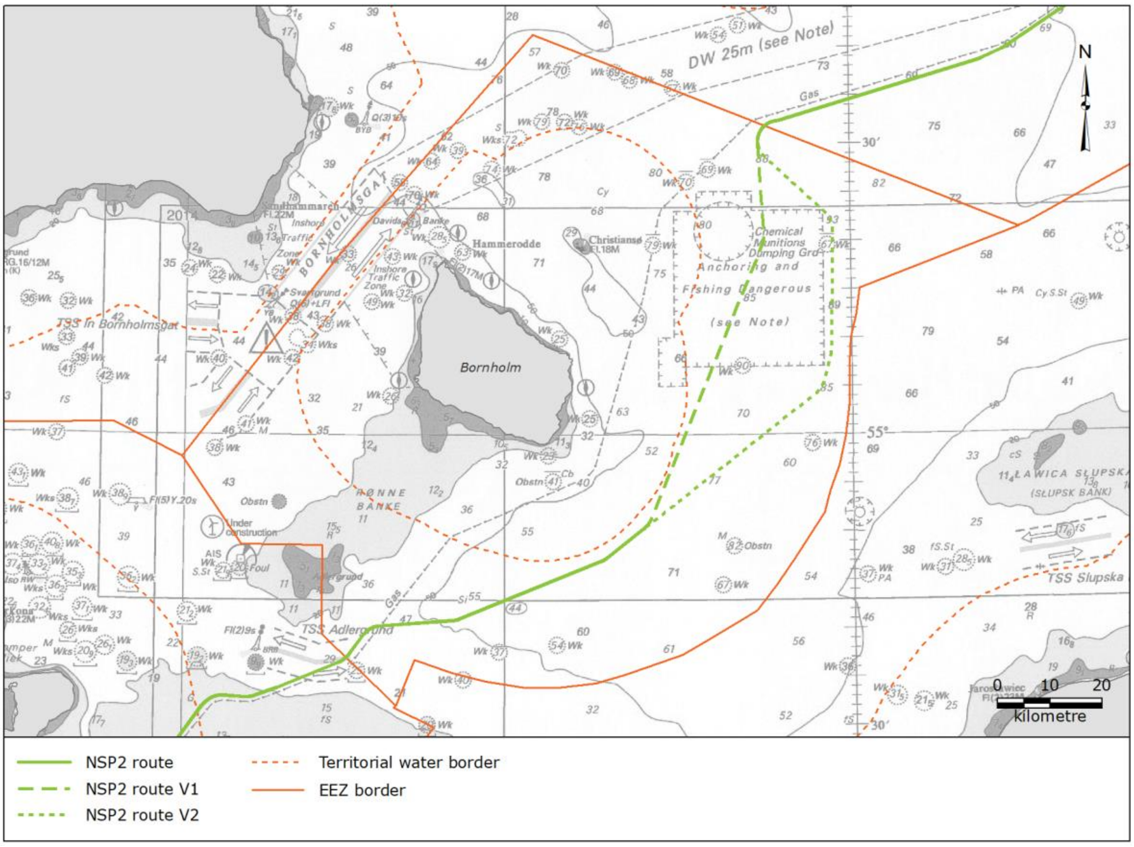


Figure 6-3 Proposed NSP2 route in Denmark.

The two NSP2 pipelines (Line A and Line B) will run parallel to one another. The separation distance of the two lines may vary between approximately 35 m and 155 m in Denmark.

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 safe-guarded;
- To determine the crossing points of existing infrastructure, e.g. pipelines, cables.

In 2007, various reconnaissance engineering surveys were conducted along the route; reconnaissance environmental surveys were performed in 2005-2006. To confirm that no changes to the seabed have occurred since then, additional surveys have been initiated, see Figure 6-4. Engineering surveys aimed for design and route optimization and environmental surveys have started in 2018 and will be finalised in 2019. Final surveys for route optimization will continue in 2019. Engineering surveys are discussed shortly in this section, and environmental surveys are discussed in section 7.

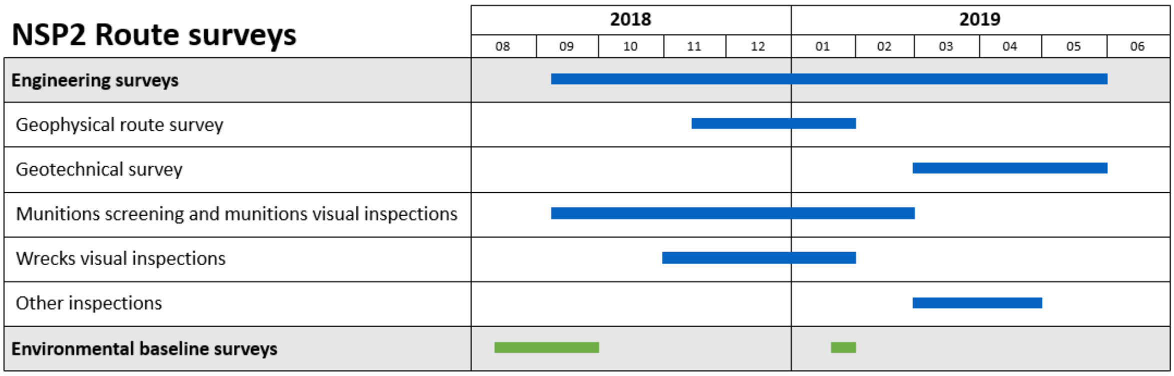


Figure 6-4 Schedule of surveys in Danish waters.

A geophysical route survey along the NSP2 route covering a corridor of approximately 500 m has been carried out to confirm the preliminary pipeline route and to evaluate whether any local route adjustments are necessary.

A detailed route survey covering a corridor with a width of approximately 200 m has been conducted to support route optimisation, enable all objects to be detected and enable detailed profiling along each planned pipeline centreline. This will reduce the likelihood of positioning errors known to be problematic in the Baltic Sea due to pycnoclines.

A geotechnical survey will be 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.

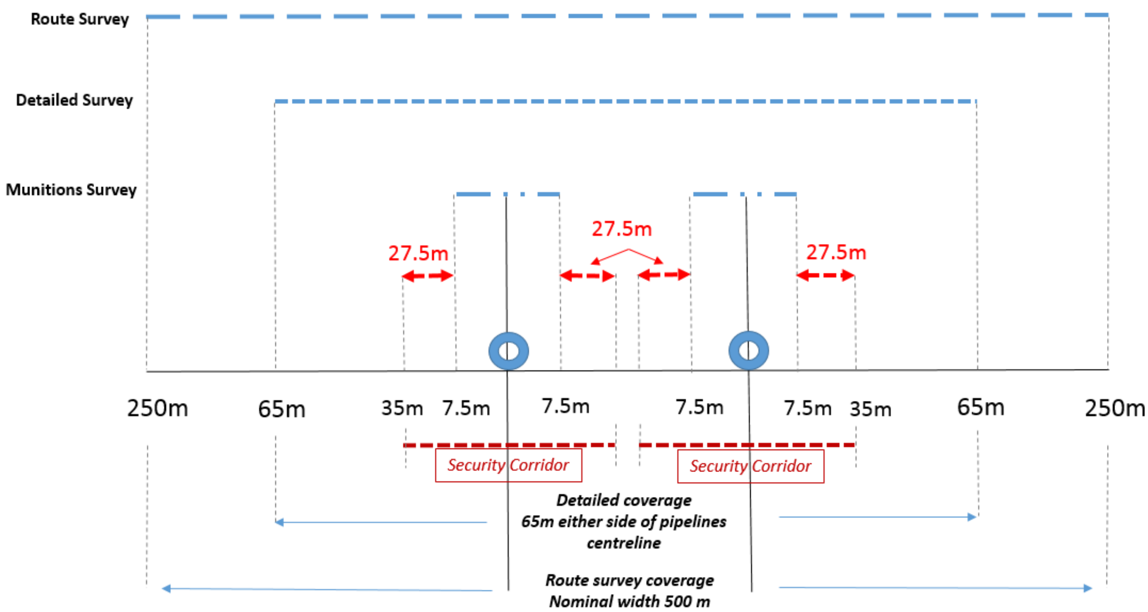


Figure 6-5 Schematic representation of surveys conducted in Danish waters.

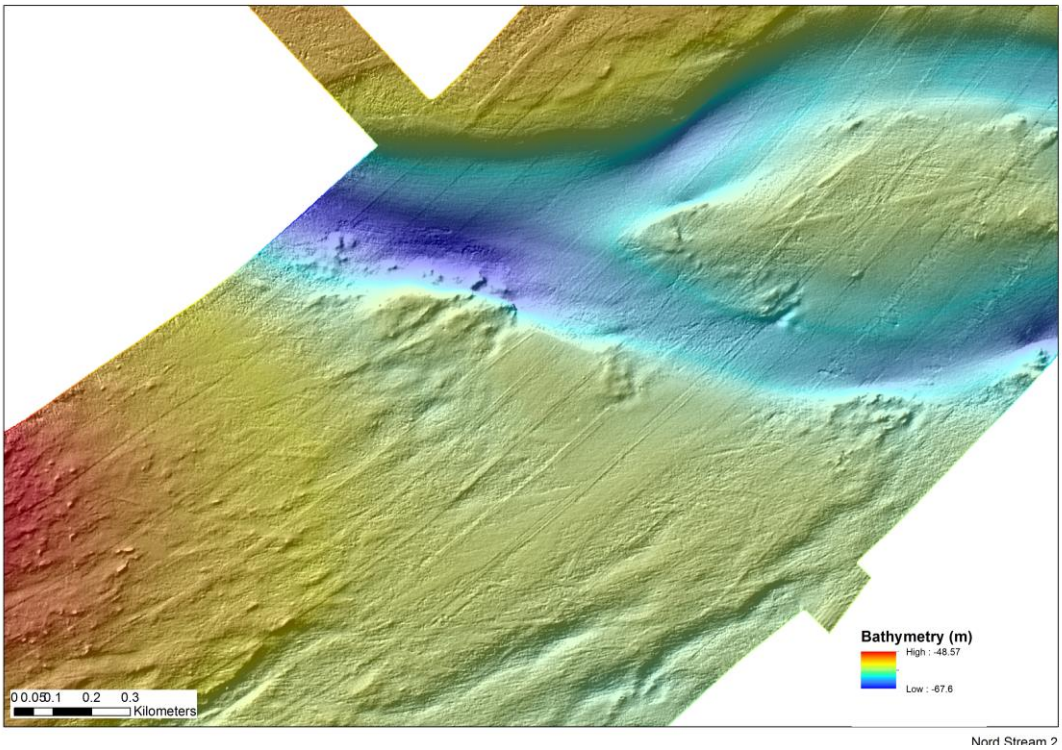


Figure 6-6 Example of bathymetry profile data acquired during a previous reconnaissance survey for the NSP2 base case route.

A munitions screening survey is being performed to establish that the selected pipeline corridor is 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 covers a pipe-lay corridor +/- 7.5 m on either side of the nominal pipeline route. Wider sections are also covered where the pipelines may be subject to post-lay trenching or will involve any seabed intervention works. Magnetic anomalies over a calibrated threshold are then visually investigated using video and still cameras mounted on a remotely operated vehicle (ROV). The larger targets identified during the detailed geophysical survey are additionally visually inspected by ROV.

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

Other surveys include visual inspections and further route optimisation surveys. In the event that an anchored pipe-lay vessel is used, an anchor corridor survey will be undertaken to identify, verify and catalogue all obstructions. A 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, as-laid and as-built surveys will be performed to document the as-built status of each pipeline.

In addition, environmental baseline surveys have been performed in 2018 along the proposed NSP2 route and NSP2 route V2, and in 2019 along the NSP2 route V1. The results of the 2018-2019 surveys have been assessed and are incorporated into this report.

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 below description may be made during the detailed design period. The design development will not, however, change the project significantly, i.e. result 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 1230.4 (NSP2 route with NSP2 route V1) / 1248.1 (NSP2 route with NSP2 route V2): 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 / 41.0 mm (34.6 mm in Denmark)
Line pipe 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	90 mm to 110 mm, 2,400 kg/m^3 to 3,040 kg/m^3
Corrosion protection anodes	Zinc-based anodes in low-salinity water; aluminium anodes in other areas (in Denmark, only aluminium anodes are expected to 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 its 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 NSP2 pipelines.

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

6.2.3 Materials and corrosion protection

In this section, the pipeline material design, manufacture and construction 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 a length of 12.2 m (average length is 12 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 PE external anticorrosion coating consists of an inner layer of fusion-bonded epoxy, a middle adhesive layer and a top layer of PE (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 (for additional density) will be applied over the external anti-corrosion coating (see Figure 6-7). The primary purpose of the CWC is to provide on-bottom stability of the constructed pipeline. Bare line pipes are already designed against external impact loads; however, the coating will provide additional protection above and beyond project requirements.

Once the single line pipe joints are transferred onto the pipe-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, Automated Ultrasonic Testing (AUT), field joint coating and subsequent pipe-lay.

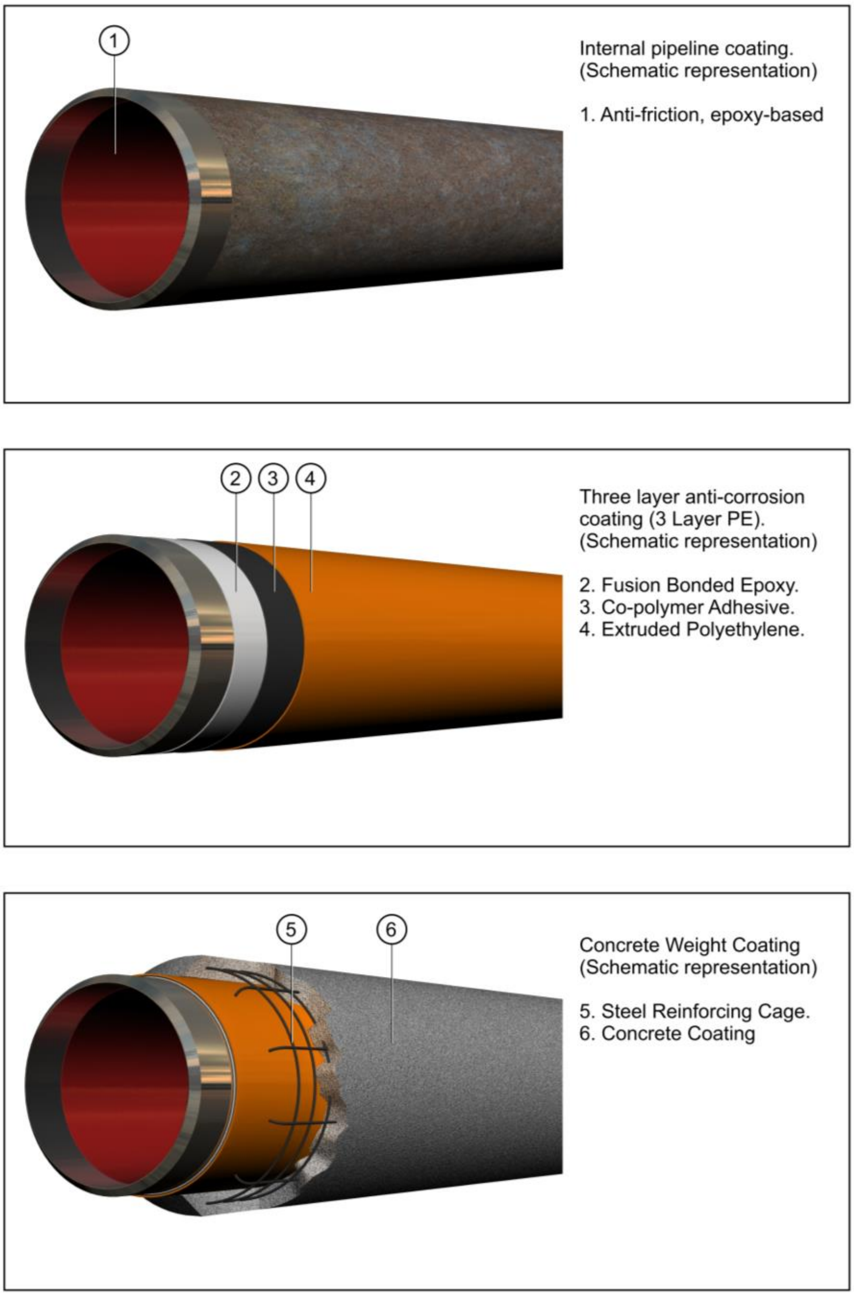


Figure 6-7 Line pipe design.

6.2.3.2 Field joint coatings

After the pipe joints are welded together, and non-destructive examination (via AUT) of the weld has been performed, a field joint coating (FJC) system will be installed to prevent corrosion of the uncoated welded pipe ends, and to fill the space between the CWC sections on either side of the field joint to facilitate safe tension control (see Figure 6-8).

The field joint area will be cleaned using grit blasting before the steel is pre-heated using an induction heating coil, prior to the application of a PE heat shrinkable 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 was used for the pre-heating.

Once the HSS has been installed, a PE former will be installed circumferentially around the field joint and secured onto the CWC on each side of the field joint using a maximum of five banding straps (three of carbon steel and two of stainless steel; the latter is used to protect against band corrosion). Polyurethane foam (PUF) will then be injected into the annular void created by the former. After a short period of time, the PUF will solidify and the coated field joint will become 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.

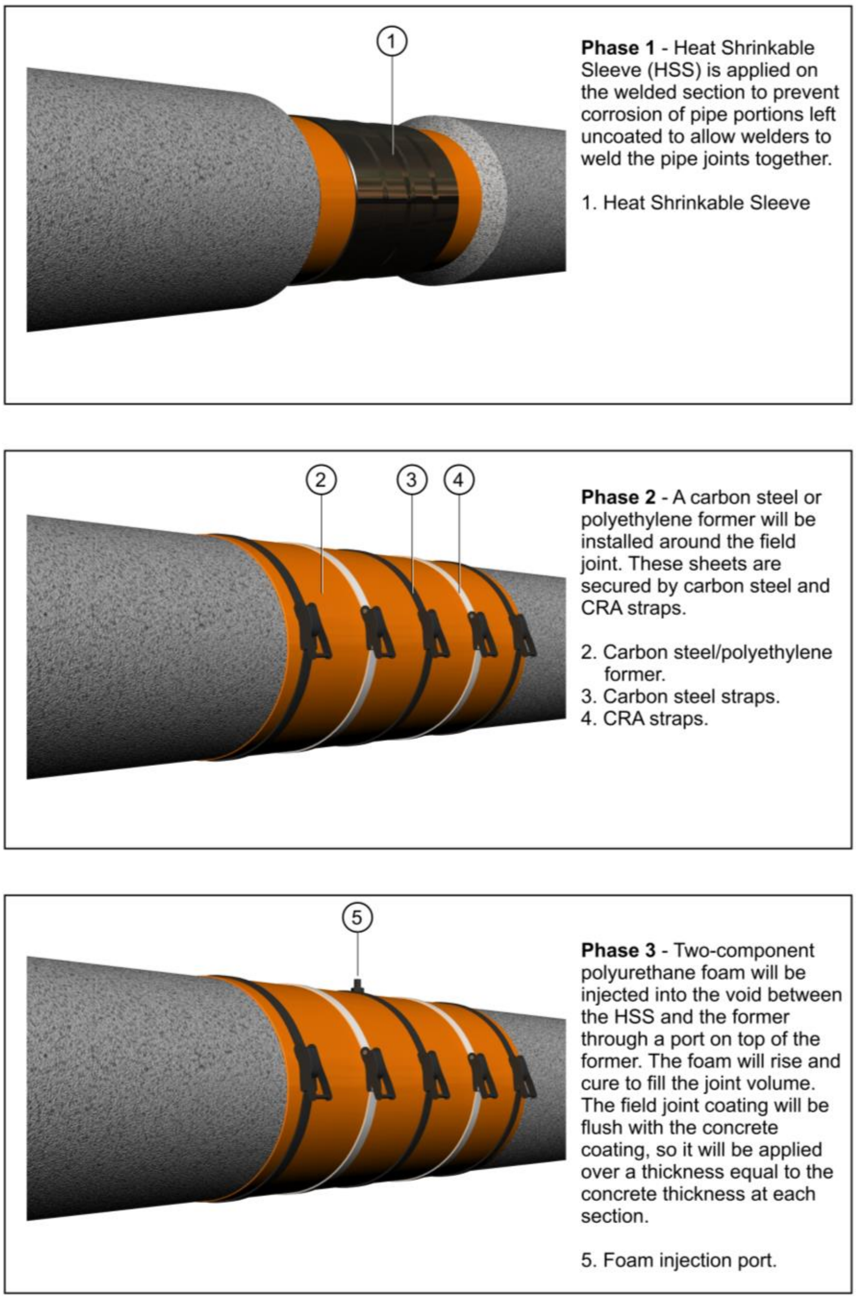


Figure 6-8 Field joint coating, schematic representation.

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 (see Figure 6-9). The pipeline is at risk of collapse when it is empty, i.e. mainly during installation. Buckle arrestors are full-length pipe joints with overdimensioned thickness that are installed in the deep-water sections, typically with a 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 for welding offshore. The material requirements and properties for the buckle arrestors are generally the same as for the line pipe.

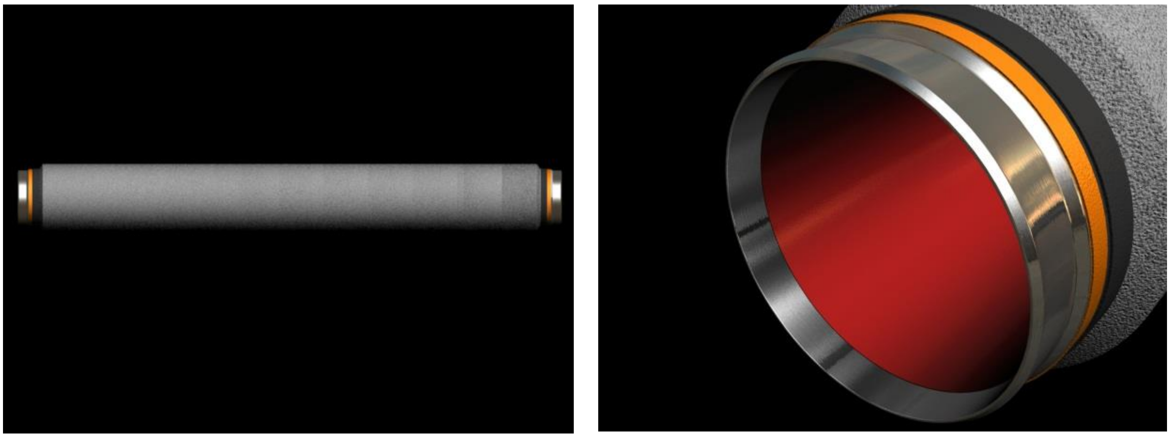


Figure 6-9 Buckle arrestor, schematic representation. Left: full length view; right: zoomed-in view.

6.2.3.4 Anodes for cathodic protection

In addition to the three-layer PE external anti-corrosion pipe coating, 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 (see Figure 6-10). 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 the environmental conditions of the Baltic Sea have 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 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 are expected to be used. The chemical composition of the aluminium anodes is shown in Table 6-2. The anodes will typically be spaced every eight to ten pipe joints apart, but this may be adjusted to suit the local environmental conditions. A total of approximately 3,000 anodes are expected to be installed in the Danish sector if the combination of the proposed NSP2 route with V1 is selected, and approximately 3,370 anodes are expected to be installed in the Danish sector if the combination of the proposed NSP2 route with V2 is selected. The number of anodes is subject to further optimisation.

Table 6-2 Aluminium anode composition.

Element	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	Maximum 0.02 each	
Al	Remainder	

6.2.3.5 Total material 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 NSP2 route with the NSP2 route V1	Denmark NSP2 route with the NSP2 route V2
Total length of two pipelines (km)	293.1	328.6
Steel (t) (including buckle arrestors)	228,745	256,530
Concrete weight coating (t)	330,250	370,200
Anodes, aluminium (t)	1,105	1,240

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 or onshore transportation are planned within Danish territory. Offshore pipe supply and material supply (e.g. rocks) are the major logistics activities in Danish waters. Onshore logistics are, however, briefly described below to provide a more complete 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. Nord Stream 2 AG has entered into agreements with four ports. The port of HaminaKotka (Mussalo) in Finland is considered to serve as a weight-coating location and a marshalling yard for the eastern part of the route. The port of Mukran in Germany is selected to serve as the weight-coating location and a 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.

The logistics concept considers at present that all pipes to be laid in Danish waters come out of German production and will be concrete-weight-coated in the Port of Mukran/Germany. To avoid additional transportation, the base concept foresees to load out and ship the pipes to the lay barge operational in Danish waters principally from Port Mukran.

Generally, line pipes will be produced at pipe mills in Russia and Germany (55% and 45% of the total quantity, respectively). At the mills, the line pipes 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, Mukran in Germany and Volzhsky in Russia, where weight-coating will be applied.

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

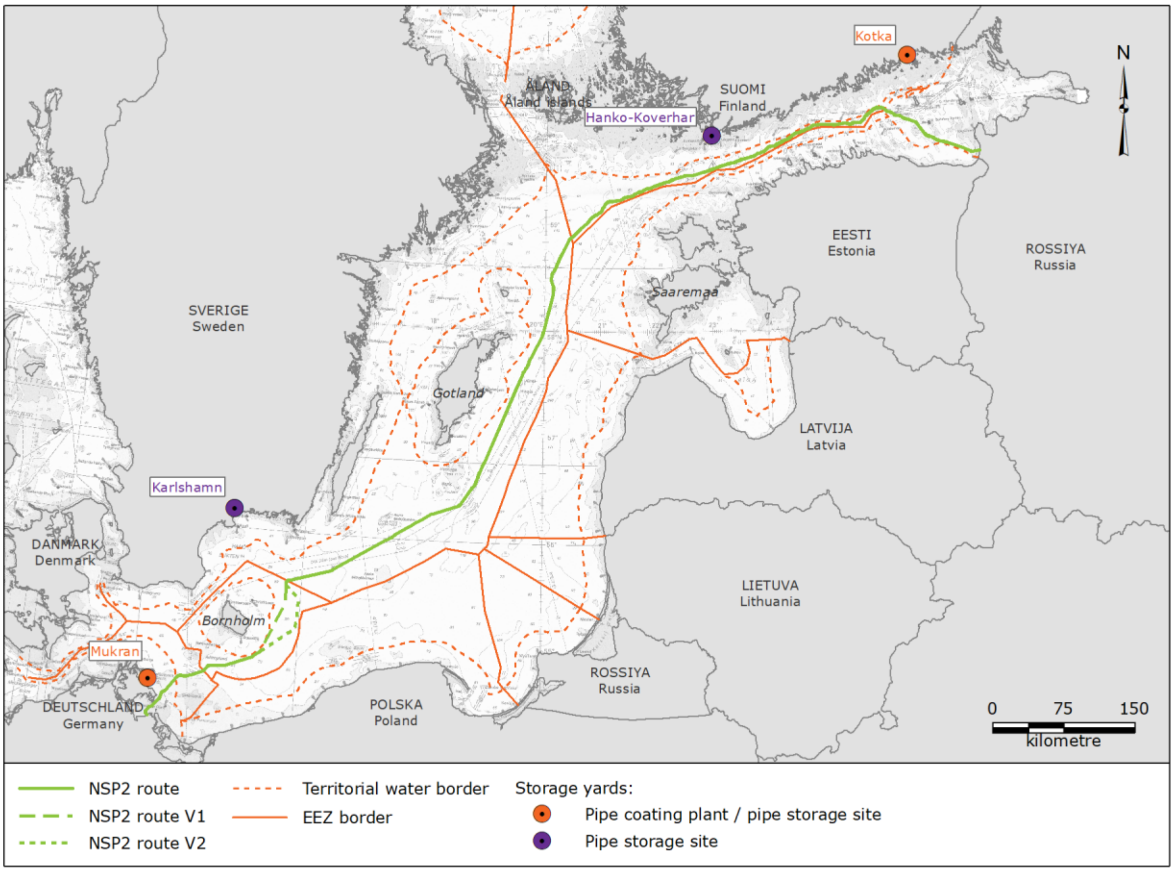


Figure 6-11 Overview of the pipe coating plants and marshalling yards to be used in the NSP2 project. Note that the PCT pipe coating plant in Volzhsky, Russia is not shown on the map due to the distance from the proposed NSP2 route.

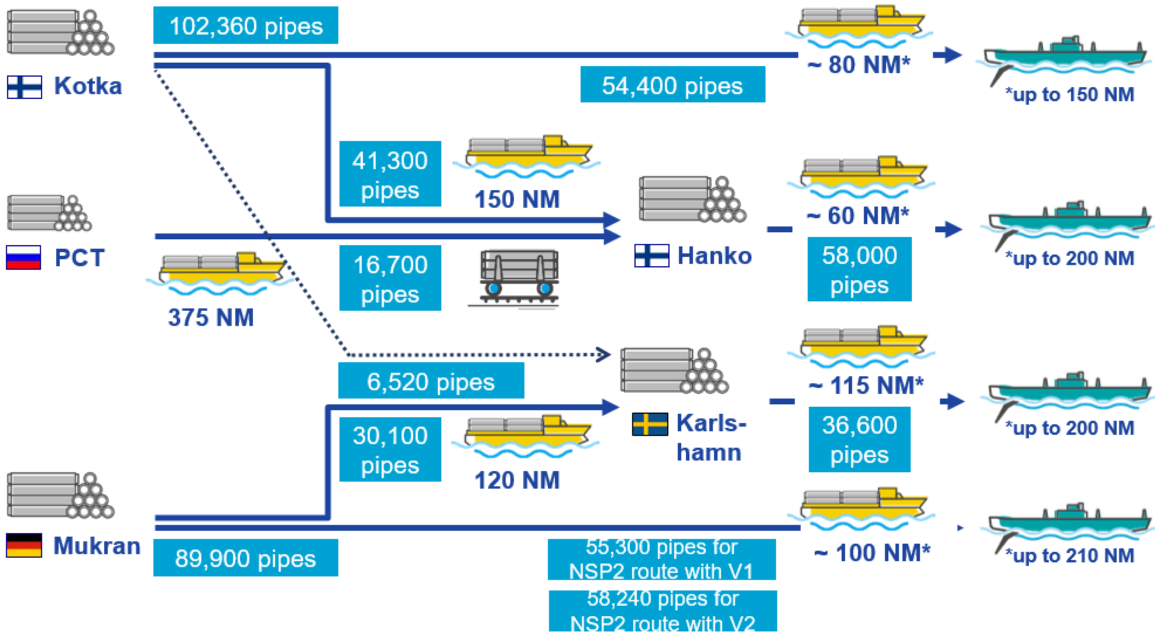


Figure 6-12 Transshipment quantities (approximate). PCT = Pipeline Coating and Technologies, located in Volzhsky, Russia.

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. Weight-coated pipes will be transported to the Danish route principally from Mukran; approximately 24,100 pipes are expected to be needed for the combination of the proposed NSP2 route with V1 or, alternatively, approximately 26,900 pipes are expected to be needed for the combination of the proposed NSP2 route with V2.

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

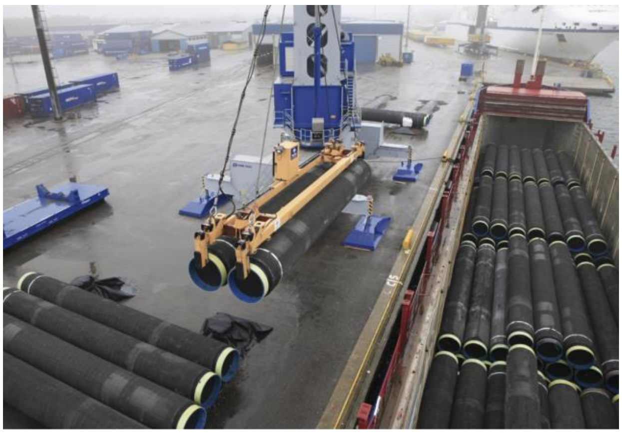


Figure 6-13 Offshore pipe supply.

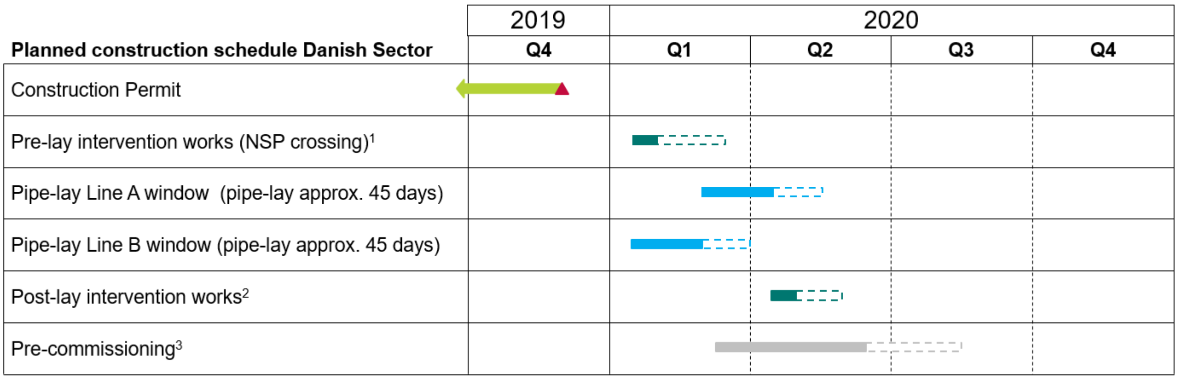
6.3.3 Rock placement material logistics

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 a fall pipe.

6.4 Construction activities and status

Construction activities in Danish waters include pipe-lay and seabed intervention works, see Figure 6-14.



[1] Rock placement (e.g. as a preparation for the NSP crossing) and mattress placement for cable crossings
[2] Rock placement (e.g. NSP crossing) and potentially, according to as-laid survey results, rock placement or plough trenching
[3] No planned intervention works associated with the Pre-commissioning operations, other than tracking of pigs by surface vessel

Figure 6-14 NSP2 construction activities in the Danish sector.

The pipeline installation phase in Danish waters is expected to last approximately 115 days for the NSP2 route with the NSP2 route V1 or 125 days for the proposed NSP2 route with the NSP2 route V2 in total 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 in Danish waters is expected to be undertaken in 2020. It is noted that the schedule may be subject to change during project development.

6.4.1 Pipe-lay

Pipeline installation will be carried out by pipe-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 pipe-lay vessel and onto the seafloor, as it forms an elongated "S" (see Figure 6-15). The individual pipe joints will be delivered to the pipe-lay vessel, where they will then be assembled into a continuous pipeline string on-board the pipe-lay vessel 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 the route. Abandonment of the pipeline may become necessary if weather conditions make positioning difficult or cause too much movement within the system.

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

Generally, pipe-lay can be carried out using a DP or anchored pipe-lay vessel. Based on the project plan with construction in Q1/Q2 2020, a DP vessel will be used for pipe-lay in the Danish section of the route. However, in case an anchored lay vessel is to be used, it is also included in the EIA. 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. For the larger DP vessels, the average pipe-lay rate is expected to be in the order of 3 km/day for DP pipe-lay vessels, depending on weather conditions, water depth and pipe wall thickness.

In the event that an anchored pipe-lay vessel is used for pipe-lay, the anchors will interact with the seabed and may cause localised seabed disturbance. The pipe-lay vessel is kept in position by up to 12 anchors, each weighing up to 25 t. 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 pipe-lay vessel to move the pipe-lay vessel forward and ensure tension can be maintained on the pipeline during pipe-lay. A typical anchor pattern is shown in Figure 6-16.

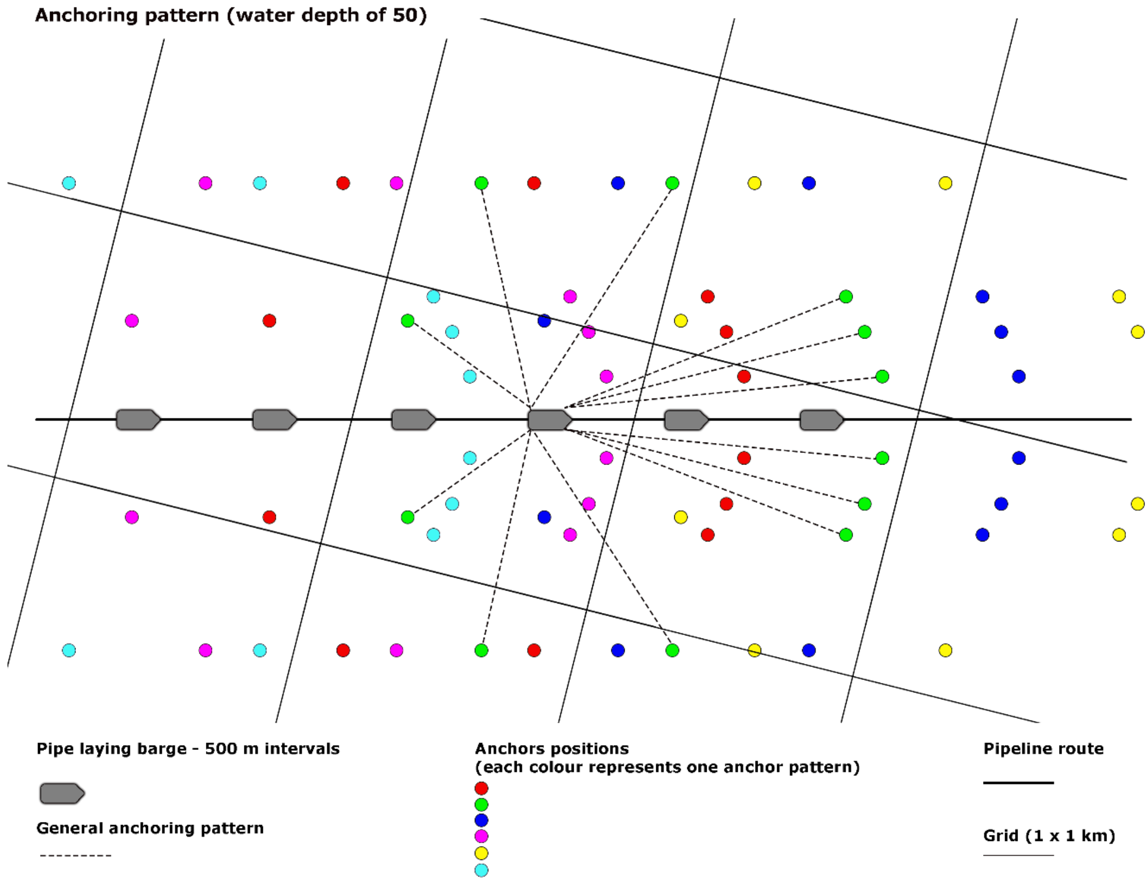


Figure 6-16 Anchoring patterns on the seabed as the pipe-lay vessel moves forward.

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

6.4.2 Seabed intervention works

The pipelines potentially require pre- or post-lay intervention works in some areas. These intervention works may be required for pipeline stabilisation or for integrity reasons. The intervention works may consist of trenching the pipeline into the seabed, or accurate placement of rock. Potential intervention works are summarised as follows:

- Pre-lay rock berm installation at pre-determined locations on the seabed prior to pipe-lay;
- Post-lay rock berm installation over the pipeline at pre-determined locations on the seabed following pipe-lay;
- Post-lay pipeline trenching by lowering the pipeline below seabed level following pipeline installation using a subsea pipeline plough.

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

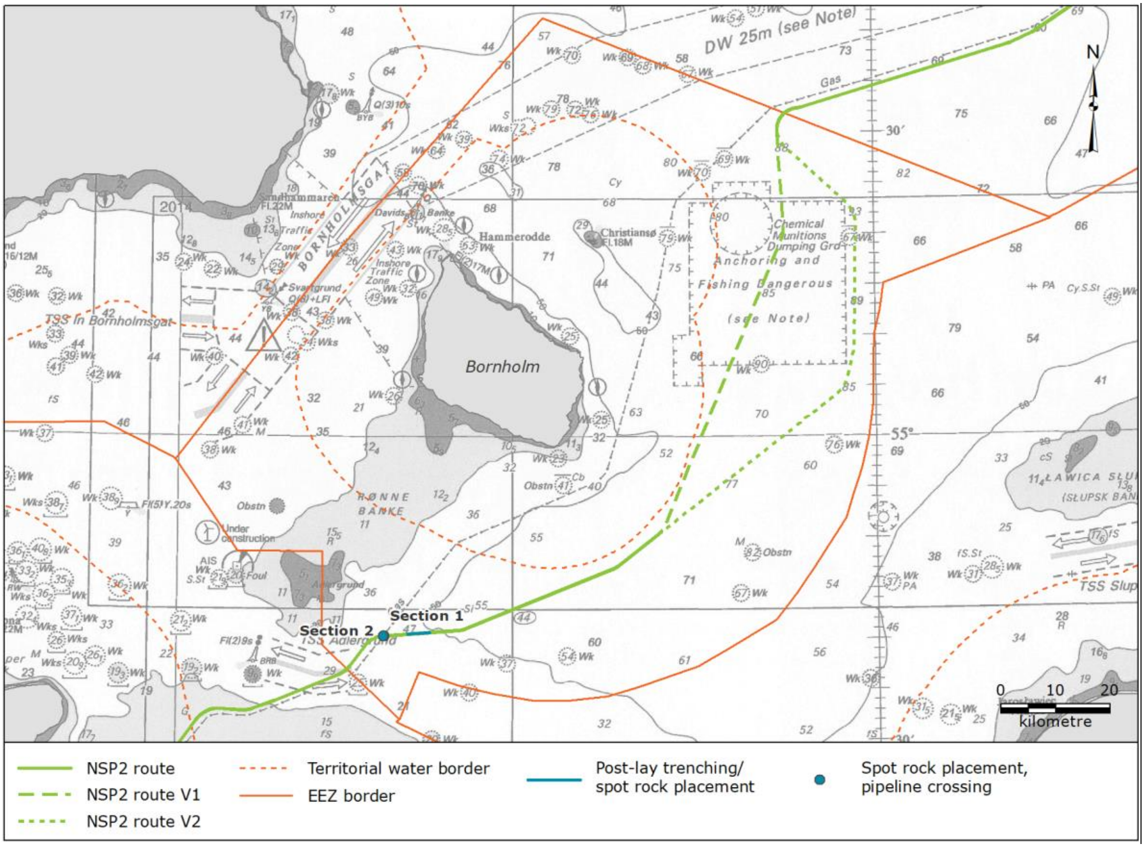


Figure 6-17 Potential intervention works in Danish waters.

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. These show the current estimates but are subject to adjustments as part of the detailed design of the pipelines.

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

Section – Intervention works	Each Line A and Line B		
	From KP	To KP	Length (km)
Section 1 – South of Bornholm, post-lay trenching or spot rock placement	129 (NSP2 route with V1) 146 (NSP2 route with V2)	133 (NSP2 route with V1) 150 (NSP2 route with V2)	4
Section 2 – South of Bornholm, spot rock placement at crossing with NSP pipelines	137 (NSP2 route with V1) 155 (NSP2 route with V2)	137 (NSP2 route with V1) 155 (NSP2 route with V2)	<1

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 pipeline in Danish waters (numbers are volumes per line).

Section / Intervention works	Approx. volume (m^3)*
Rock placement - South of Bornholm, NSP pipeline crossing - South of Bornholm, stabilisation	 30,000 21,440
Post-lay trenching - South of Bornholm, stabilisation	 24,600

* Quantities are approximate and subject to final optimisation.

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.

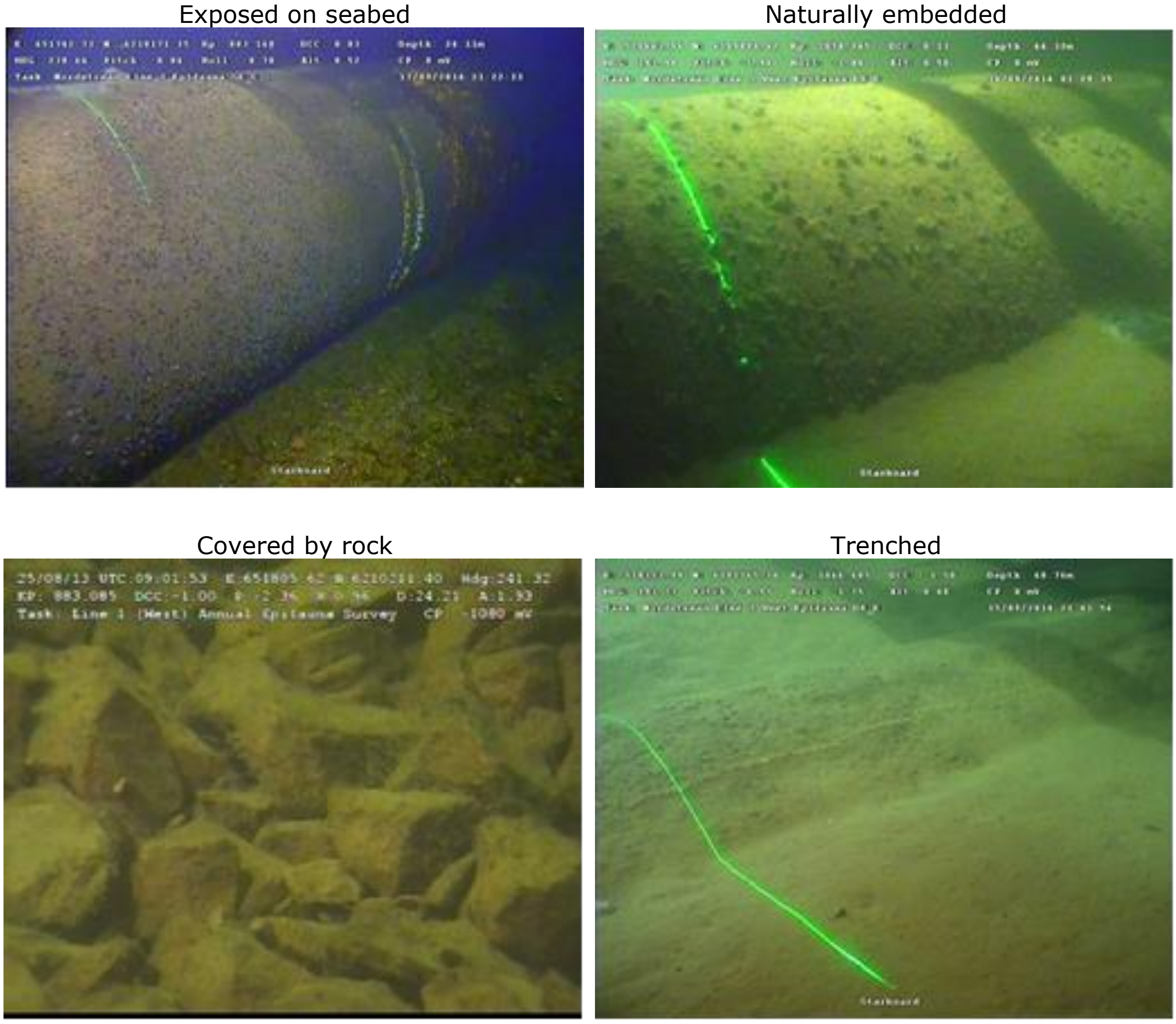


Figure 6-18 Examples of how NSP appears on the seabed.

6.4.2.1 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 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 is surveyed beforehand. Pre-lay gravel berms will then be strategically placed in order to support the pipeline in areas of uneven seabed (causing unacceptable pipeline free spans), 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 crossings of infrastructure and where necessary as pre-lay and post-lay intervention works for the reduction of anticipated freespans and as a pipeline stability measure.

Rock placement activities include gravel works in which coarse crushed rock material is placed in a controlled manner by a fall-pipe (see Figure 6-19).

Figure 6-19 Rock placement on the seabed through a fall-pipe.

The geometry of each gravel support is engineered according to seabed conditions, bathymetry in the surroundings, currents, etc. A typical geometry of the rock berms that would be placed on the NSP2 pipelines is shown in Figure 6-20. The final shape/dimensions and position of the berms will be developed as part of the detailed pipeline design.

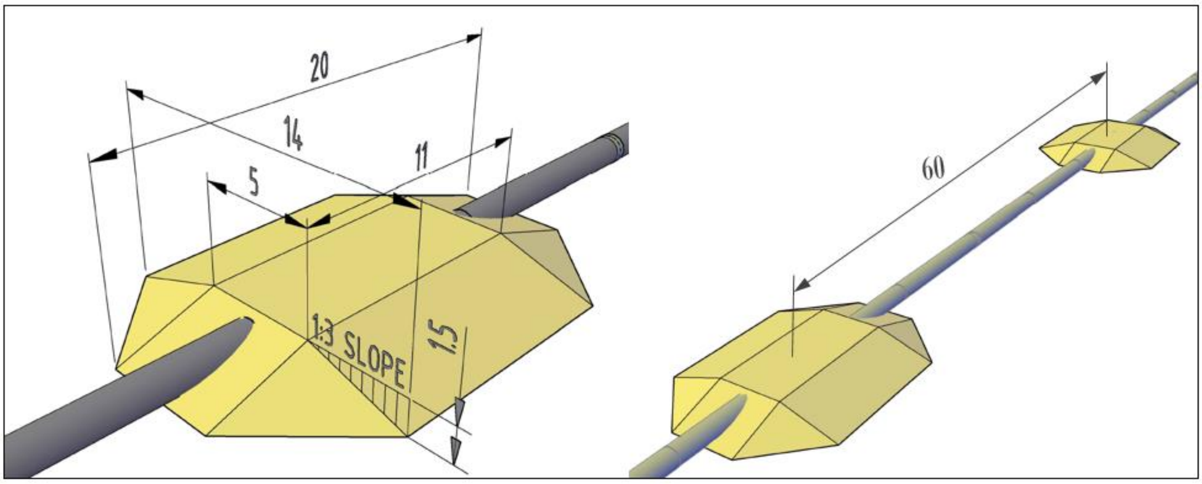


Figure 6-20 Rock berm; typical dimensions are shown in metres.

6.4.2.2 Post-lay trenching

In sections where additional stabilisation of the pipelines might be required, the possible approach is post-lay trenching, with a trench depth of approximately one pipeline diameter. Post-lay trenching will be carried out using a pipeline plough (see Figure 6-21) 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, and the mother vessel or a separate tow vessel 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.

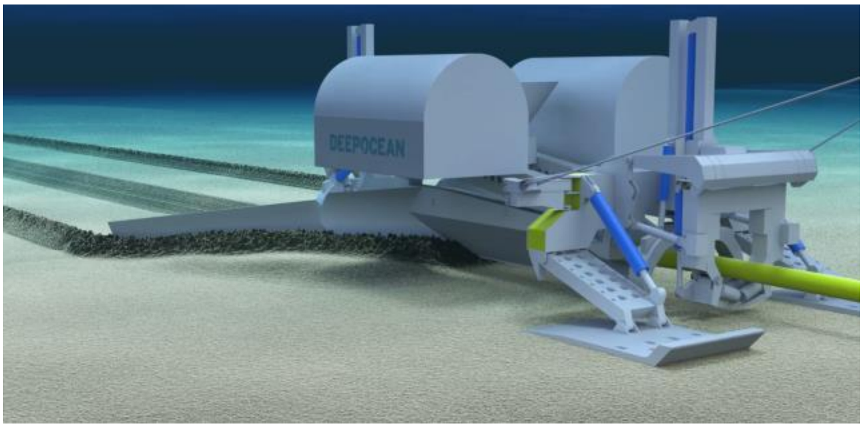


Figure 6-21 Post-lay trenching. Typical pipeline plough in operation on the seabed.

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.

Due to the nature of post-lay trenching operations, seabed soils will be present on the pipeline plough when it is recovered on board the plough support vessel. Accordingly, it is proposed that an expert lead from the Danish Navy be mobilised to the plough support vessel for the duration of the post-lay plough operations in order to check for any chemical munitions that may have come into contact with the trenched pipeline section.

6.4.3 Crossings of infrastructure (cables and pipelines)

The proposed NSP2 route crosses power and communication cables (existing and planned) and the two existing NSP 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. An example of a cable crossing configuration is shown in Figure 6-22. The crossing configuration shown comprises a combination of flexible and rigid mattresses.

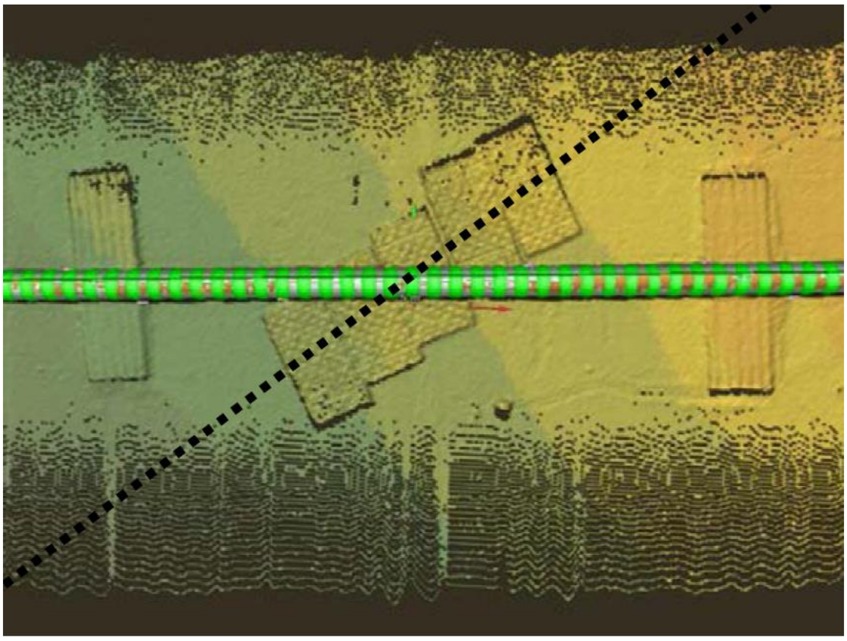


Figure 6-22 Layout of a typical cable crossing (cable is shown as a black dotted line).

There were no pipeline crossings on the NSP project. Pipeline crossings will be similar to that undertaken in Finnish waters for the crossing of NSP2 Line A over the NSP pipelines.

The typical crossing of pipelines is shown in Figure 6-23.

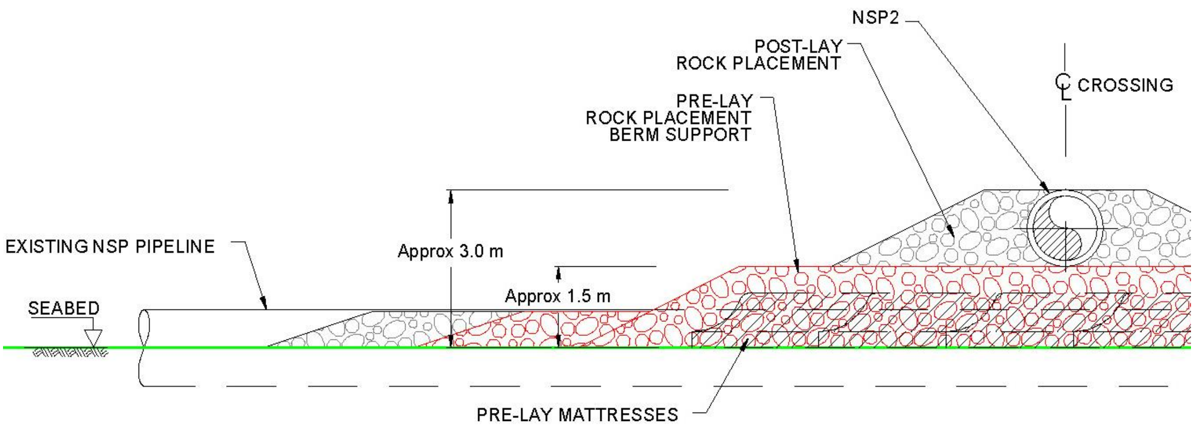


Figure 6-23 Typical design for crossing of pipelines.

6.4.4 Construction status

Permits have been granted in Germany, Sweden, Finland and Russia, and construction work is ongoing in these jurisdictions. The Allseas DP pipe-lay vessels Solitaire and Pioneering Spirit are performing offshore pipe-lay in Swedish, Finnish and Russian waters.

Almost 2,500 km of pipes have been delivered from the pipe mills to the coating plants. Concrete-weight-coating of the pipes has been completed at two of the three coating sites: Kotka, Finland and Volzhsky, Russia. The coating plant in Mukran, Germany will coat the additional line-pipes required for SE route.

Construction at the German landfall site commenced in February 2018 and is progressing as planned. The two offshore pipelines were pulled-in from the offshore lay vessel through microtunnels to the gas receiving area in early August 2018 and as of the end of December 2018, both pipelines have been installed to 16.5 km from the Danish/German EEZ border. In Sweden the two pipelines in Sweden have been partially installed. One pipeline is being installed from Finland heading south and the second is being installed from a point 6 km from the Danish/Swedish EEZ border towards Finland. Over 500 km of pipeline have been laid in Swedish waters. The munitions clearance and prelay rock placement are completed in Finland and the first line has been installed. The second pipeline will be laid during the summer 2019. In Russia landfall construction is progressing as planned and the nearshore dredging and onshore trenching works are nearing completion to allow the two offshore pipelines to be pulled-in during summer 2019.

6.5 Pre-commissioning and commissioning

The chosen “Dry” pre-commissioning concept includes 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 is then inserted into the pipelines as an inert buffer 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.

During pre-commissioning and commissioning, a support vessel may be employed to monitor the processes occurring within the pipeline. Given the limited nature of such activities in Danish waters, they are 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 will take 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 Centre (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 system 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 the 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 MCC in the head office in Switzerland. The MCC 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. Nord Stream 2 AG will only provide operational flow measurements used to monitor pipeline operation.

6.6.3 Maintenance operations

Maintenance operations comprise the inspection and maintenance of the NSP2 pipeline system in order to ensure the integrity of the system and enable the 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 best industry practice. Planned inspection and maintenance of 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 using an ROV 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 freespan 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 /85/). This section describes the generation and management of offshore waste relevant to construction and operational 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 experience from NSP, 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% – this includes 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 the relative proportions of the waste types generated during NSP offshore activities.

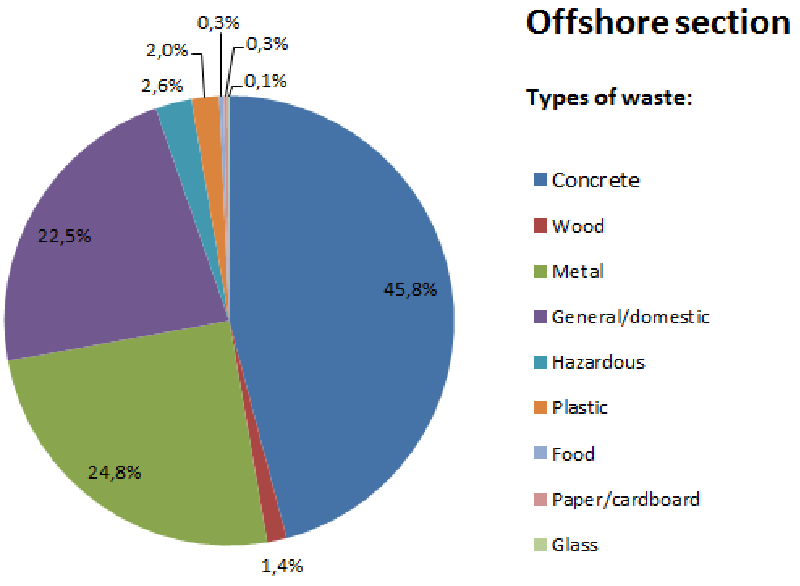


Figure 6-24 Types of waste generated during NSP offshore construction activities.

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 /85/).

The total amount of waste derived from offshore construction is expected to be approximately 7,200 t. Taking into account that the length of the proposed pipeline route in Danish waters is approximately 13% of the total route, waste generated in the Danish section is expected to be approximately 900 t.

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 manage wastes to acceptable international standards. Contractor waste management plan(s) and supporting procedures will be developed and implemented for each vessel and Nord Stream 2 AG will track waste volumes and types in a waste inventory.

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 Swedish EEZ border north-east of Bornholm through the Danish EEZ east and south of Bornholm to the German EEZ border south-west of Bornholm. Conditions along both variants of the NSP2 route are described in this section. Given that general conditions are overall similar in the areas of the two route alternatives, the baseline descriptions are considered applicable to both alternatives, unless otherwise specified.

The following environmental and socio-economic resources or receptors have been identified and will be described in detail in sections 7.3 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 sites;
- 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 sites
- Military practice areas;
- Environmental monitoring stations.

Although conventional and chemical munitions are not a resource or receptor, and therefore not included in the list above, the topic was identified during consultation as an issue requiring particular consideration, and 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 surveys completed in the project area

The environmental baseline description has been prepared on the basis of surveys undertaken along the proposed NSP2 route corridor, peer-reviewed scientific literature, relevant EIAs (e.g. the national EIA reports for NSP and the NSP2 base case route, which provided valuable sources of empirical data for the area), data from the monitoring programme for NSP, as well as other relevant technical reports and data for the area. The existing information includes survey data for a number of parameters relevant to the baseline descriptions for this EIA. Specifically, the following environmental surveys have been performed in the area relevant to the NSP2 route:

- 2005-2006: Peter Gaz surveys for the planning of the NSP route;
- 2015-2016: surveys for the planning of the NSP2 base case route;
- 2018-2019: surveys for the planning of the NSP2 route.

The present data basis for this EIA is described in more detail in the sections below

7.1.1 Survey data basis for this EIA

Several surveys were conducted in Danish waters in connection with preparation of the national EIA report for the NSP2 base case route /73/. These surveys serve as valuable sources of empirical data for the general area of the proposed NSP2 route. These surveys were conducted in order to inform route development as well as to ensure a solid basis for the baseline descriptions and subsequent impact assessment. Surveys have also been undertaken through the previously disputed area between Denmark and Poland in connection with an earlier route alternative considered for NSP (carried out by Peter Gaz, /86/).

The general locations of prior sampling events (i.e., in Danish waters east and south of Bornholm) are similar in character to the area of the proposed NSP2 route. It is furthermore assessed that conditions in the Danish section of the Baltic Sea have not changed significantly since the completion of these surveys. As such, the data gathered in the previously described surveys are considered to be relevant to the present EIA.

New surveys were conducted along the proposed NSP2 route (SE route) corridor and along the NSP2 route V2 corridor in August-September 2018, in order to verify the validity of the previously collected data in the general project area and to provide a more robust data basis for the baseline descriptions and impact assessments provided in this EIA /87//88//92/.

These prior environmental surveys are described in general terms below, whilst further details can be found in the survey reports, see references below.

7.1.1.1 Surveys along the NSP2 base case and proposed NSP2 route (SE route)

Environmental baseline surveys were undertaken in the Danish waters east and south of Bornholm in 2015 and 2016 in order to inform route development for the NSP2 base case route. In August-September 2018, surveys of the same environmental parameters were completed along the Danish section of the proposed NSP2 route and NSP2 route V2, with the purpose of providing baseline data for use in the EIA report. These surveys are described further below, and the survey results have been included in this report where relevant.

Seabed sediment

In October 2015, an environmental survey of surface sediment conditions was undertaken in Danish waters in connection with the NSP2 base case route /89/. These survey results were supplemented in August-September 2018 with surveys of surface sediment along the proposed NSP2 route (SE route) and NSP2 route V2 (SE route V2) /87/. The locations of the survey stations pertinent to the route alternatives assessed in this EIA are shown in Figure 7-1.

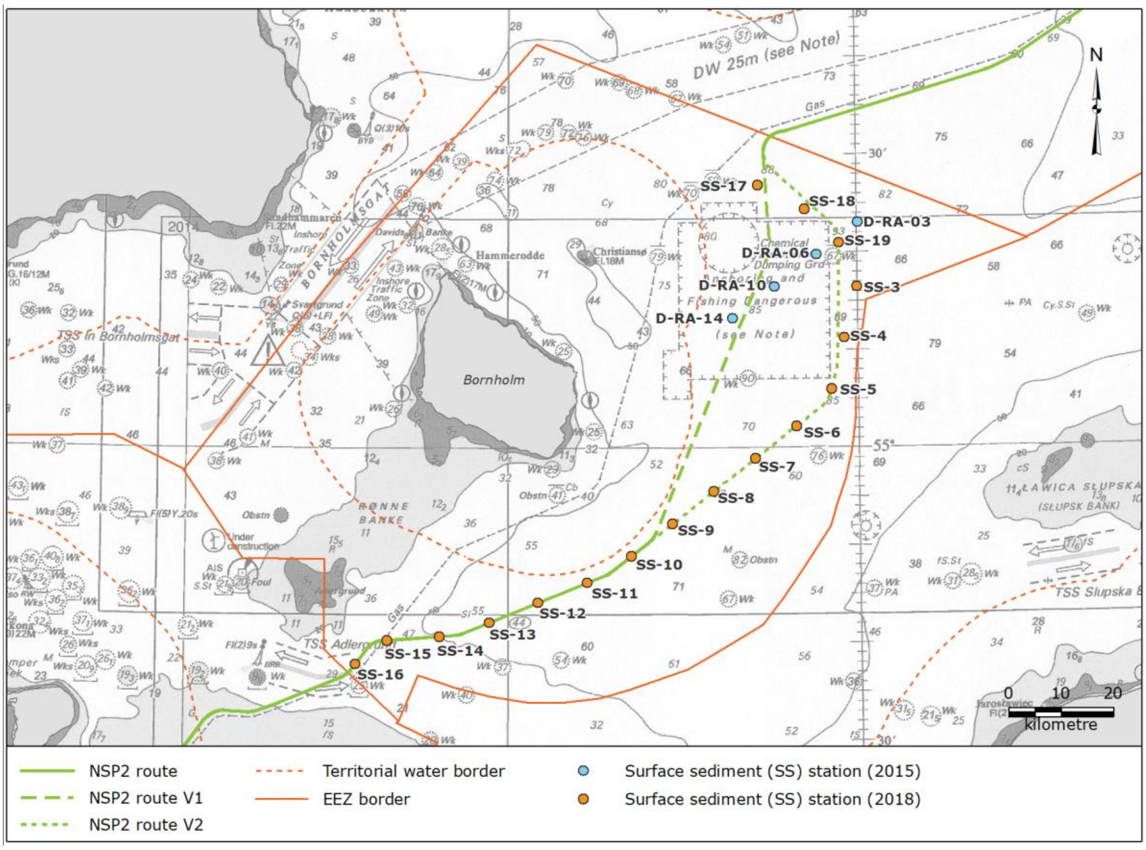


Figure 7-1 Survey stations for analysis of surface sediment conditions in Danish waters.

The surveys included the following sampling activities /89/:

- Photographic documentation of the sediment surface at all sampling stations using a video camera mounted in a frame;
- Analysis of surface sediments performed with a HAPS core sampler.

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

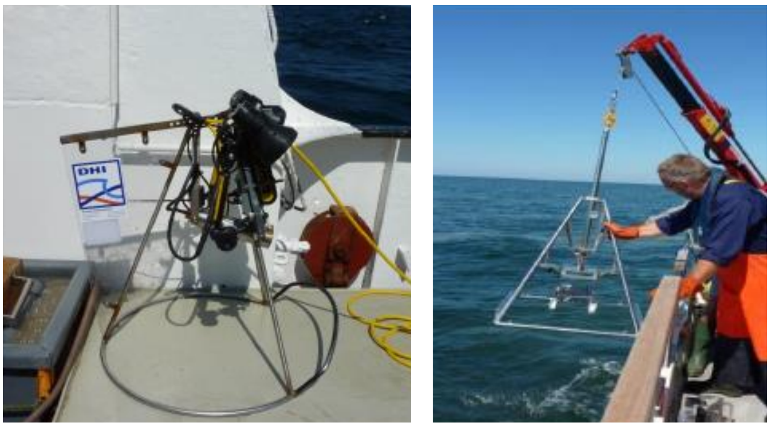


Figure 7-2 Sampling of the surface sediment was undertaken using a video camera (left) and HAPS core sampler (right).

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, CWA, and nutrients /89/.

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

Infauna

In October 2015, an environmental survey of infauna was undertaken in Danish waters in connection with the NSP2 base case route /90/. These survey results were supplemented in August-September 2018 with surveys of infauna along the proposed NSP2 route (SE route) and NSP2 route V2 (SE route V2) /88/. The locations of the survey stations pertinent to the route alternatives assessed in this EIA are shown in Figure 7-3.

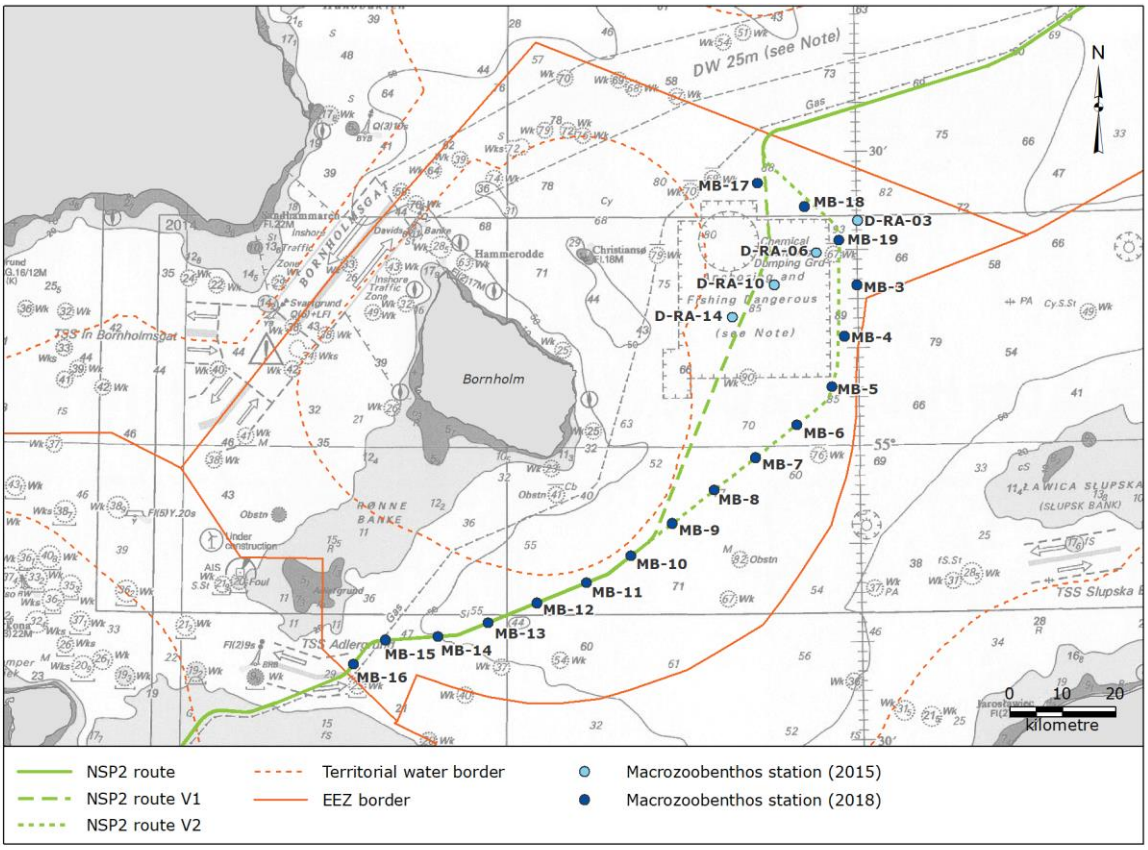


Figure 7-3 Survey stations for analysis of surface infauna (macrozoobenthos) in Danish waters.

The surveys 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 7-4 Sampling of infauna was undertaken with a Van Veen sampler (left). An example of an infauna sample (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. The key survey results are presented in section 7.8.

Chemical warfare agents in seabed sediment

In October 2015, an environmental survey of CWA was undertaken in Danish waters along the NSP2 base case route and through the risk area /91/. During surveys conducted in August-September 2018 /92/, sampling was undertaken at approx. 5-km intervals along the NSP2 route V2, where the 2015 NSP2 base case route survey identified a higher frequency of CWA-positive samples. This part of the route is relatively close to the known chemical munitions dumping area and within the risk area in which fishing vessels are required to have first aid gas equipment on board. Sampling was undertaken at approx. 10-km intervals along the remaining, western part of the route. The locations of the survey stations sampled in 2015 and 2018 are shown in Figure 7-5.

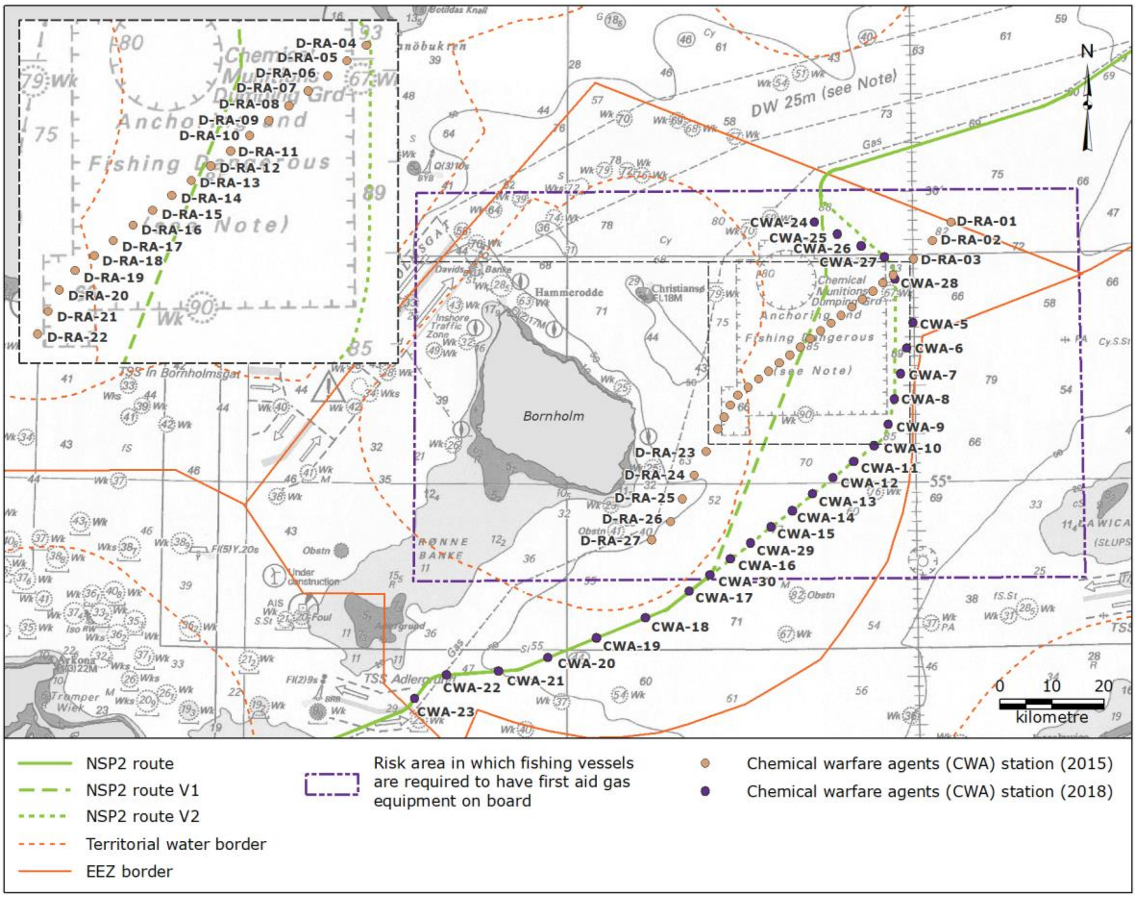


Figure 7-5 Survey stations for CWA in Danish waters.

The survey included the following sampling activities:

- Seabed sampling performed with a Van Veen sampler or HAPS core sampler (see Figure 7-2 and Figure 7-4);
- 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 /91/, as summarised in Table 7-22. The key survey results are presented in section 7.3.3.8.

7.1.1.2 Peter Gaz surveys

In 2005 and 2006, Peter Gaz conducted surveys of seabed sediments and benthic fauna in the waters of Russia, Finland, Sweden, Denmark and Germany /86/. The surveys included sampling of:

- Organic pollutants and radionuclides in sediments, sampled with a grab sampler to a sediment depth of up to 20 cm (12 stations in the Danish EEZ).
- Metals and organic carbon in sediments, sampled with a grab sampler to a sediment depth of up to 20 cm (12 stations in the Danish EEZ).
- Biomass and abundance of phytoplankton in six main groups. Water samples for phytoplankton investigation were taken from the subsurface layer (approximately 1 m depth) and from the near bottom layer (2 m above the bottom) and mixed. Water sampling was carried out simultaneously with hydrochemical sampling using plastic bathometers, attached to submerged hydrological rosette probe. The samples were fixed in lugol for further identification (six stations in the Danish EEZ).

- Biomass and abundance of zooplankton in four main groups, as well as six species of copepod, sampled with an inversely coned net (BJN – Big Jedi Net) with a filtration cone made of capron sieve № 68 (mesh size 76 µm) (six stations in the Danish EEZ).
- Biomass and abundance of zoobenthos in six main groups, as well as four species of bivalve, sampled with a 0.025 m^2 Petersen grab scoop bottom sampler (six stations in the Danish EEZ);
- Planktonic fish, sampled with a special net made of capron sieve № 38 (mesh size approx. 0.4 mm) (five stations in the Danish EEZ).

Sampling stations in the Danish EEZ are shown in Figure 7-6.

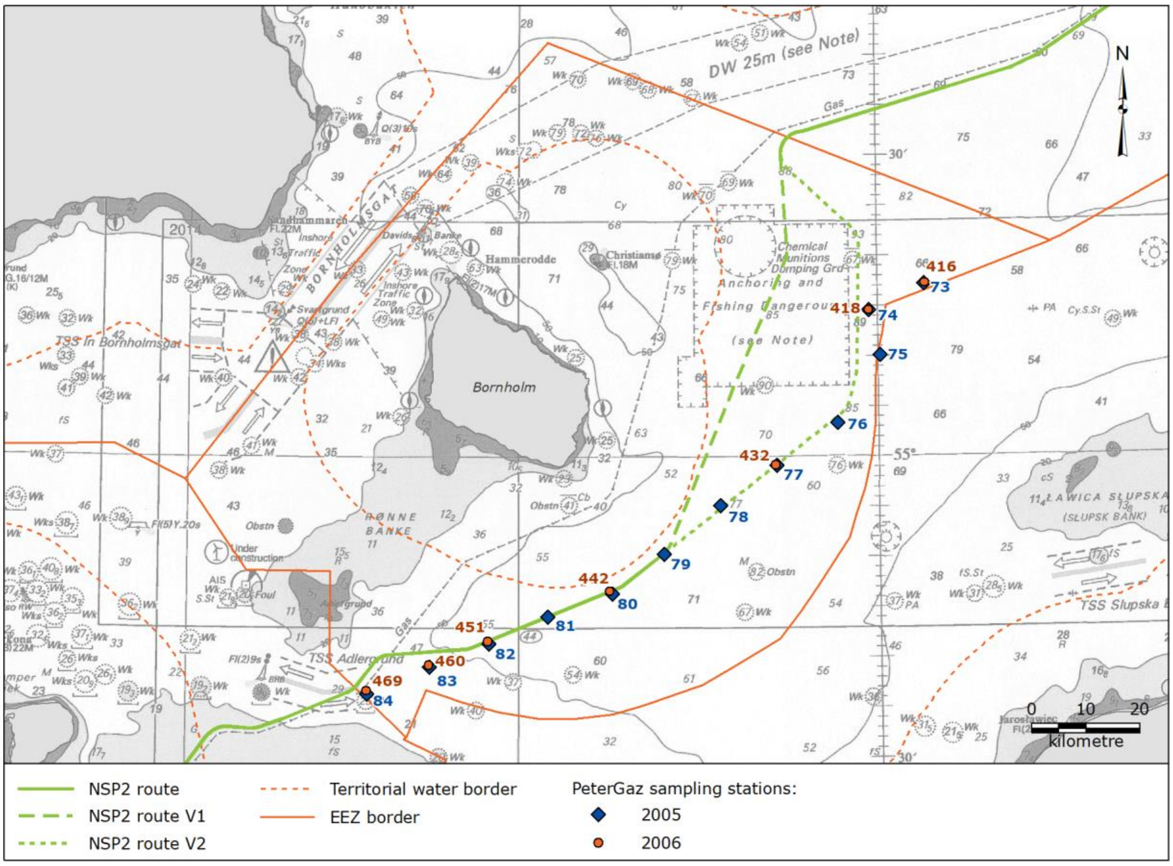


Figure 7-6 Survey stations for the Peter Gaz surveys in 2005 (blue diamonds) and 2006 (red dots) in the Danish EEZ.

Key results are presented in sections 7.3, 7.7 and 7.8.

7.1.2 Surveys along the proposed NSP2 route V1

Additional environmental baseline surveys were carried out in January 2019 along the NSP2 route V1. The objective of these surveys is to verify the validity of the baseline data used in the EIA report (i.e. data collected during investigations of previously considered route alternatives for NSP2, as described in section 7.1.1) and thereby confirm the assessments and conclusions contained herein. The results of the surveys can be provided to the authorities upon request.

The baseline surveys included:

- Survey of the physical and chemical characteristics of the seabed sediment;
- Survey of benthic infauna;
- Survey of CWA in seabed sediment.

The surveys are performed by sample collection and subsequent analysis. Details of each surveyed parameter are provided in the sections below.

7.1.2.1 Seabed sediment

The purpose of the seabed sediment baseline surveys is to map the physical and chemical characteristics of the surface sediment along the proposed NSP2 route V1 inside the Danish EEZ.

Sediment was sampled at approx. 10 km intervals along the proposed NSP2 route V1. Sediment was sampled with a HAPS core sampler (or alternatively with a Van Veen grab) for physical and chemical analysis. The locations of the survey stations along the proposed NSP2 route V1 are shown in Figure 7-7.

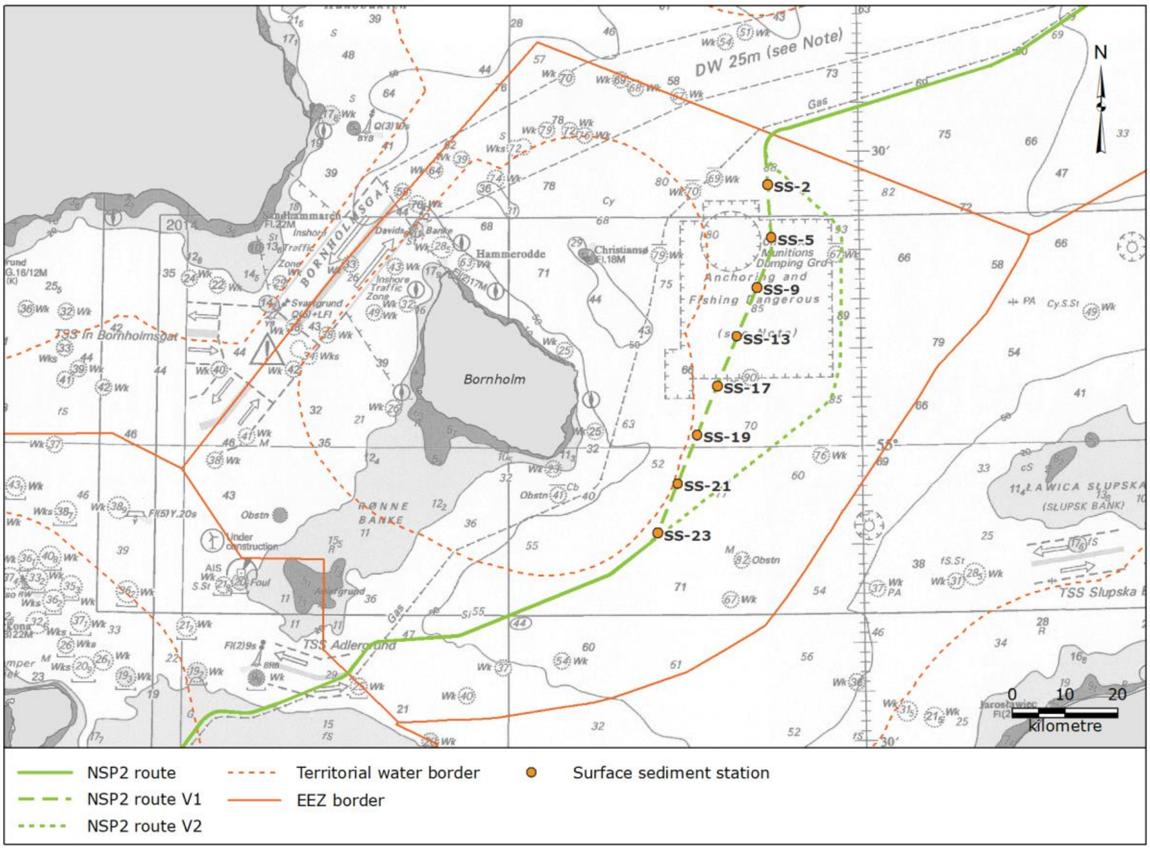


Figure 7-7 Surface sediment stations along the proposed NSP2 route V1 in the Danish EEZ.

7.1.2.2 Infauna

The purpose of the infauna baseline survey was to map the current characteristics of and variation in the benthic macrozoobenthos communities along the proposed NSP2 route V1.

The seabed was sampled at approx. 10 km intervals along the proposed NSP2 route V1. The survey was completed by taking three replicate samples of the seabed with a van Veen sampler at each station for macrozoobenthos analysis. The locations of the survey stations along the proposed NSP2 route V1 are shown in Figure 7-8.

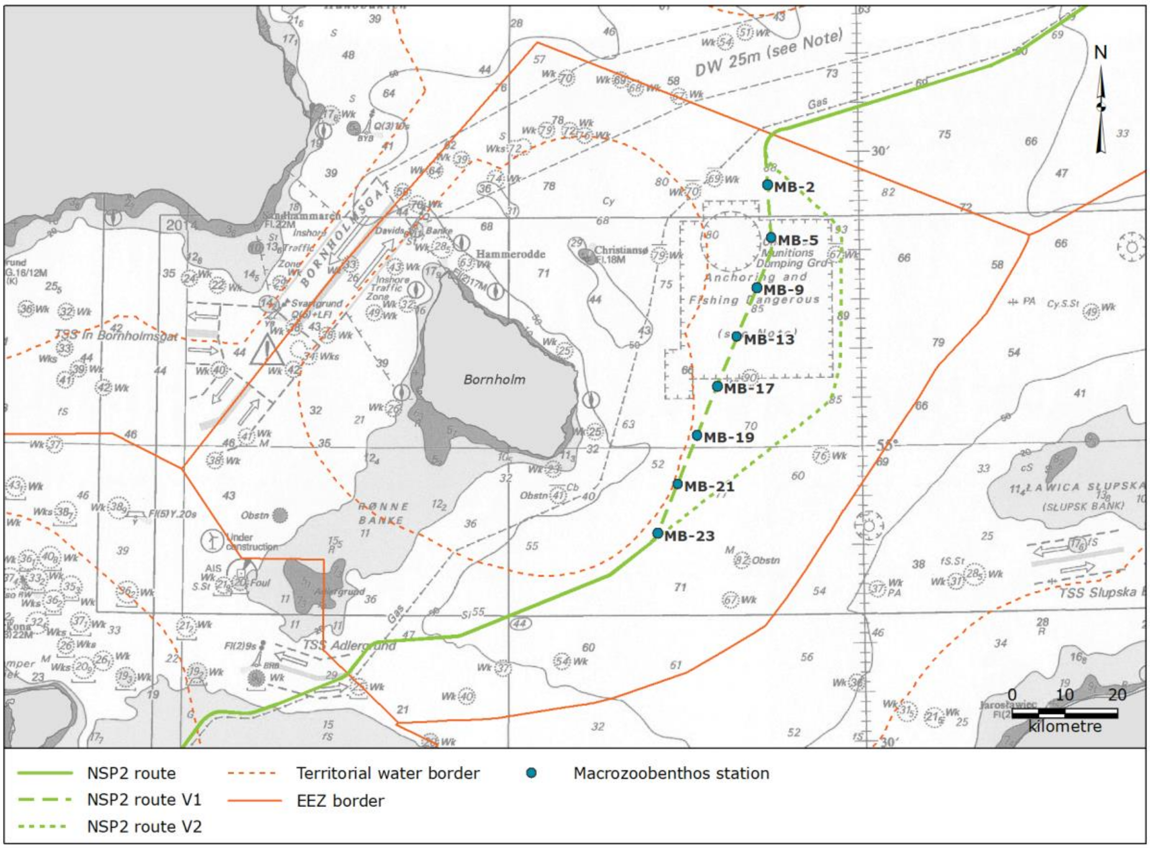


Figure 7-8 Macrozoobenthos stations along the proposed NSP2 route V1 in the Danish EEZ.

7.1.2.3 Chemical warfare agents in seabed sediment

The purpose of the CWA baseline survey is to map the concentrations of CWA in the surface sediment along relevant sections of the proposed NSP2 route V1.

Sampling was undertaken at approx. 5-km intervals in the eastern part of the proposed NSP2 route V1, where the 2015 NSP2 base case route survey identified a higher frequency of CWA-positive samples (see section 7.1.1). This part of the route is relatively close to the known chemical munitions dumping area and within the risk area in which fishing vessels are required to have first aid gas equipment on board. Within the area in which bottom trawling, anchoring and seabed intervention works are discouraged due to known and suspected historical chemical munitions dumping, through which the NSP2 route V1 crosses, sampling was undertaken at approx. 2.5-km intervals. The locations of the survey stations along the proposed NSP2 route V1 are shown in Figure 7-9.

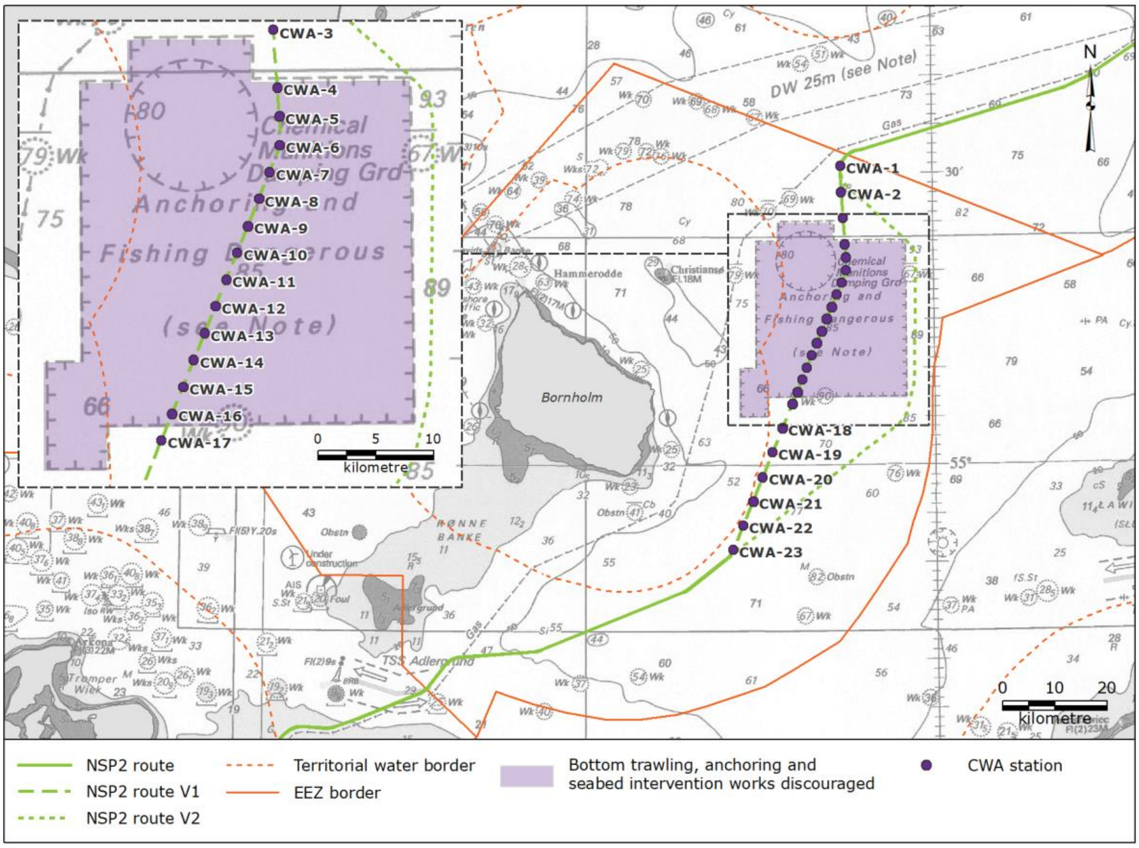


Figure 7-9 CWA stations along the proposed NSP2 route V1 in the Danish EEZ.

Preliminary data from this survey have been received, and are referred to in sections 7.3.3.8 and 8.4.4.

7.2 Bathymetry

7.2.1 General conditions

The Baltic Sea is characterised by its deep basins and shallow sills that, together with meteorological conditions, control the exchange of saltwater 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 a defining factor for marine 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, eastern 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 /93//94/. The topography of the seabed is characterised by several basins separated by sills at different depths /95/. The names of the major basins of the Baltic Sea are shown in Figure 7-10, and the bathymetry is shown in Figure 7-11 and in Atlas Map BA-01-D.

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 the Femern Belt, with a water depth of 18 m, and the Drogden Sill in the 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.

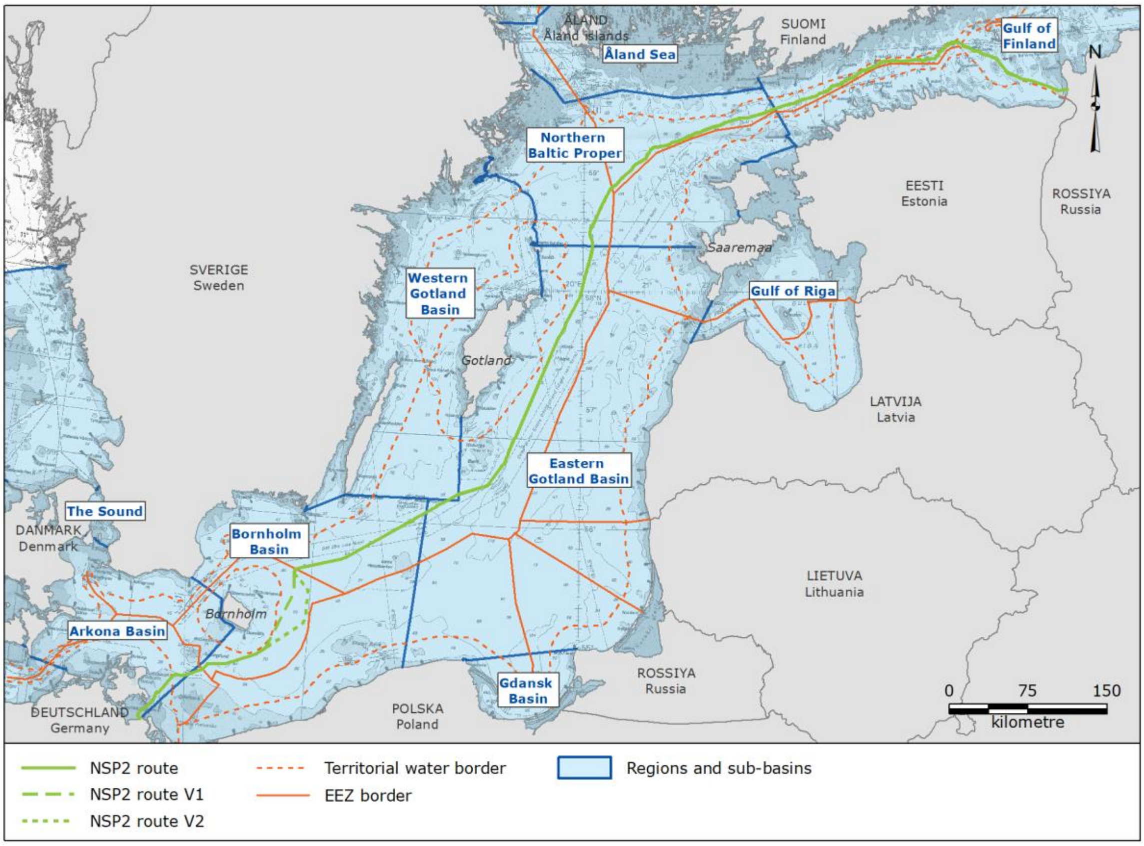


Figure 7-10 Major basins in the Baltic Sea.

The Danish waters around Bornholm include the Arkona Basin (maximum depth of 55 m) and the Bornholm Basin (maximum depth of 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 /96/. The bathymetry of the Danish waters around Bornholm and the areas mentioned above is shown in Figure 7-11. The bathymetry and sub-basins in the Baltic Sea and Danish waters are shown in Atlas Map BA-01-D.

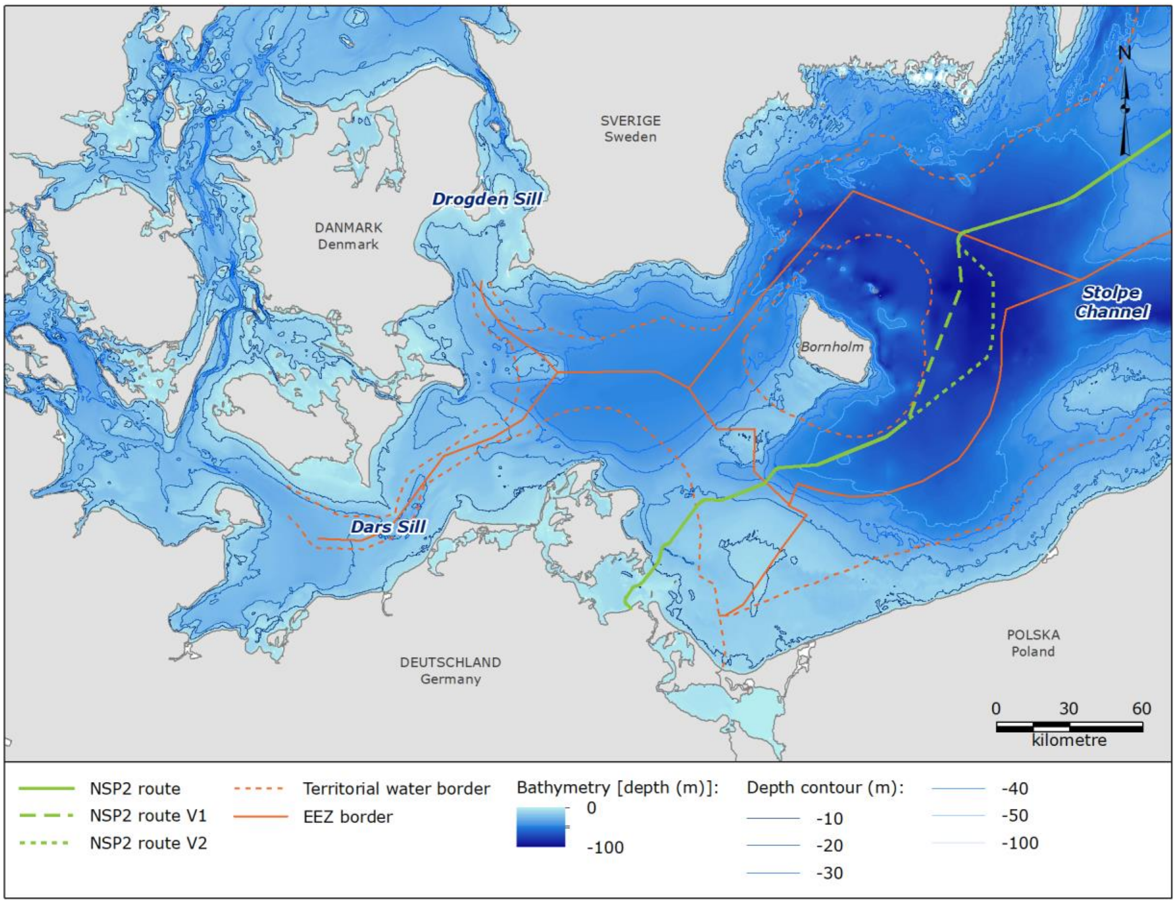


Figure 7-11 Bathymetry in the Danish sector of the Baltic Sea.

7.2.2 Proposed NSP2 route with NSP2 route V1

The bathymetry along the proposed NSP2 route with NSP2 route V1 is illustrated in Figure 7-12, and is very similar to the bathymetry along the proposed NSP2 route with NSP2 route V2 (compare Figure 7-12 with Figure 7-13).

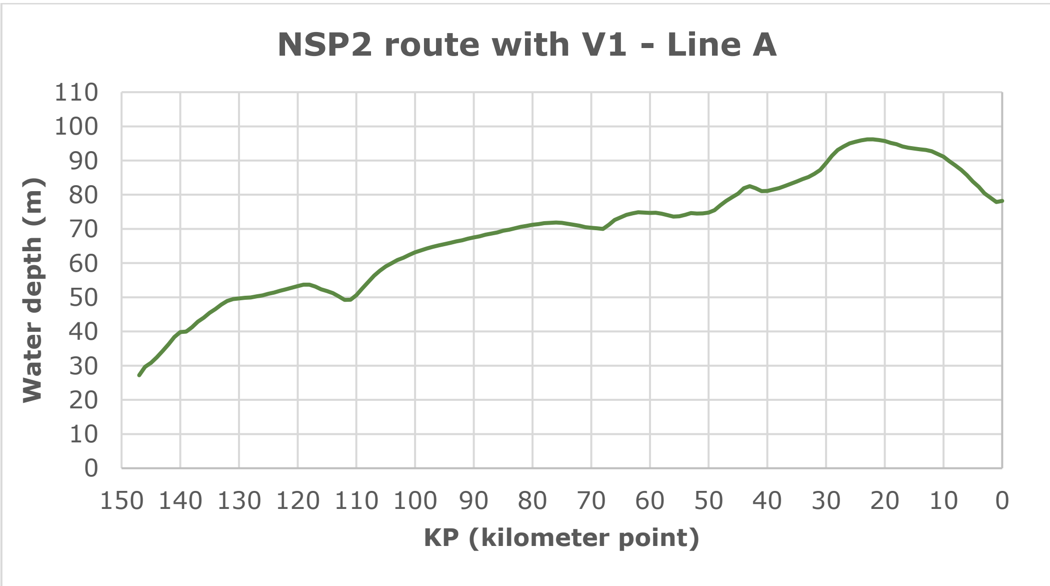


Figure 7-12 Water depth (m) along the combination of the proposed NSP2 route with V1 in Danish waters. The profile for Line A is shown, but the depth profile is also representative for Line B.

7.2.3 Proposed NSP2 route with NSP2 route V2

The bathymetry along the proposed NSP2 route with NSP2 route V2 is illustrated in Figure 7-13 and shows that the seabed is generally deep (>50 m) and featureless throughout most of the proposed route. The water depth decreases gradually towards the south-west, and is less than 30 m in the area close to the German EEZ. At KP 142, where the proposed NSP2 route crosses the NSP pipelines, the water depth is approximately 45 m.

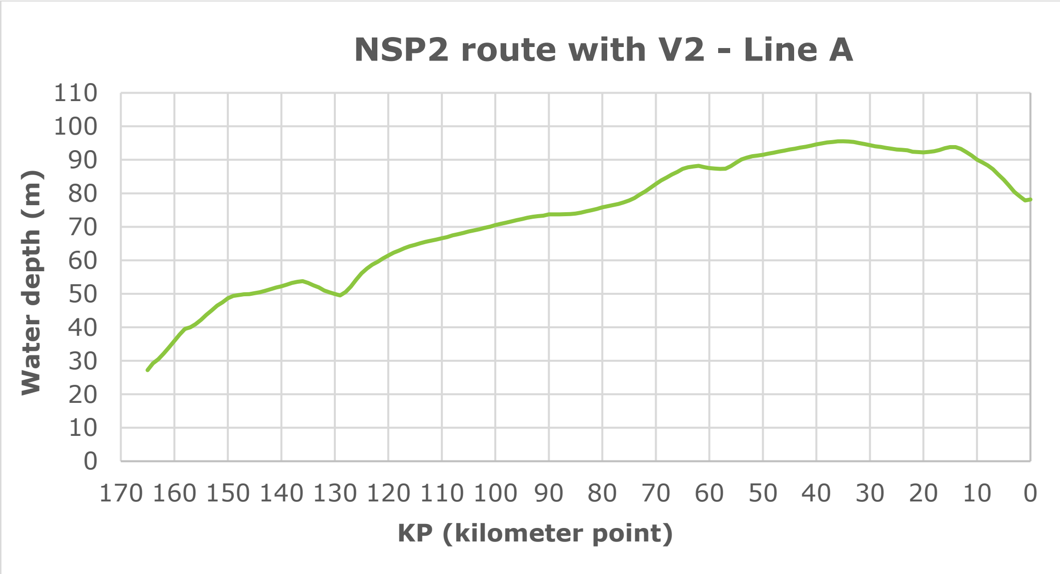


Figure 7-13 Water depth (m) along the combination of the proposed NSP2 route with V2 in Danish waters. The profile for Line A is shown, but the depth profile is also representative for Line B.

7.3 Sediment quality

The quality of the sediment in the Baltic Sea, including its chemical and physical characteristics, is an important factor that influences the benthic environment and the living conditions for associated fauna and flora. Benthic organisms such as mussels, crustaceans and bottom-dwelling 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, thus affecting 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 7-14 and in Atlas Map GE-01-D. Along the Danish section of the proposed NSP2 route, the bedrock consists mainly of sandstone and mudstone.

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 proposed NSP2 route, the recent relative uplift varies between less than 3 mm/year to about -1 mm/year. In the Danish section, the uplift ranges from -1 to 0 mm/year /97/.

The Tornquist zone in the southern part of the Baltic Sea, 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 /98/. 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 proposed NSP2 route.

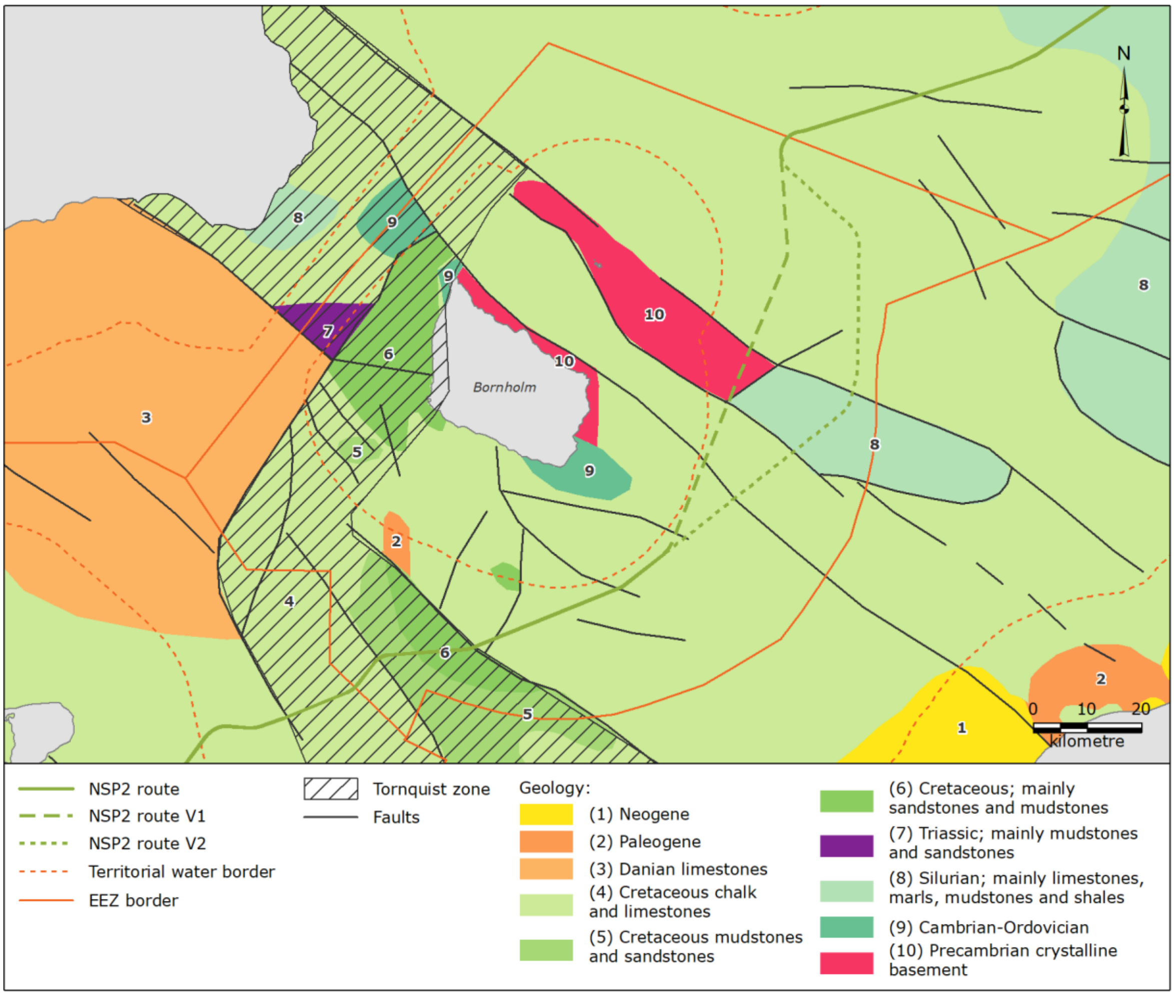


Figure 7-14 Bedrock geology along the proposed NSP2 route in Danish waters.

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 /99/. More recently, on 16 August 2014, an earthquake measuring 2.6 on the Richter scale with an epicentre approximately 10 km off the southern coast of Bornholm was registered /100/. Atlas Map GE-03-D and Figure 7-15 show the positions of all seismic events detected around Bornholm in the period from January 2000 to December 2018. It should be noted that a number of the events recorded on the figure are likely related to man-made activities, such as detonations of munitions left from WWII /100/.

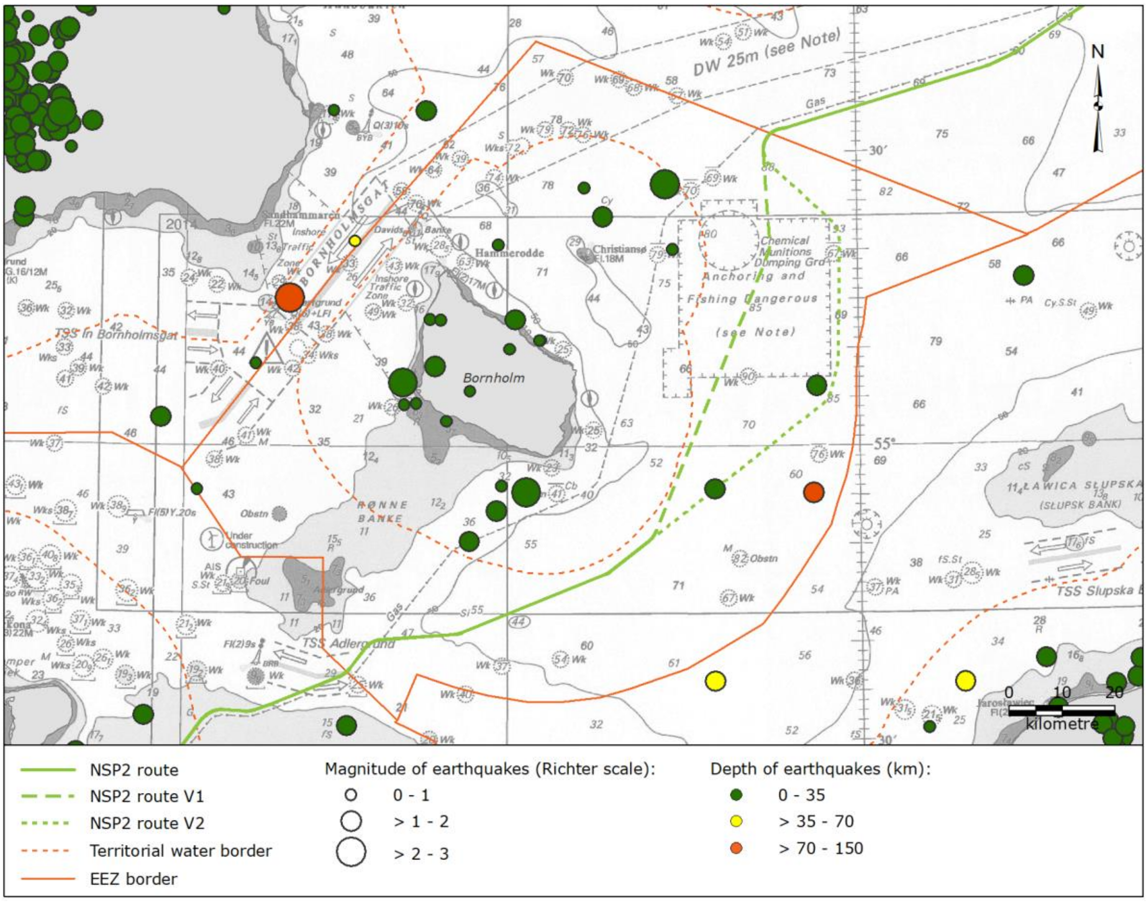


Figure 7-15 Recordings of all earthquake-like seismic events in the area around Bornholm in the period January 2000 to December 2018 /100/.

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 located at approximately 100 km intervals along the proposed route /101/. 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 and route variant, is ”very low to low”, also compared with other regions in Europe. The same was concluded for the risk of seismic hazard. A recent review of updated seismic data from the region has confirmed this conclusion /102/. The low seismic activity and risk of the Baltic Sea area (including the Danish waters around Bornholm) can also be shown graphically by referring to a seismic hazard map for other regions in Europe (see Figure 7-16) /103/.

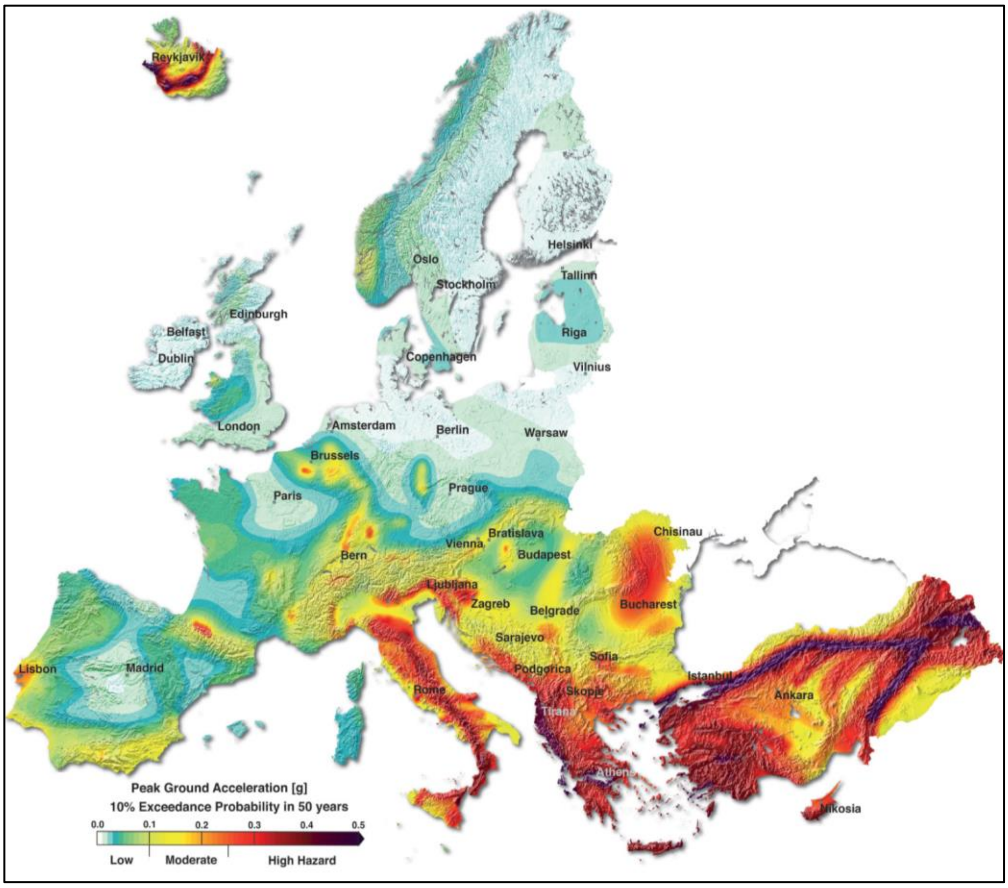


Figure 7-16 European Seismic Hazard Map (ESHM13) displaying the 10% exceedance probability in 50 years for peak ground acceleration (PGA) in units of gravity (g) /103/. Blue-green colours indicate comparatively low hazard areas (PGA ≤ 0.1 g), yellow and orange colours indicate moderate hazard areas (0.1 g < PGA ≤ 0.25 g) and red colours indicate high hazard areas (PGA ≥ 0.25 g).

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, are consolidated and possess high strength 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 comprise mainly clay, silt and sand. These deposits are often 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 for Bornholm Basin were estimated in a historical reference to be in the range of 0.5 to 1.5 mm/ year /104/. More recent studies show that sedimentation rates of organic material are approximately 20 g total organic carbon (TOC)/m^2/year in the Arkona Basin and 60 g TOC/m^2/year in the Bornholm Basin /105/. Assuming that the sedimented material contains approximately 4% TOC and has a dry content of 30% (typical values based on previous surveys in these areas), this corresponds to total sedimentation rates of 1.5 - 4.5 mm/year.

Figure 7-17 shows the seabed surface sediments present in Danish waters, based on a data compilation performed by the Geological Survey of Denmark and Greenland (GEUS) /106/.

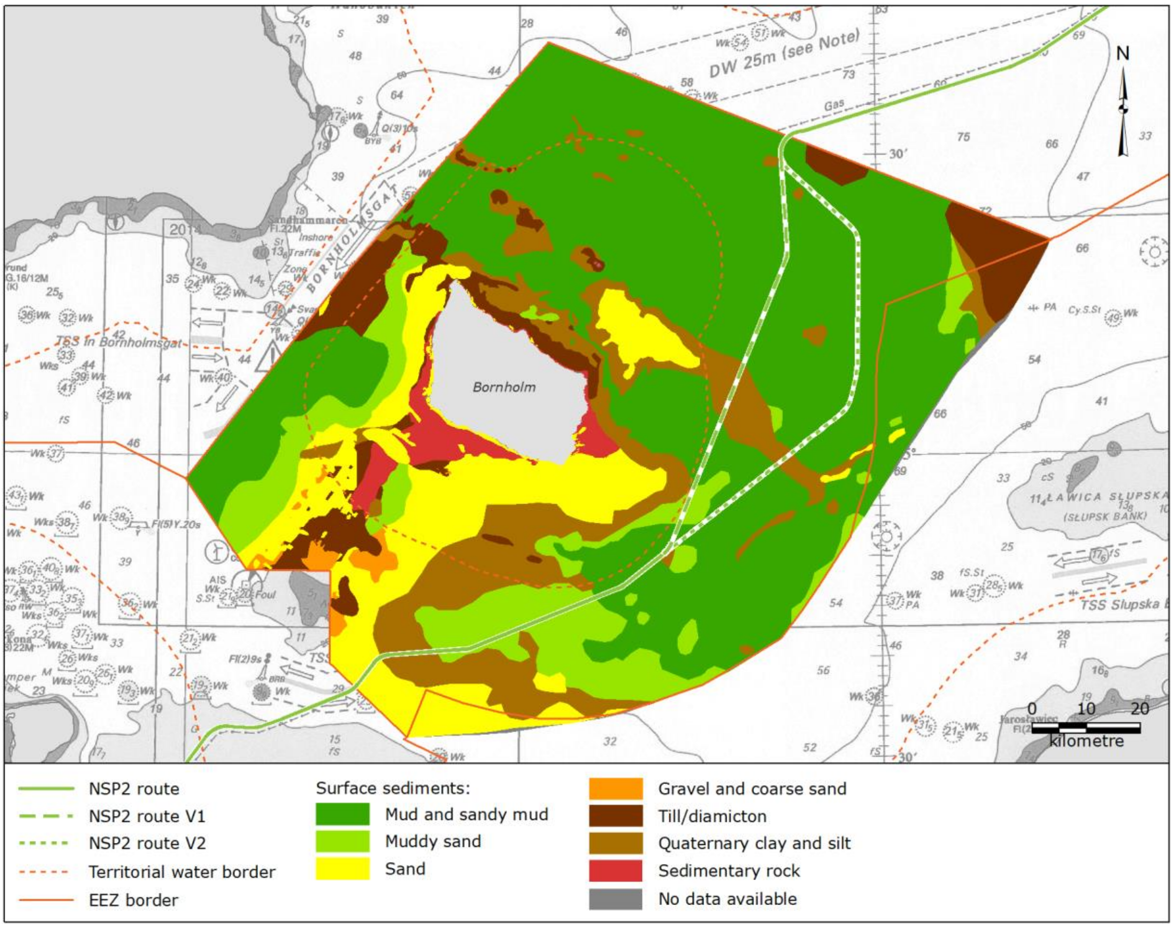


Figure 7-17 Seabed surface sediment types in the Danish Baltic Sea.

The seabed along the proposed NSP2 route mainly consists of mud and sandy mud, Quaternary clay and silt and muddy sand. In the shallowest parts close to the German EEZ, the bottom becomes more sandy.

7.3.3 Physical and chemical characteristics of seabed sediments

Inorganic and organic chemical contaminants enter the Baltic Sea via several routes /107/. 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 /108/. CWA were dumped in designated areas of the Baltic Sea after WWII and are now identifiable 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 sediments rich in organic particulate 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

Sediment properties in the area around the proposed NSP2 route and the NSP2 route V2 were studied based on samples collected during surveys carried out in 2018 /87/. Sediment properties in the area around the NSP2 route V1 were surveyed in January 2019, and the results will be available in separate reports. The baseline description of conditions along the NSP2 route V1 is based on sampling results from the previously considered "RA route" alternative for NSP2, collected in 2015 /89/. These results are considered representative for the area where the NSP2 route V1 diverges from the proposed NSP2 route. The locations of the sampling stations in relation to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are indicated in Figure 7-6. The appearance of the sediment at each station is summarised in Table 7-1 and Table 7-2, and the chemical/physical characteristics are summarised in Figure 7-18 and Figure 7-19.

Table 7-1 Description of sediment substrate at the sampling stations visited in 2018 /87/.

Station	Water depth, m	Description of sediment
SS-4	88	Grey and dark clay
SS-5	86	Grey and dark clay
SS-6	84	Grey and dark clay
SS-7	79	Grey and dark clay
SS-8	75	Grey and dark clay
SS-9	72	Grey and dark clay
SS-10	68	Grey and dark clay
SS-11	64	Grey and dark clay
SS-12	57	Grey and dark clay
SS-13	55.6	Grey and dark clay
SS-14	52	mainly clay with some sand
SS-15	46.1	Sandy with dark clay
SS-16	30.2	Sandy
SS-17	85	Grey and dark clay
SS-18	90	Grey and dark clay
SS-19	90	Grey and dark clay

Table 7-2 Description of sediment substrate at the sampling stations visited in 2015 /89/.

Station	Water depth, m	Description of sediment
RA_03	86	Black mud
RA_06	86	Black mud
RA_10	95	Black mud
RA_14	95	Fine sand and clay

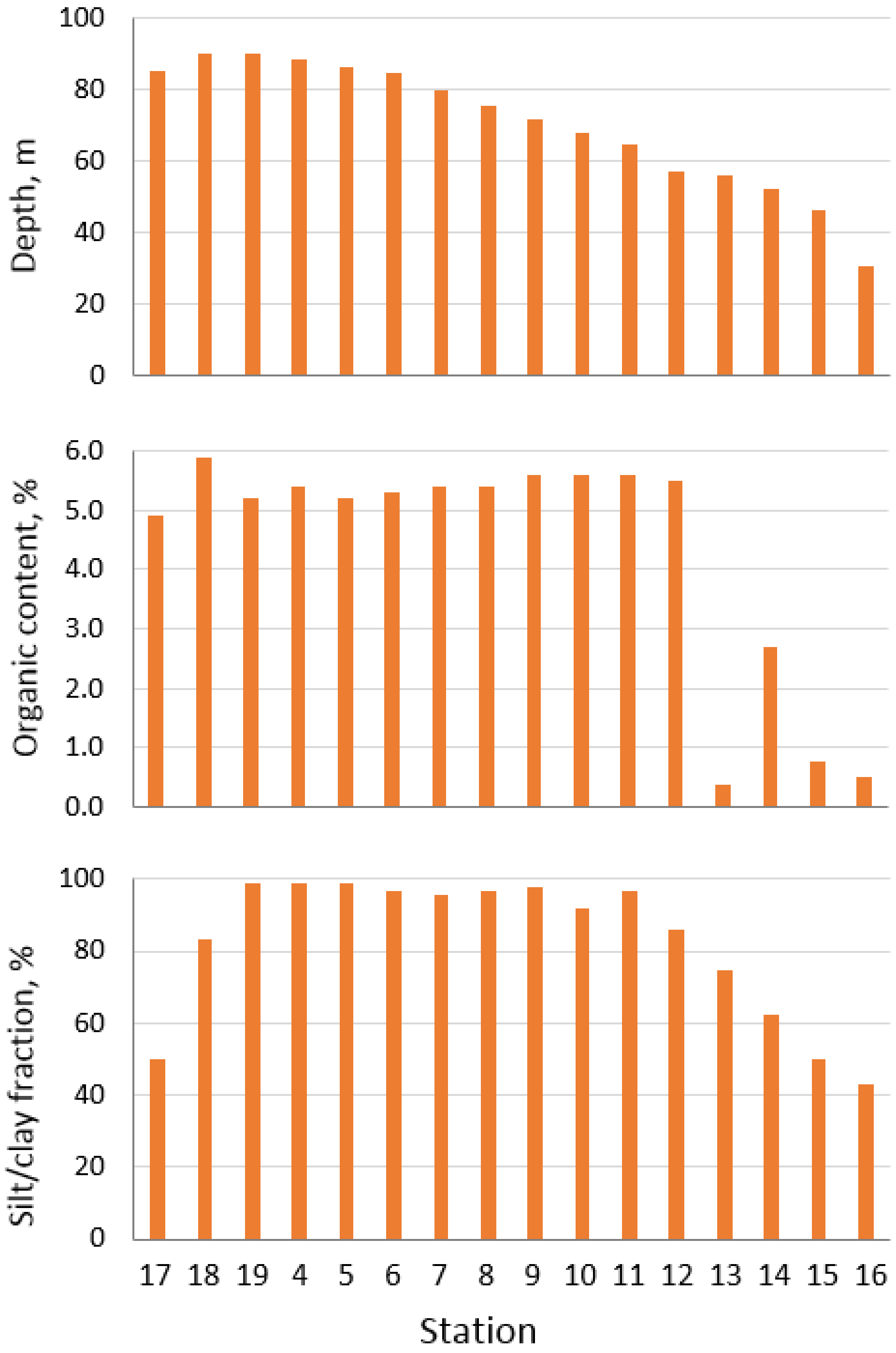


Figure 7-18 Water depth and sediment properties at the 16 stations sampled during the survey in 2018 /87/.

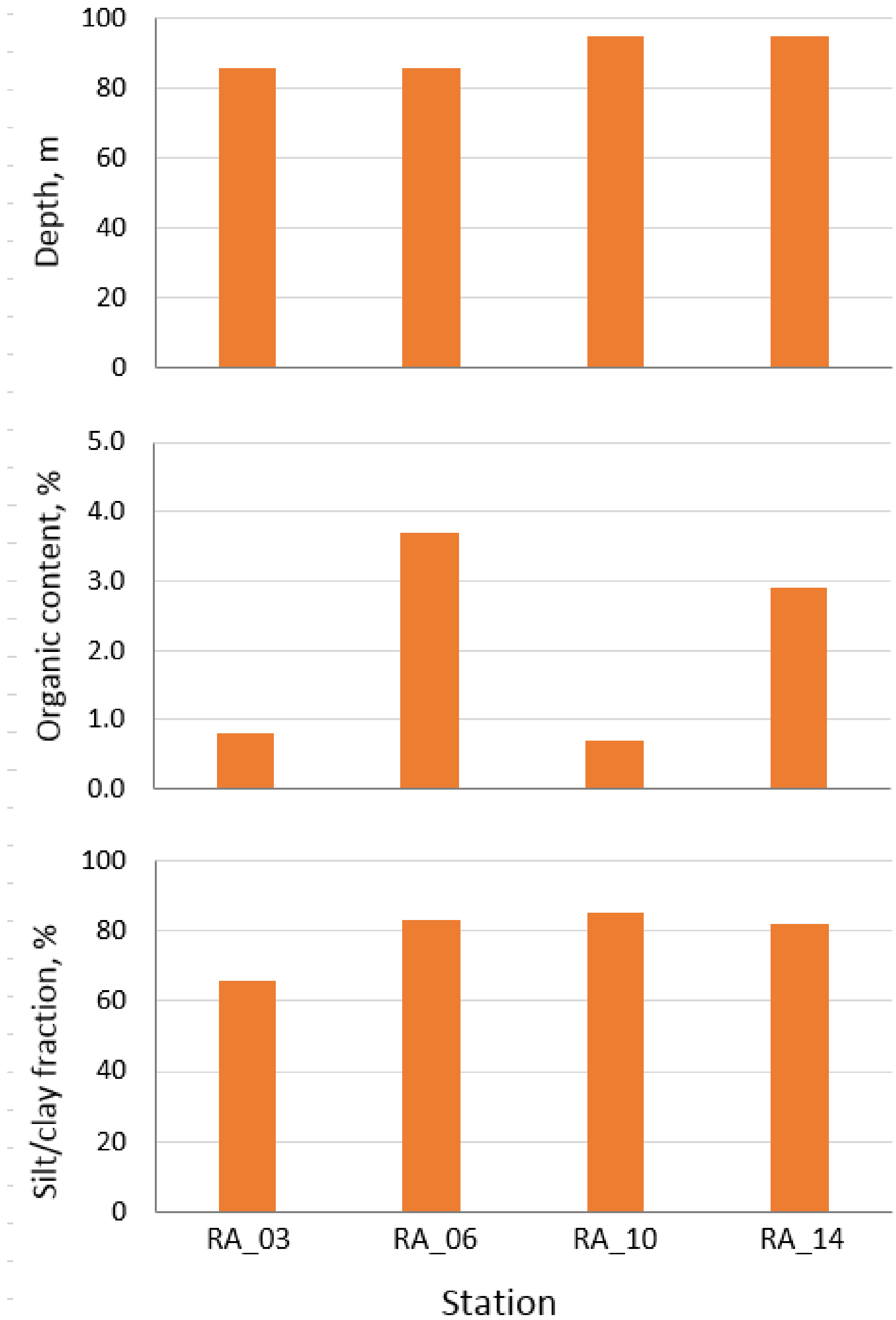


Figure 7-19 Water depth and sediment properties at the 4 stations sampled during the survey in 2015 /89/.

All survey stations at depths greater than 50 m were characterised by muddy, organic-rich sediments consisting mainly of silt and clay. The shallower stations close to the German EEZ were characterised by more sandy sediments with less organic content.

7.3.3.2 Metals

Heavy metals are transported to the Baltic Sea via rivers, run-off in coastal areas, direct waterborne 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 microorganisms, 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 /109/.

Mercury, lead, and cadmium are included in the set of core indicators for hazardous substances defined by HELCOM /110/, and based on HELCOM criteria regarding concentrations in sediment and biomass, the environmental status of all three metals is currently considered "not good" in the waters around Bornholm /111/.

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 the 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 proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. Both are used by the OSPAR Commission; the BAC is thought to represent the natural background concentration of metals that could be expected without any anthropogenic influence, whereas the ERL indicates the limit above which negative effects may be expected /112//113/. HELCOM has implemented assessment criteria for cadmium, lead and mercury in marine sediments. In general, the threshold concentration indicating GES and "moderate environmental status" (MES) is the same as the BAC, and the threshold concentration indicating "bad environmental status" (BES) is the same as the ERL. Other assessment criteria that can be used for comparison of environmental measurements of metals in sediment include the lower action levels (LAL) that have been 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 /114/.

Since NSP2 will not cause any addition of contaminants to the sediment, and the concentrations will thus not be changed, the project has no implications for the environmental status of the Danish part of the Baltic Sea in regard to contaminant loads in the sediment. A comparison with the environmental quality requirements (Danish: "*Miljøkvalitetskrav*") for sediment given in Order 1625 of 19/12/2017 was therefore not undertaken /115/.

Table 7-3 and Table 7-4 summarise the content of heavy metals in the sediment sampled at relevant stations in surveys during 2015 and 2018 along with concentrations corresponding to BAC and ERL as given by the OSPAR Commission /87//89/.

Table 7-3 Content of heavy metals (mg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 in Danish waters in 2018 /87/. Values exceeding the ERL are indicated in bold. ."<" indicates that the concentration is below the indicated detection threshold.

Station	As	Pb	Cd	Cr	Cu	Co	Hg	Ni	Zn
BAC[1]	25	38	0.31	81	27	-	0.07	36	122
ERL	-	47	1.20	81	34	-	0.15	-	150
NSP2 base case min-max[2]	3.6-19.1	8.2-80.8	0.019-0.480	11.1-50.1	8.54-57.8	4.28-20.70	<0.010-0.140	9.0-43.5	27.2-207
Highest value measured	18	**66**	1.1	54	**48**	21	0.052	44	100
Average value measured	12	**48**	1	41	**36**	14	0	29	65
SS-4	18	**54**	0.80	48	**41**	18	0.041	39	88
SS-5	17	**66**	1.10	52	**46**	20	0.046	40	93
SS-6	14	**61**	0.97	51	**48**	21	0.023	40	87
SS-7	16	**56**	0.72	51	**42**	19	0.043	38	80
SS-8	13	**61**	0.63	49	**42**	16	0.046	34	78
SS-9	15	**53**	0.55	45	**40**	14	0.052	32	68
SS-10	14	**57**	0.49	51	**45**	14	0.044	34	74
SS-11	13	**58**	0.49	42	**39**	10	0.051	28	61
SS-12	13	**59**	0.37	46	**41**	9.3	0.048	28	60
SS-13	9.3	42	0.26	32	29	5.8	0.038	19	41
SS-14	5.8	29	0.20	24	19	3.8	0.034	13	30
SS-15	2.3	12	0.10	14	10	1.4	0.000	5.1	16
SS-16	2.9	4.4	0.05	2.6	8.4	<1	0.000	1.4	6.1
SS-17	14	**49**	0.91	48	**42**	17	0.030	37	77
SS-18	13	**48**	0.78	47	**42**	19	0.035	38	84
SS-19	18	**61**	0.93	54	**48**	20	0.034	44	100

[1] Values of BAC are normalised to 5% aluminium. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-4 Content of heavy metals (mg/kg DW) measured along the NSP2 route V1 in Danish waters in 2015 /89/. Values exceeding the ERL are indicated in bold. ."<" indicates that the concentration is below the indicated detection threshold.

Station	As	Pb	Cd	Cr	Cu	Co	Hg	Ni	Zn
BAC[1]	25	38	0.31	81	27	-	0.07	36	122
ERL	-	47	1.20	81	34	-	0.15	-	150
NSP2 base case min-max[2]	3.6-19.1	8.2-80.8	0.019-0.480	11.1-50.1	8.54-57.8	4.28-20.70	<0.010-0.140	9.0-43.5	27.2-207
Highest value measured	19	**67**	0.76	50	**46**	18	0.12	39	**156**
Average value measured	9.7	34	0.50	27	23	9.0	0.073	24	73
RA_03	1.2	9.7	0.26	10	5.0	1.5	0.031	<5.0	15
RA_06	13	**67**	0.65	50	**46**	18	0.11	39	**156**
RA_10	5.9	6.3	0.34	11	5.4	2.7	0.031	6.6	15
RA_14	19	**52**	0.76	38	**34**	14	0.12	27	107

[1] Values of BAC are normalised to 5% aluminium. [2] Range of values measured along the NSP2 base case route in Denmark.

Lead, copper, and zinc exceeded the ERL values at one or several stations. The average value of lead and copper measured in 2018 also exceeded the ERL value. All metals were below their respective ERL values at stations with water depths less than 57 m (i.e. stations SS-13, -14, -15, and -16).

7.3.3.3 Polycyclic aromatic hydrocarbons (PAHs)

PAHs are environmental contaminants that are primarily formed by the 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 neighbouring rings. PAHs comprise a large and heterogeneous group, the most toxic of which being 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). PAH concentrations in sediments have been linked to liver neoplasms and other abnormalities in bottom-dwelling fish /116/. 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 PAH benzo[a]pyrene is included in the set of core indicators for hazardous substances defined by HELCOM /110/, and the environmental status is currently considered "good" in the waters west of Bornholm /111/, whereas there are no data regarding the areas north, east and south of Bornholm.

The threshold concentrations between GES and MES set by HELCOM for a range of PAHs are equal to their respective ERL values /110/. The results of PAH measurements during the 2018 survey are listed in Table 7-5, Table 7-6, and Table 7-7 below, together with BAC and ERL values /87/. Results of PAH measurements during the 2015 survey are listed in Table 7-8, Table 7-9, and Table 7-10 /89/.

Table 7-5 Content of PAHs (mg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 in 2018. The BAC and ERL concentrations are also shown (BAC is normalized to 2.5% TOC). Values exceeding ERL are indicated in bold /87/. "<" indicates that the concentration is below the indicated detection threshold.

Station	Naphthalene	Acenaphthylene	Acenaphthene	Phenanthrene	Anthracene	Fluorene
BAC[1]	0.008	-	-	0.032	0.005	-
ERL	0.160	0.044	0.016	0.240	0.085	0.019
NSP2 base case min-max[2]	<0.002-0.046	<0.002-0.010	<0.002-0.009	<0.002-0.110	<0.002-0.029	<0.002-0.016
Highest value measured	0.093	0.021	0.000	0.210	0.034	**0.030**
Average value measured	0.032	0.002	0.000	0.068	0.015	0.012
SS-4	0.039	0.000	0.000	0.056	0.017	0.012
SS-5	0.038	0.000	0.000	0.057	0.018	0.012
SS-6	0.093	0.021	0.000	0.120	0.034	**0.030**
SS-7	0.026	0.000	0.000	0.052	0.015	0.013
SS-8	0.030	0.000	0.000	0.067	0.019	0.014
SS-9	0.035	0.011	0.000	0.077	0.022	0.016
SS-10	0.025	0.000	0.000	0.078	0.014	0.012
SS-11	0.034	0.000	0.000	0.210	0.022	**0.021**
SS-12	0.029	0.000	0.000	0.067	0.019	0.016
SS-13	0.030	0.000	0.000	0.067	0.016	0.017
SS-14	0.017	0.000	0.000	0.033	0.000	0.000
SS-15	0.000	0.000	0.000	0.014	0.000	0.000
SS-16	0.000	0.000	0.000	0.000	0.000	0.000
SS-17	0.034	0.000	0.000	0.049	0.014	0.010
SS-18	0.052	0.000	0.000	0.098	0.013	0.014
SS-19	0.032	0.000	0.000	0.048	0.016	0.010

[1]The BAC concentrations are normalised to 2.5% TOC. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-6 Content of PAHs (mg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 in 2018. The BAC and ERL concentrations are also shown (BAC is normalized to 2.5% TOC). Values exceeding ERL are indicated in bold /87/. "<" indicates that the concentration is below the indicated detection threshold.

Station	Fluor anthene	Pyrene	Benz[a] anthracene	Chrysene	Benzo[b+j] fluoranthene	Benzo[k] fluoranthene
BAC[1]	0.039	0.024	0.016	0.020	-	-
ERL	0.600	0.665	0.261	0.384	-	-
NSP2 base case min-max[2]	<0.002-0.280	<0.002-0.250	<0.002-0.140	<0.002-0.120	<0.002-0.340	<0.002-0.180
Highest value measured	0.510	0.310	0.130	0.099	0.400	0.180
Average value measured	0.158	0.129	0.064	0.050	0.227	0.104
SS-4	0.130	0.130	0.075	0.056	0.280	0.120
SS-5	0.170	0.140	0.079	0.061	0.270	0.140
SS-6	0.250	0.210	0.130	0.099	0.390	0.180
SS-7	0.120	0.110	0.065	0.049	0.270	0.110
SS-8	0.150	0.140	0.080	0.063	0.260	0.130
SS-9	0.180	0.170	0.095	0.070	0.390	0.160
SS-10	0.160	0.210	0.060	0.047	0.240	0.100
SS-11	0.510	0.310	0.093	0.069	0.400	0.160
SS-12	0.150	0.120	0.075	0.058	0.240	0.120
SS-13	0.140	0.097	0.057	0.049	0.200	0.089
SS-14	0.077	0.055	0.035	0.029	0.120	0.051
SS-15	0.030	0.020	0.011	0.012	0.021	0.014
SS-16	0.000	0.000	0.000	0.000	0.000	0.000
SS-17	0.110	0.096	0.053	0.044	0.170	0.093
SS-18	0.240	0.140	0.045	0.040	0.140	0.080
SS-19	0.110	0.120	0.072	0.052	0.240	0.120

[1]The BAC concentrations are normalised to 2.5% TOC. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-7 Content of PAHs (mg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 in 2018. The BAC and ERL concentrations are also shown (BAC is normalized to 2.5% TOC). Values exceeding ERL are indicated in bold /87/. "<" indicates that the concentration is below the indicated detection threshold.

Station	Benzo[a] pyrene	Indeno-[1,2,3-cd]pyrene	Dibenzo[a,h]-anthracene	Benzo[ghi]-perylene	Sum of 9 PAHs[1]	Total PAH
BAC[2]	0.030	0.103	-	0.080	-	-
ERL	0.430	0.240	0.063	0.085	-	-
NSP2 base case min-max[3]	<0.002-0.190	0.002-0.550	<0.002-0.075	<0.002-0.460	0.002-1.865	0.002-2.798
Highest value measured	0.170	**0.650**	**0.130**	**0.460**	2.274	2.988
Average value measured	0.085	**0.377**	**0.069**	**0.274**	1.220	1.666
SS-4	0.099	**0.440**	**0.080**	**0.330**	1.333	1.864
SS-5	0.100	**0.490**	**0.088**	**0.360**	1.475	2.023
SS-6	0.170	**0.650**	**0.130**	**0.460**	2.123	2.967
SS-7	0.092	**0.410**	**0.073**	**0.300**	1.213	1.705
SS-8	0.110	**0.500**	**0.090**	**0.360**	1.489	2.013
SS-9	0.130	**0.580**	**0.100**	**0.430**	1.754	2.466
SS-10	0.075	**0.400**	**0.073**	**0.290**	1.334	1.784
SS-11	0.120	**0.550**	**0.099**	**0.390**	2.274	2.988
SS-12	0.100	**0.450**	**0.082**	**0.320**	1.359	1.846
SS-13	0.080	**0.320**	0.062	**0.230**	1.056	1.454
SS-14	0.049	0.150	0.028	**0.110**	0.538	0.754
SS-15	0.012	0.033	0.000	0.023	0.155	0.190
SS-16	0.000	0.000	0.000	0.000	0.000	0.000
SS-17	0.073	**0.360**	**0.066**	**0.270**	1.069	1.442
SS-18	0.054	**0.250**	0.048	**0.180**	1.060	1.394
SS-19	0.090	**0.450**	**0.080**	**0.330**	1.288	1.770

[1] Sum of the following nine PAHs: anthracene, benzo[a]anthracene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, fluoranthene, indeno[1,2,3-cd]pyrene, pyrene and phenanthrene. [2]The BAC concentrations are normalised to 2.5% TOC. [3] Range of values measured along the NSP2 base case route in Denmark.

Table 7-8 Content of PAHs (mg/kg DW) measured along the NSP2 route V1 in 2015. The BAC and ERL concentrations are also shown (BAC is normalized to 2.5% TOC). Values exceeding ERL are indicated in bold /89/. "<" indicates that the concentration is below the indicated detection threshold.

Station	Naphtha-lene	Acenaph-thylene	Acenaph-thene	Phen-an-threne	Anthracene	Fluorene
BAC[1]	0.008	-	-	0.032	0.005	-
ERL	0.160	0.044	0.016	0.240	0.085	0.019
NSP2 base case min-max[2]	<0.002-0.046	<0.002-0.010	<0.002-0.009	<0.002-0.110	<0.002-0.029	<0.002-0.016
Highest value measured	0.038	0.011	0.006	0.071	0.020	0.010
Average value measured	0.020	0.006	0.004	0.037	0.010	0.005
RA_03	0.007	0.002	<0.0020	0.016	0.004	0.003
RA_06	0.025	0.007	0.003	0.043	0.010	0.005
RA_10	0.011	0.004	<0.0020	0.018	0.005	0.003
RA_14	0.038	0.011	0.006	0.071	0.020	0.010

[1]The BAC concentrations are normalised to 2.5% TOC. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-9 Content of PAHs (mg/kg DW) measured along the NSP2 route V1 in 2015. The BAC and ERL concentrations are also shown (BAC is normalized to 2.5% TOC). Values exceeding ERL are indicated in bold /89/. "<" indicates that the concentration is below the indicated detection threshold.

Station	Fluor-anthene	Pyrene	Benz[a] anthracene	Chrysene	Benzo[b+j] fluoranthene	Benzo[k] fluoranthene
BAC[1]	0.039	0.024	0.016	0.020	-	-
ERL	0.600	0.665	0.261	0.384	-	-
NSP2 base case min-max[2]	<0.002-0.280	<0.002-0.250	<0.002-0.140	<0.002-0.120	<0.002-0.340	<0.002-0.180
Highest value measured	0.210	0.170	0.092	0.076	0.270	0.150
Average value measured	0.101	0.087	0.047	0.038	0.144	0.078
RA_03	0.039	0.035	0.019	0.015	0.063	0.033
RA_06	0.100	0.097	0.053	0.041	0.170	0.091
RA_10	0.056	0.046	0.022	0.018	0.071	0.039
RA_14	0.210	0.170	0.092	0.076	0.270	0.150

[1]The BAC concentrations are normalised to 2.5% TOC. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-10 Content of PAHs (mg/kg DW) measured along the NSP2 route V1 in 2015. The BAC and ERL concentrations are also shown (BAC is normalized to 2.5% TOC). Values exceeding ERL are indicated in bold /89/. "<" indicates that the concentration is below the indicated detection threshold.

Station	Benzo[a] pyrene	indeno-[1,2,3-cd]pyrene	Dibenzo[a,h]-anthra-cene	Benzo[ghi]-perylene	Sum of 9 PAHs[1]	Total PAH
BAC[2]	0.030	0.103	-	0.080	-	-
ERL	0.430	0.240	0.063	0.085	-	-
NSP2 base case min-max[3]	<0.002-0.190	0.002-0.550	<0.002-0.075	<0.002-0.460	0.002-1.865	0.002-2.798
Highest value measured	0.130	**0.430**	0.062	**0.340**	1.539	2.086
Average value measured	0.063	0.230	0.033	**0.179**	0.790	1.078
RA_03	0.026	0.099	0.014	0.077	0.330	0.452
RA_06	0.066	**0.280**	0.040	**0.210**	0.900	1.241
RA_10	0.030	0.110	0.014	0.087	0.392	0.533
RA_14	0.130	0.430	0.062	**0.340**	1.539	2.086

[1] Sum of the following nine PAHs: anthracene, benzo[a]anthracene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, fluoranthene, indeno[1,2,3-cd]pyrene, pyrene and phenanthrene. [2]The BAC concentrations are normalised to 2.5% TOC. [3] Range of values measured along the NSP2 base case route in Denmark.

Fluorene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene exceeded their respective ERL values at one or more of the stations during the two surveys. The average measured values of indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[ghi]perylene exceeded their respective ERL values in at least one of the surveys. At stations with water depths of less than 50 m, no PAHs exceeded their respective ERLs.

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. They are 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 has been suggested as the cause of reproductive failures, increased susceptibility to disease and developmental instability. The effects on birds also include eggshell thinning /116/.

PCBs are included in the set of core indicators for hazardous substances defined by HELCOM /110/, and the environmental status is currently considered "good" in the waters east of Bornholm but "not good" west of Bornholm, based on the PCB levels in fish biomass /118/.

HELCOM has established threshold sediment concentrations for PCB-118 and PCB-153 as indicators of GES. Both of these thresholds are equal to the OSPAR Commission environmental assessment criteria (EAC) values, which are normalized to the TOC content of the sediment /117/. 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. BAC values are also given by the OSPAR Commission /112/. The Danish Nature Agency has implemented a LAL value of 20 µg/kg DW for the sum of PCB congeners 28, 52, 101, 118, 138, 153 and 180.

In Table 7-11, the values measured in sediments during the 2018 survey are shown together with the OSPAR Commission BAC and EAC values for each PCB /87/. Results from the 2015 survey are shown in Table 7-12 /89/.

Table 7-11 Content of PCB congeners (µg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 in 2018 /87/. Values exceeding EAC are indicated in bold. "<" indicates that the concentration is below the indicated detection threshold.

Station	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	Total
BAC[1]	0.22	0.12	0.14	0.17	0.15	0.19	0.10	-
EAC[1]	1.7	2.7	3.0	0.6	7.9	40	12	-
NSP2 base case min-max[2]	<0.1-0.2	<0.1-0.2	<0.1-0.5	<0.1-0.4	<0.1-0.8	<0.1-1.0	<0.1-0.5	<0.1-3.6
Highest value measured	0.25	0.33	0.74	**0.71**	1.10	1.50	0.71	5.18
Average value measured	0.18	0.25	0.47	0.49	0.70	1.00	0.52	3.23
SS-4	0.18	0.31	0.58	0.52	0.91	1.20	0.61	4.31
SS-5	0.15	0.26	0.51	0.51	0.86	1.10	0.58	3.97
SS-6	0.21	0.33	0.66	**0.67**	1.10	1.50	0.71	5.18
SS-7	0.16	0.21	0.47	0.47	0.75	0.99	0.48	3.53
SS-8	0.20	0.28	0.57	0.55	0.93	1.20	0.59	4.32
SS-9	0.22	0.31	0.61	**0.61**	1.00	1.40	0.66	4.81
SS-10	0.16	0.19	0.39	0.45	0.71	0.92	0.45	3.27
SS-11	0.25	0.26	0.74	**0.71**	0.11	1.40	0.64	4.11
SS-12	0.16	0.31	0.42	0.48	0.78	1.00	0.49	3.64
SS-13	0.17	0.18	0.34	0.39	0.68	0.83	0.40	2.99
SS-14	<0.1	<0.1	0.19	0.26	0.45	0.56	0.29	1.75
SS-15	<0.1	<0.1	<0.1	<0.1	0.15	0.17	<0.1	0.32
SS-16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.00
SS-17	0.18	0.25	0.49	0.51	0.77	1.10	0.50	3.80
SS-18	0.15	0.19	0.42	0.46	0.78	1.00	0.52	3.52
SS-19	<0.1	0.16	0.25	0.29	0.45	0.63	0.30	2.08

[1]The BAC and EAC concentrations are normalised to 2.5% TOC. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-12 Content of PCB congeners (µg/kg DW) measured along the NSP2 route V1 in 2015 /89/. Values exceeding EAC are indicated in bold. "<" indicates that the concentration is below the indicated detection threshold.

Station	PCB 28	PCB 52	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	Total
BAC[1]	0.22	0.12	0.14	0.17	0.15	0.19	0.10	-
EAC[1]	1.7	2.7	3.0	0.6	7.9	40	12	-
NSP2 base case min-max[2]	<0.1-0.2	<0.1-0.2	<0.1-0.5	<0.1-0.4	<0.1-0.8	<0.1-1.0	<0.1-0.5	<0.1-3.6
Highest value measured	0.11	0.15	0.36	0.30	0.47	0.66	0.32	2.37
Average value measured	0.03	0.04	0.18	0.14	0.27	0.38	0.21	1.24
RA_03	<0.1	<0.1	<0.1	<0.1	0.13	0.18	0.10	0.41
RA_06	<0.1	<0.1	0.18	0.13	0.27	0.34	0.22	1.14
RA_10	<0.1	<0.1	0.16	0.12	0.22	0.32	0.21	1.03
RA_14	0.11	0.15	0.36	0.30	0.47	0.66	0.32	2.37

[1]The BAC and EAC concentrations are normalised to 2.5% TOC. [2] Range of values measured along the NSP2 base case route in Denmark.

PCB 118 exceeded the EAC threshold at several stations in the 2018 survey, but not at any of the stations with depths less than 64 m. During the 2015 survey, the levels of PCB's did not exceed EAC at any of the stations.

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

Organochlorine pesticides have low water solubility 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 food chains poses a threat to fish, seabirds and marine mammals. The presence of elevated concentrations of organochlorines in marine mammals has been suggested as the cause of reproductive failures, increased susceptibility to disease, developmental instability and premature pupping /116/.

Persistent organochlorine pesticides are banned, and concentrations of most compounds in Baltic Sea sediments have been declining since the 1970s. Chlordane (with limited historical use in the Baltic Sea area) was banned at the Stockholm Convention on Persistent Organic Pollutants in 2001. Dichlorodiphenyltrichloroethane (DDT), 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. Organochlorine pesticides are not included in the set of core indicators for hazardous substances defined by HELCOM /110/.

The results of the measurements of organochlorine pesticides in sediment samples from the 2018 survey are summarised in Table 7-13 together with ERL values for HCH, DDE, and HCB /87//108/. Results from the 2015 survey are shown in Table 7-14 /89/.

Table 7-13 Content of organochlorine pesticides measured along the proposed NSP2 route and the NSP2 route V2 in 2018 /87/. The unit in all columns is µg/kg DW. Values exceeding EAC are indicated in bold. "<" indicates that the concentration is below the indicated detection threshold.

Station	Cis-chlor-dane	Trans-chlor-dane	HCH	DDE	DDD	DDT	Trans-nona Chlor	HCB
ERL	-	-	3.0 (γ-HCH)	2.2	-	-	-	20
NSP2 base case min-max[2]	<0.10-0.132	<0.10-0.148	<0.10-0.37	<0.10-3.29	<0.10-10.1	<0.10-0.43	<0.10-0.11	<0.10-0.23
Highest value measured	0.18	0.18	0.53	**2.93**	10.40	0.33	<0.5	0.21
Average value measured	0.13	0.14	0.30	1.80	4.94	0.20	<0.5	0.13
SS-4	0.18	0.18	0.34	**2.43**	10.40	0.22	<0.5	0.11
SS-5	0.16	0.14	0.25	2.10	6.40	0.21	<0.5	0.10
SS-6	0.14	0.12	0.24	**2.93**	5.90	0.27	<0.5	0.11
SS-7	0.10	<0.1	0.22	1.80	4.23	0.18	<0.5	0.10
SS-8	0.11	0.10	0.38	**2.31**	5.52	0.22	<0.5	0.13
SS-9	0.12	0.12	0.42	**2.62**	8.60	0.25	<0.5	0.15
SS-10	<0.1	<0.1	0.24	1.70	3.80	0.13	<0.5	0.11
SS-11	0.16	0.14	0.34	**2.43**	5.80	0.33	<0.5	0.14
SS-12	0.12	<0.1	0.29	1.80	5.17	0.23	<0.5	0.11
SS-13	0.13	<0.1	0.53	1.30	4.62	0.21	<0.5	0.21
SS-14	<0.1	<0.1	<0.1	0.78	1.78	0.11	<0.5	<0.1
SS-15	<0.1	<0.1	<0.1	0.20	0.28	<0.1	<0.5	<0.1
SS-16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
SS-17	0.18	0.16	0.24	2.00	5.47	0.16	<0.5	<0.1
SS-18	0.11	<0.1	0.11	1.50	3.03	0.14	<0.5	<0.1
SS-19	0.10	<0.1	<0.1	1.10	3.16	<0.1	<0.5	<0.1

[1]Detection limit during NSP measurements. [2] Range of values measured along the NSP2 base case route in Denmark.

Table 7-14 Content of organochlorine pesticides measured along the NSP2 route V1 in 2015 /89/. The unit in all columns is µg/kg DW. Values exceeding EAC are indicated in bold. "<" indicates that the concentration is below the indicated detection threshold.

Station	Cis-chlor-dane	Trans-chlor-dane	HCH	DDE	DDD	DDT	Trans-nona Chlor	HCB
ERL	-	-	3.0 (γ-HCH)	2.2	-	-	-	20
NSP2 base case min-max[2]	<0.10-0.132	<0.10-0.148	<0.10-0.37	<0.10-3.29	<0.10-10.1	<0.10-0.43	<0.10-0.11	<0.10-0.23
Highest value measured	<0.1	<0.1	<0.1	1.20	3.34	0.17	<0.1	0.12
Average value measured	<0.1	<0.1	<0.1	0.70	1.88	0.07	<0.1	0.03
RA_03	<0.1	<0.1	<0.1	0.46	1.26	0.11	<0.1	<0.1
RA_06	<0.1	<0.1	<0.1	0.60	1.40	<0.1	<0.1	<0.1
RA_10	<0.1	<0.1	<0.1	0.54	1.51	<0.1	<0.1	<0.1
RA_14	<0.1	<0.1	<0.1	1.20	3.34	0.17	<0.1	0.12

[1]Detection limit during NSP measurements. [2] Range of values measured along the NSP2 base case route in Denmark.

Concentrations of DDE exceeded the ERL value at several stations during the 2018 survey, but not at any of the stations with water depths of less than 64 m. The average values of all organochlorine pesticides measured in 2018 were below ERL. The values measured in the 2015 survey did not exceed the ERL.

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 TBT 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 /116/. It has been reported that TBT affects the endocrine systems of marine gastropods, causing e.g. imposex in red whelk (*Neptunea antiqua*) and common whelk (*Buccinum undatum*) /136/.

TBT is included in the set of core indicators for hazardous substances defined by HELCOM /110/. The status of the TBT indicator has not yet been fully assessed in the waters around Bornholm, but an initial assessment of sediment in the Arkona Basin reported a failure to meet the threshold for GES /111/.

Since the use of TBT was banned under international law in 2003, its concentration has been decreasing in the Baltic Sea /108/. TBT compounds associated with sediments appear to be much less available to sediment-living organisms compared with TBT in the water column /119/. Therefore, the recommended impact monitoring is focused on imposex in gastropods (being a specific effect of dissolved TBT) rather than sediment monitoring. The OSPAR Commission suggests an EAC concentration in sediment of 0.01 µg TBT/kg DW /120/. However, very few commercial laboratories can meet such low detection limits /120/. The Danish Nature Agency operates with a LAL of 7 µg TBT/kg DW.

TBT levels as well as levels of the degradation products dibenzothiophene (DBT) and 2-mercaptobenzothiazole (MBT) measured in sediment along the proposed NSP2 route and the NSP2 route V2 are summarized in Table 7-15 /87/. Levels measured in the 2015 survey are summarized in Table 7-16 /89/.

Table 7-15 Content of organotin (µg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 during the 2018 survey /87/. Values that exceed EAC are indicated in bold. Please note that the detection limit of 1.0 µg/kg DW is higher than the EAC.

Station	Tributyltin-cation	Dibutyltin-cation	Monobutyltin-cation
EAC	0.01	-	-
NSP2 base case min-max[1]	<1-5.79	<1-5.47	<1-7.26
Highest value measured	**6.0**	4.9	6.7
Average value measured	**3.8**	2.9	3.0
SS-4	**3.6**	2.3	1.8
SS-5	**4.4**	2.6	2.6
SS-6	**4.4**	3.4	6.7
SS-7	**4.9**	2.9	3.5
SS-8	**3.9**	3.3	3.4
SS-9	**3.7**	3.3	3.5
SS-10	**2.3**	2.2	3.1
SS-11	**3.2**	2.5	2.4
SS-12	**3.5**	3.4	3.3
SS-13	**2.9**	2.6	3.3
SS-14	**2.3**	2.4	3.3
SS-15	<1.0	<1.0	1.2
SS-16	<1.0	<1.0	<1.0
SS-17	**6.0**	4.9	3.2
SS-18	**5.8**	3.1	2.6
SS-19	**2.9**	2.2	1.8

[1] Range of values measured along the NSP2 base case route in Denmark.

Table 7-16 Content of organotin (µg/kg DW) measured along the NSP2 route V1 during the 2015 survey /89/. Values that exceed EAC are indicated in bold. Please note that the detection limit of 1.0 µg/kg DW is higher than the EAC.

Station	Tributyltin-cation	Dibutyltin-cation	Monobutyltin-cation
EAC	0.01	-	-
NSP2 base case min-max[1]	<1-5.79	<1-5.47	<1-7.26
Highest value measured	**4.2**	6.5	5.7
Average value measured	**1.9**	3.2	3.7
D_RA_03	<1	1.1	2.0
D_RA_06	<1	<1	1.3
D_RA_10	**4.2**	6.5	5.7
D_RA_15	**3.2**	5.0	5.6

[1] Range of values measured along the NSP2 base case route in Denmark.

Most of the sediments sampled contained levels of TBT and/or the degradation products DBT and MBT above the detection limit. The TBT concentration did not exceed the LAL (7 µg/kg) at any of the stations.

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.

Nitrogen and phosphorus levels measured in sediment along the proposed NSP2 route and the NSP2 route V2 are summarized in Table 7-17 /87/. Levels measured in the 2015 survey are summarized in Table 7-18 /89/.

Table 7-17 Content of N and P (mg/kg DW) measured along the proposed NSP2 route and the NSP2 route V2 during the survey in 2018 /87/.

Station	Total nitrogen	Total phosphorus
NSP2 base case min-max[1]	345-3,110	600-1,220
Highest value measured	6,500	1,300
Average value measured	5,109	931
SS-4	5,900	1,000
SS-5	5,900	1,200
SS-6	6,000	1,000
SS-7	5,800	1,000
SS-8	6,100	1,100
SS-9	5,800	1,100
SS-10	6,300	1,300
SS-11	6,200	1,100
SS-12	6,500	940
SS-13	5,000	820
SS-14	3,600	740
SS-15	1,000	490
SS-16	150	110
SS-17	5,600	1,000
SS-18	6,400	1,000
SS-19	5,500	1,000

[1] Range of values measured along the NSP2 base case route in Denmark.

Table 7-18 Content of N and P (mg/kg DW) measured in sediment along the NSP2 route V1 during the survey in 2015 /89/.

Station	Total nitrogen	Total phosphorus
NSP2 base case min-max[1]	345-3,110	600-1,220
Highest value measured	3690	870
Average value measured	3375	720
RA_03	3,000	550
RA_06	3,460	870
RA_10	3,350	730
RA_14	3,690	730

[1] Range of values measured along the NSP2 base case route in Denmark.

As would be expected, the sediment at deep stations dominated by sediments rich in clay and silt contained higher amounts of nutrients than the shallower sediment at stations dominated by coarser sediments.

7.3.3.8 Chemical warfare agents

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 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 /122/.

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 7-19.

Table 7-19 Examples of CWA contained within chemical munitions dumped in the Bornholm Basin /122/.

Name	Composition	CAS no.	Dumped (t)	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, headache
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

Several surveys have been carried out to determine the CWA concentrations in seabed sediments east of Bornholm in relation to the NSP and NSP2 projects /91//92//124/. The CWA and CWA degradation products included in these surveys are summarised in Table 7-20.

Table 7-20 CWA analysed in seabed sediments /91//92//123/.

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

Chemical	Description	CAS number
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 (TCA)	Component in dumped arsine oil	8011-67-4

The survey carried out in 2018 covered the proposed NSP2 route and the NSP2 route V2, which avoid the centre of the chemical munitions dumping area /92/. This survey did not detect any intact CWA in the sediment, but degradation products of sulphur mustard (1,4-Dithiane and 1,2,5-Trithiepane) and PDCA (dipropyl phenylarsonodithioite) were detected as summarized in Table 7-21.

Table 7-21 The average concentration of detected CWA degradation products (2018 survey) in samples with content above detection limits and the % of total number of samples with concentrations exceeding detection limits. Concentrations are shown in µg/kg DW.

CWA grouping	CWA degradation product	Average concentration	% of samples exceeding detection limit
Sulphur mustard	1,4-D[1]	0.31	43
	1,2,5-T[2]	0.77	63
Phenyldichloroarsine	DPP[3]	3.5	60

[1]1,4-Dithiane, [2]1,2,5-Trithiepane, [3]Dipropyl phenylarsonodithioite.

The survey carried out in 2015 covered a transect through the centre of the chemical munitions area, and can be considered representative with regard to the amounts and frequencies of CWA findings in the sediment along the NSP2 route V1 /91/. These results are summarized in Table 7-22.

Table 7-22 The average concentration of detected CWA and CWA degradation products (2015 survey) in samples with content above detection limits and the % of total number of samples with concentrations exceeding detection limits. Concentrations are shown in µg/kg DW.

CWA grouping	CWA or respective degradation product	Average concentration	% of samples exceeding detection limit
Sulphur mustard	Sulphur mustard	0.75	7
	1,4-D[1]	0.94	15
	1,4,5-O[2]	1.67	11
	1,2,5-T[3]	2.61	33
Adamsite	Adamsite	254	63
	5,10-D[4]	51.2	41
Clark I/II	DPA[5]	372	48
	DBT[6]	14.0	22
Triphenylarsine	TPA[7]	9.11	30
	TPAO[8]	32.6	41
Phenyldichloroarsine	PAA[9]	52.7	37
	DPP[10]	25.0	26

[1]1,4-Dithiane, [2]1,4,5-Oxadithiepane, [3]1,2,5-Trithiepane, [4]5,10-Dihydrophenarsazin-10-ol 10-oxide, [5]Diphenylarsinic acid, [6]DPT = Diphenylpropylthioarsine, [7]Triphenyl arsine, [8]Triphenylarsine oxide, [9]Phenylarsonic acid, [10]Dipropyl phenylarsonodithioite.

No traces of intact CWA or degradation products were found for Tabun, Lewisite I or Lewisite II in the 2015 survey /91/.

As described in section 7.1.2, a survey of CWA in sediment along the NSP2 route V1was conducted in 2019, and the preliminary results of this survey indicate that the frequency of single finds for intact CWA and their degradation products are mainly comparable to the results of the 2015 survey. At the time this report was written (April 2019), the results regarding Clark I/II-type CWA are still awaiting final validation at the test laboratory. However, the preliminary results are summarized in Table 7-23.

Table 7-23 The average concentration of detected CWA and CWA degradation products (2019 survey) in samples with content above detection limits and the % of total number of samples with concentrations exceeding detection limits. Concentrations are shown in µg/kg DW.

CWA grouping	CWA or respective degradation product	Average concentration	% of samples exceeding detection limit
Sulphur mustard	Sulphur mustard	0.27	13
	1,4-O[1]	0.32	13
	1,4,5-O[2]	0.96	65
	1,2,5-T[3]	28.39	17
Adamsite	Adamsite	15.10	35
*Clark I/II**	*Clark II*	*15,60*	*43*
	DPA[4]	*6.51*	*61*
	DPT[5]	*2.16*	*35*
Triphenylarsine	Triphenylarsine	76.20	17
Phenyldichloroarsine	Phenyldichloroarsine	13,51	48
	PAA[6]	6.79	100

*Final validation of laboratory test results for Clark-I/II type chemicals is still pending at the time this document was issued, and numbers may thus change, [1]1,4-Oxathiane, [2]1,4,5-Oxadithiepane, [3]1,2,5-Trithiepane, [4]Diphenylarsinic acid, [5]Diphenylpropylthioarsine, [6]Phenylarsonic acid.

Generally, the surveys carried out in 2015, 2018 and 2019 show that the highest frequencies and concentrations of CWA and CWA degradation products are found within the chemical munitions risk area. CWA and their degradation products are also found outside this area, but as a general rule the frequency of findings decreases with increasing distance from the area. These findings are similar to recent results from the Chemical Munitions Search and Assessment (CHEMSEA) project, which found that 86% of the samples from the Bornholm Basin contained one or more CWA or their degradation products /125/. Similar to the findings of the 2015 and 2018 NSP2 surveys, CHEMSEA also reports a low frequency of intact mustard gas detections, whereas arsenic-containing compounds are more frequent.

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 of the Baltic Sea

The semi-enclosed Baltic Sea forms a large estuary. The area is permanently stratified because it receives freshwater from rivers as well as saltwater inflows from the North Sea, which flow 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 /126/.

The temperature in the bottom water of the Bornholm Basin is typically within the range of 5-7 °C throughout the year, and is sensitive to inflows from the Kattegat and the North Sea. In the winter, the temperature of the bottom water is warmer than the overlying 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 the summer and 4 °C during the winter.

In general, the currents in the Baltic Sea are weak, except for in 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 /127//128/.

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 Sea. From there, it slowly moves as a thin bottom layer into the central Baltic Sea 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 7-20. Before 1980, such events were relatively frequent and could be observed on average once per year. In the last two decades, however, the frequency has decreased /129/.

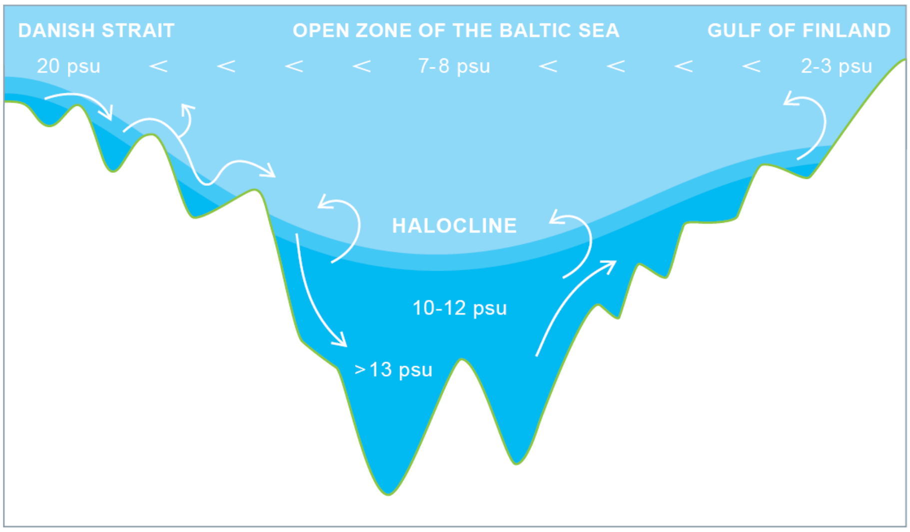


Figure 7-20 The heavy, saline water flows along the bottom, and the less saline surface water flows out of the Baltic Sea. The water becomes stratified, and a halocline separates the layers of varying salinity /129/.

The Arkona Basin is the first basin that new deep water flowing into the Baltic Proper encounters after crossing the entrance sills in the Sound (Drogden Sill) and the Fehmarn Belt (Dars Sill). The deep-water flows along the bottom as a gravity-forced dense bottom current that mixes with resident Baltic Sea 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 that carries 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 of 0.5-1 m during the summer and 1-1.5 m during the winter. Higher waves of up to >4 m occur during storm events /130/. 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 7-21 /131/. Such storm events occur mainly during the winter months (November to February) and are very rare in the months of May to August.

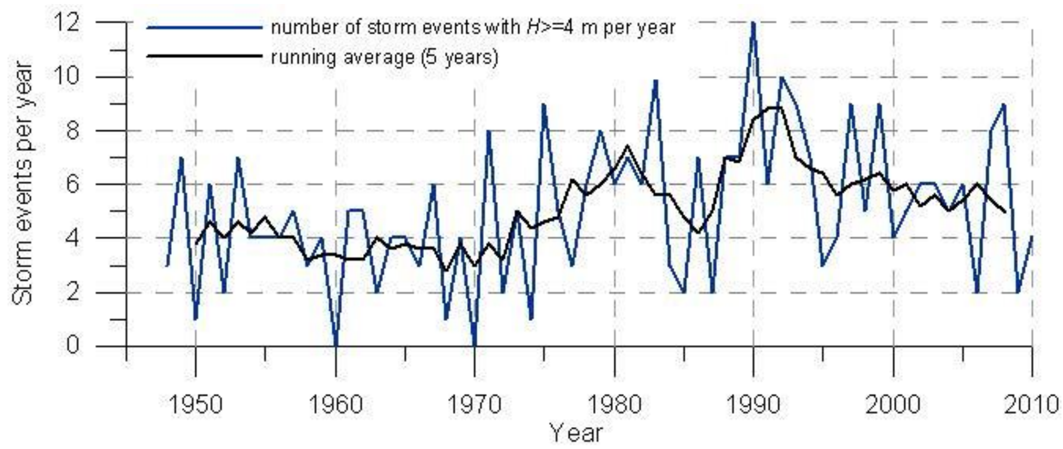


Figure 7-21 Annual number of storm events with significant wave heights of 4 m or more in the Baltic Sea /131/.

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 /132/.

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 to limited water renewal.

Inflows of oxygenated seawater from the North Sea to the deep basins occur irregularly, and lead to temporary increases in salinity in the bottom water, as well as fluctuations in temperature (Figure 7-22 shows an example of this effect measured during the field survey in October 2015). These inflows of marine water are highly important for oxygenating the deep-water areas of the Baltic Sea, and for supporting the physical environment of marine species. The inflows have been rare since the 1980s, but have had a slightly higher frequency in recent years /111/.

A relatively large saltwater inflow was detected in the western Baltic Sea during the winter of 2011-2012. This event ventilated the Bornholm Basin and could be traced as far as the southern part of the eastern Gotland Basin. Oxygen conditions in the deep have been improved by a series of inflow events since the end of 2013. First, a series of smaller inflow events occurred in November 2013, December 2013 and March 2014. These interacted positively and reached the deep water of the central Baltic Sea for the first time since 2003 /133/. In December 2014 and January 2015, a very strong inflow occurred, which transported 198 km^3 of saline water into the Baltic Sea and was followed by smaller events. An inflow of moderate intensity also occurred between 14 and 22 November 2015. These events caused intensified oxygen dynamics in the Arkona Basin, Bornholm Basin, and Eastern Gotland Basin, but the northern parts were not affected. As a result, the near-bottom oxygen concentrations in the Bornholm Deep ranged from 0.11 mg/l (in November 2015) to 7.2 mg/l (in February 2015), both measured at 95 m water depth. In the Gotland Deep, oxygen conditions ranged from -11.6 mg/l (in November 2013) to 3.9 mg/l (in April 2015) at 235 m water depth /134/. The negative value measured in November 2013 represent the content of sulphide in the water given as oxygen equivalents, and is referred to as "oxygen debt".

Salinity, temperature and oxygen were measured in the water column at numerous locations in the Danish EEZ east and south of Bornholm during surveys performed in 2015-2019 /89//135/. In general, the measurements show that the water is stratified with a well-mixed surface layer reaching a water depth of approximately 40 m with a salinity of around 8 psu. Below this, salinity generally increases with water depth, reaching values of around 20 psu in the deepest bottom waters at >90 m water depth. The temperature varies with water depth in a complex pattern reflecting both the time of year and the recent history of minor and major saltwater inflows. The oxygen content in the water decreases gradually with water depth below the well-mixed surface layer, and the bottom water at deep stations is generally highly oxygen-depleted and unsuitable for higher life. An example of a water column profile is shown in Figure 7-22.

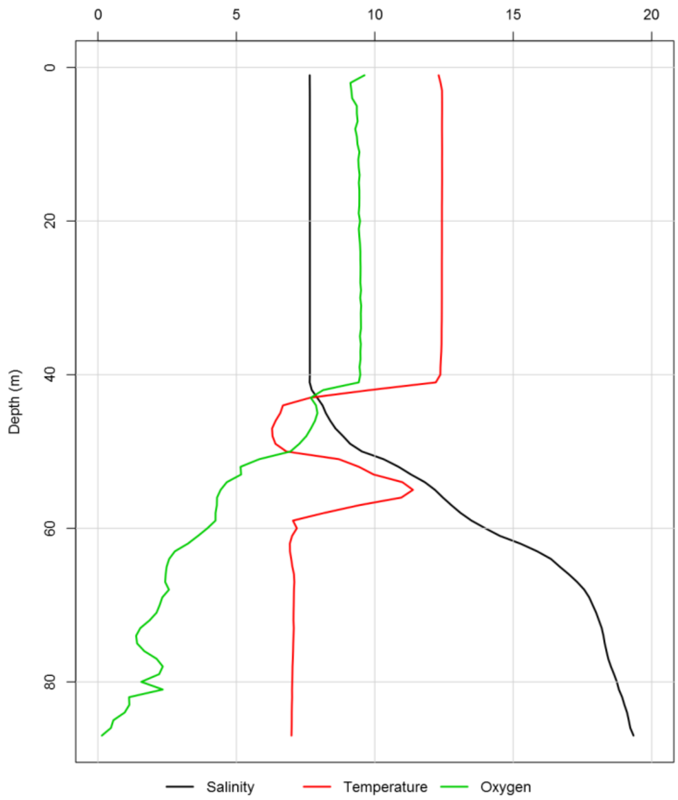


Figure 7-22 Profiles of salinity (psu), temperature (°C) and oxygen (mg/l) in the water column at station ES_07 in October 2015 /89/.

7.5 Water quality

The water quality in the Baltic Sea is an important factor that influences the environment and the living conditions for associated fauna and flora. On this basis, and demonstrated by the requirements outlined in the MSFD and WFD (see sections 4.2.5 and 4.2.6, respectively), water quality is considered an important receptor. This section describes the current water quality in the Baltic Sea, particularly with respect to contaminant and nutrient concentrations, turbidity and oxygen content.

7.5.1 Metals

The main sources of heavy metals to the Baltic Sea are diffuse sources (e.g. leakage from forest and agricultural soils) and industrial and municipal point sources /107/. Heavy metals are discharged directly, transported via rivers or supplied from the air. Significant airborne heavy metal pollution originates from sources outside the Baltic Sea catchment area.

Three metals, mercury (Hg), lead (Pb) and cadmium (Cd), are included in the HELCOM list of environmental core indicators, and their status was recently reported. The primary matrix for cadmium and lead is water, as the primary threshold values for these two core indicators are agreed to be the respective EQS values for water (0.2 µg/l and 1.3 µg/l, respectively). The preferred matrix for monitoring of metals in the HELCOM COMBINE monitoring programme is biota and sediment, and as a result, very little direct data are available for cadmium and lead in Baltic Sea water. Cadmium concentrations in the water phase have been measured by Russia (1995–1998), Germany (1998–2015), Lithuania (2007–2015) and Poland (2011-2015), and only a small percentage of these measurements were above the annual average EQS (AA-EQS) of 0.2 µg/l. Lead concentrations in seawater have been measured by Russia (1995–1998), Germany (1998–2015), Lithuania (2007–2015) and Poland (2011-2015), and 11% of German and Lithuanian measurements were above the AA-EQS of 1.3 µg/l. When including monitoring results from sediments and biomass in the assessment, the environmental status of core indicators cadmium and lead in the waters around Bornholm (and most of the Baltic Sea in general) is considered poor. Mercury is measured in fish tissue as a primary matrix in the HELCOM monitoring programme, and no recent water measurements have been reported. However, a substantial dataset for fish tissue exists, indicating that the environmental status of the core indicator mercury is poor throughout the Baltic Sea, including in the waters around Bornholm.

Administrative Order 1625 of 19/12/2017 issued by DEPA /115/ lists a number of threshold concentrations for metals that describe GES. These include values both for the AA-EQS and for maximum allowable concentrations, as summarised in Table 7-24.

Table 7-24 Thresholds for GES of water in regard to metals /115/.

Metal	Annual average concentration in seawater, µg/l	Maximum concentration in seawater, µg/l
Ag	0.2	1.2
As	0.6	1.1
Cd	0.2	0.45
Cr	3.4	17
Co	0.28	34
Cu	4.9	4.9
Hg	-	0.07
Ni	8.6	34
Pb	1.3	14
V	4.1	57.8
Zn	7.8	8.4

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 /136/.

Recent data regarding organic pollutants in the water are scarce, because the HELCOM COMBINE monitoring programme is based on measurements of biomass and sediment samples. The general status of the HELCOM core indicators PAH, PCB, organochlorine pesticides and organotin were discussed in section 7.3.3.

Administrative Order 1625 of 19/12/2017 issued by DEPA /115/ lists a number of threshold concentrations for organic contaminants describing GES. These include values both for annual averages and for maximum allowable concentrations, as summarised in Table 7-25.

Table 7-25 Thresholds for GES of water in regard to organic pollutants /115/.

Group	Chemical	Annual average concentration in seawater, µg/l	Maximum concentration in seawater, µg/l
PAH	Acenaphthene	0.38	3.8
	Acenaphthylene	0.13	3.6
	Benzo[a]anthracene	0.0012	0.018
	Benzo[a]pyrene	0.00017	0.027
	Benzo[b]fluoranthene	0.00017	0.017
	Benzo[k]fluoranthene	0.00017	0.017
	Benzo[ghi]perylene	0.00017	0.00082
	Chrysene	0.0014	0.014
	Dibenzo(a,h]anthracene	0.00014	0.018
	Indeno[1,2,3-cd]pyrene	0.00017	-
	Fluoranthene	0.0063	0.12
	Fluorene	0.23	21.2
	Naphthalene	2	130
	Phenanthrene	1.3	4.1
	Pyrene	0.0017	0.023
Organochlorine pesticides	DDT	0.025	-
Organotin	TBT	0.0002	0.0015

7.5.3 Nutrients

As discussed in section 7.3.3.7, increased concentrations of nutrients, mainly relating to nitrogen (N) and phosphorus (P) compounds, can cause eutrophication, considered one of the major pressures on the Baltic Sea ecosystem /111/. N and P concentrations in the water are among the core indicators of this pressure /110/.

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 7-23. Typical pathways of nutrient inputs to the offshore environment are discussed in /137/ and are 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.

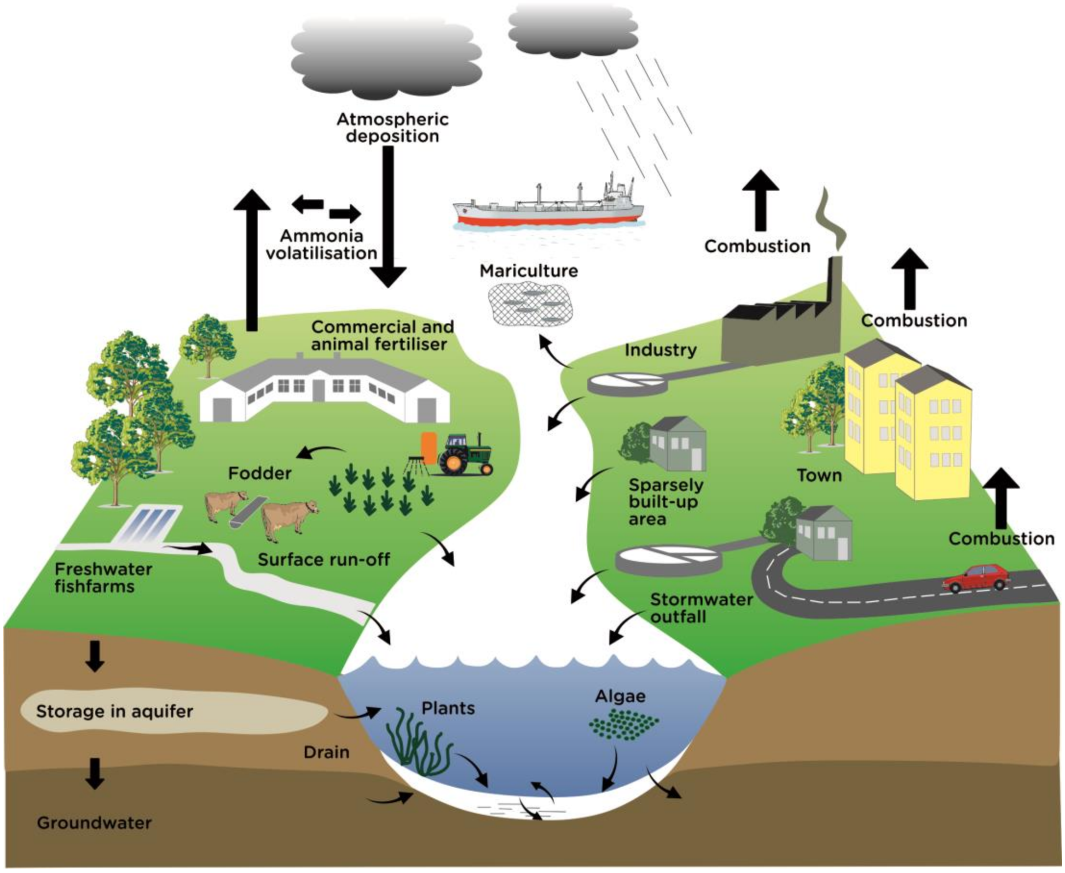


Figure 7-23 Typical sources of nutrients to the sea /138/.

As illustrated in Figure 7-24, the total inputs of N and P to the Baltic Sea from waterborne sources have been reduced since the 1980s due to measures implemented by the Baltic countries.

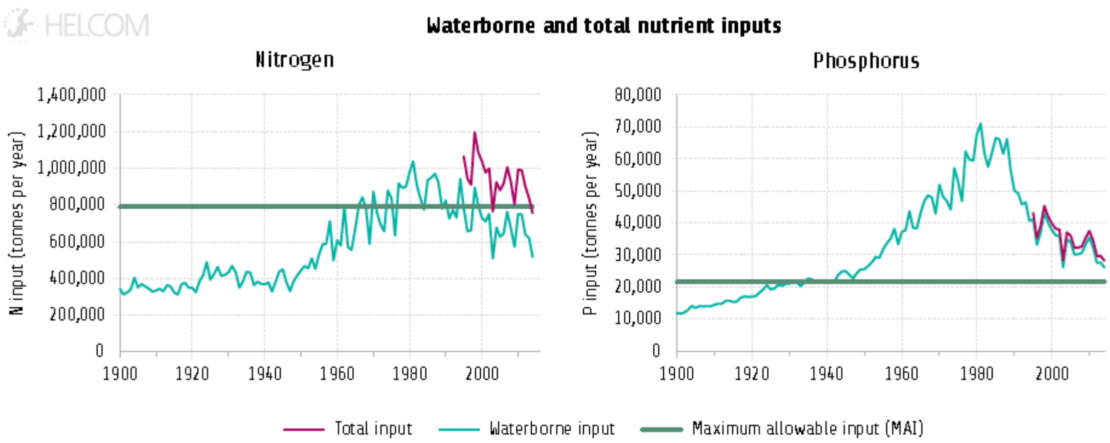


Figure 7-24 Temporal development of waterborne inputs of total nitrogen and total phosphorus to the Baltic Sea /111/.

In spite of the reduced inputs of N and P, the concentrations of dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) in seawater from the different sub-basins in the Baltic Sea have not decreased much since the 1980s, and, with a few exceptions, the core indicators DIN, total nitrogen (TN), DIP and total phosphorus (TP) all remain above the targets for GES in all sub-basins of the Baltic Sea /111/.

7.5.3.2 Eutrophication in Danish waters

Eutrophication is a condition in an aquatic ecosystem in which 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 increased inflows 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 and gases. 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 benthic fauna, e.g. biogeochemical feedback loops and biomass production /139/.

Concentrations of DIN and DIP in seawater from the Arkona and Bornholm Basins during the years 2011 to 2015 are summarised in Table 7-26. Also shown in the table are the target concentrations corresponding to GES, as agreed by HELCOM /140//141/.

Table 7-26 Concentrations (average 2011-2015) and threshold values of DIN and DIP.

Basin	DIN Average 2011-2015 µmol/l	DIN Target value µmol/l	DIP Average 2011-2015 µmol/l	DIP Target value µmol/l
Arkona	4.05	2.90	0.61	0.36
Bornholm	9.06	2.50	0.62	0.30

The general eutrophication state of the waters around Bornholm has recently been evaluated based on core indicators for nutrient levels (DIN, TN, DIP, TP), direct effects (chlorophyll a, Secchi depth, cyanobacterial bloom index), and indirect effects (oxygen debt and zoobenthos) /111/. It was concluded that the state of the water west of Bornholm was "poor", and the state of the waters north, east and south of Bornholm was "bad", see Figure 7-25.

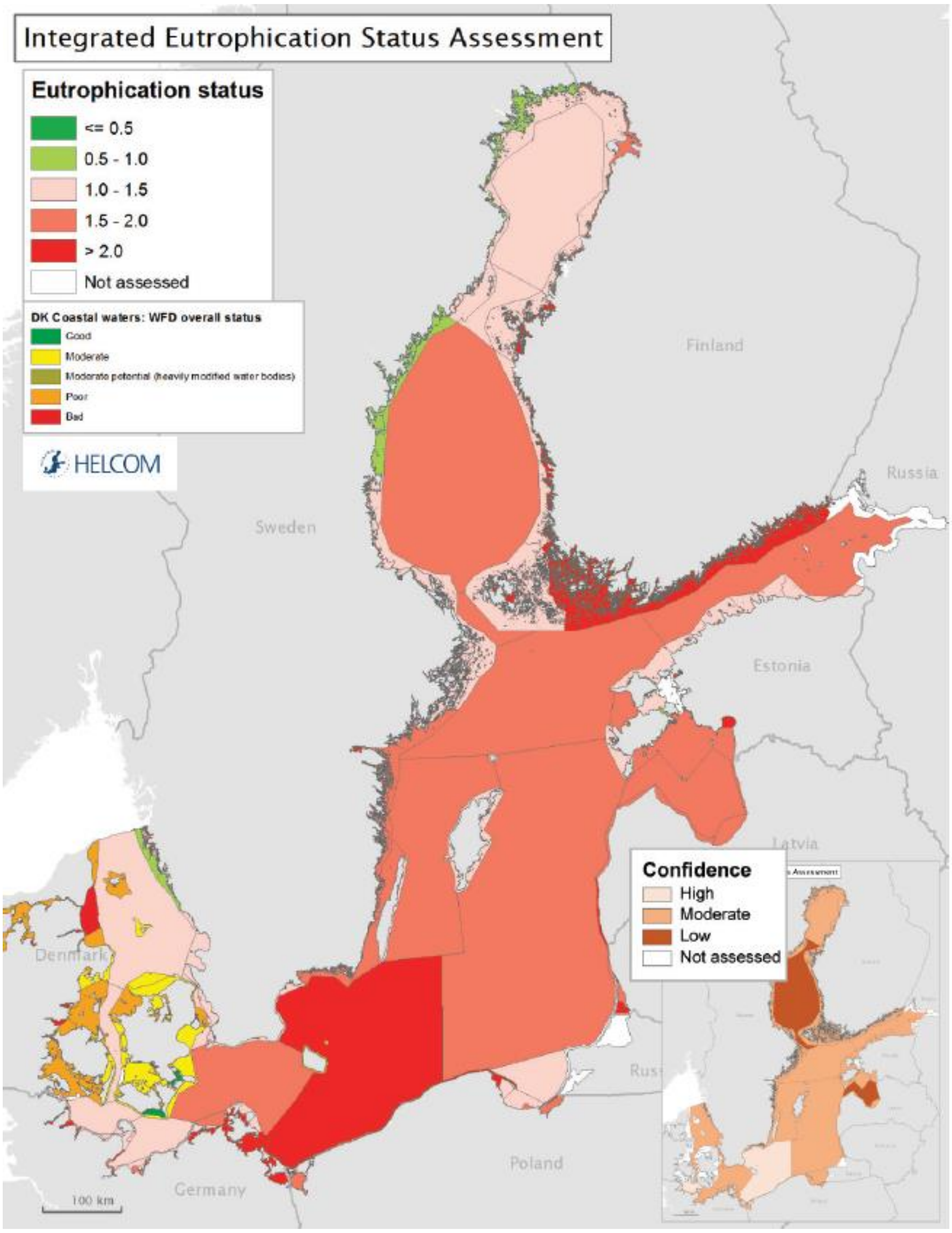


Figure 7-25 HELCOM integrated eutrophication status assessment /111/.

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 a diameter <0.063 mm), e.g. silt and clay, are often cohesive and tend to flocculate and form aggregates in seawater. When sediments are resuspended, 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.

Suspended solids usually settle to 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 a 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 /142//143/. 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 water depths greater than 20 m /144/.

Furthermore, turbidity increases during the 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, Danish waters have a relatively low turbidity level /145/. As noted above, turbidity is strongly linked to the suspended sediment concentration in the water column. The suspended sediment concentration in the saline bottom water in the Baltic Sea is typically 1-2 mg/l, although during stormy periods, the concentration of suspended sediments has been shown to increase locally to 30-40 mg/l /146/.

Secchi depth (a measure of the clarity of the water) is employed by HELCOM as a core indicator for eutrophication and is monitored routinely. The target Secchi depth for the Arkona Basin is 7.2 m and for the Bornholm Basin the target is 7.1 m /147/. The results of Secchi depth measurements in the Bornholm and Arkona Basins during the years 2011 to 2015 are shown in Figure 7-26 /148/. 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 shown in Figure 7-26 /149/.

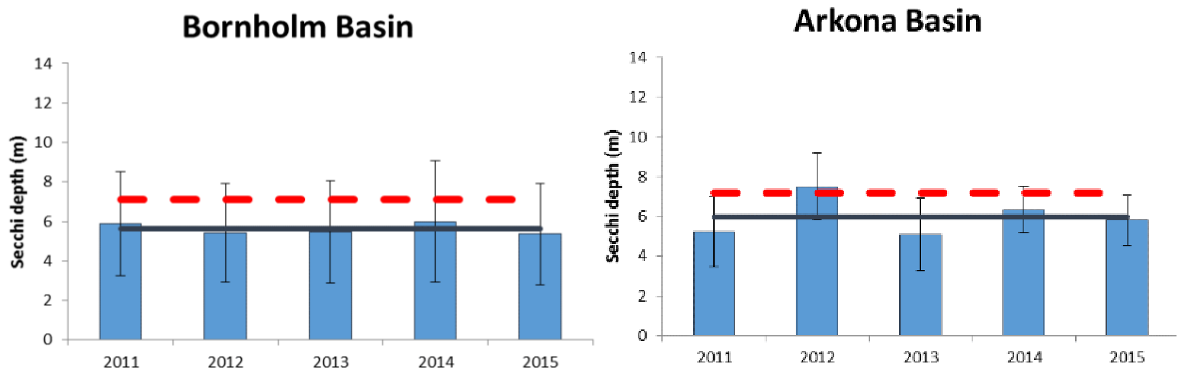


Figure 7-26 Summer (June-September) Secchi depth yearly averages in surface water from the Bornholm and Arkona Basins (blue columns). Also shown are the yearly averages for 2011-2015 (black line) and target levels as agreed by HELCOM HOD 39/2012 (red broken line).

7.5.5 Oxygen content

In the Baltic Proper, the low oxygen concentrations 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, and oxygen replenishment below the prevailing halocline is largely limited to infrequent inflows of oxygen-rich marine water from the Kattegat. Seawater inflow and stratification of the water column is further described in section 7.4.2.

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 /150/.

The increasing distribution of areas with poor oxygen conditions in the bottom water has been noted as a particular concern for the Baltic Sea, and “oxygen debt” is included in HELCOM’s list of core indicators for the environmental status of the inner basins of the Baltic Sea (including the Bornholm Basin), but not for the area west of Bornholm or the Arkona Basin. In the Bornholm Basin, the average oxygen debt during the years 2007 to 2011 was -7.10 mg/l, which is only slightly more negative than the target of -6.37 mg/l. The Bornholm Basin was assessed to be sub-GES in regard to the oxygen debt indicator of eutrophication /151/.

Measurements performed by Nord Stream 2 AG east and south of Bornholm are discussed in 7.4.2, and confirmed the pattern of decreasing oxygen concentration with depth below the halocline.

7.6 Climate and air

The climate and air quality in the Baltic region is an important factor that influences the environment and living conditions for the associated fauna and flora, as well as for 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 /127/.

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.

Within the Danish EEZ, the combination of the proposed NSP2 route with either the NSP2 route V1 or the NSP2 route V2 will extend 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 /152/.

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 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 /152/.

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 /152/.

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 /153/. 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 vast ice ridges /153/.

In the areas where the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 cross the Danish 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 NSP2 route, NSP2 route V1 and NSP2 route V2 only during severe winters, and the maximum annual ice thickness is less than 10 cm in the waters around Bornholm /154/.

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 /111/. 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 published by the Swedish Meteorological and Hydrological Institute (SMHI) in 2007 shows that average sea surface temperatures for the entire Baltic Sea could increase by some 2-4ºC by the end of the 21st century /156/. 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 Sea, oxygen concentrations may decrease and phosphate concentrations may increase, thereby resulting in increased phytoplankton biomass. A report issued by HELCOM in 2013 largely confirmed these findings /155/ and concluded 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. In a recent report from HELCOM, it is noted that long-term changes in surface water salinity and temperature occur in response to climate change and increased input of freshwater. Furthermore, increased levels of carbon dioxide in the atmosphere are expected to cause acidification, with a decreasing pH in the long term /111/.

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 coastal and inshore areas around the Baltic Sea has led to increased levels of air pollutants in these areas, which decrease with distance from shore. 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 lengths 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 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 GHGs, 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 the 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 in 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 anthropogenic NO_X emissions are due to shipping /157/.

Sulphur is naturally present in fuels. It is emitted from the burning of coal and oil at power plants and mobile 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 /157/. 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 (including the heart and brain) and tissues.

Combustion of fuels gives 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 is 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 2016, the total annual Danish emissions of CO_2, NO_X, SO_X and PM caused by shipping (national and international) were approximately 2,596,000 t of CO_2, 58,687 t of NO_x, 1,636 t of SO_x, and 1,497 t of PM, respectively /328/.

Looking at emissions from all vessels sailing in the Baltic Sea, the total emissions (2015) amounted to 15,900,000 t of CO_2, 342,000 t of NO_X, 10,000 t of SO_X and 10,000 t of PM /158/.

7.7 Plankton

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

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.

7.7.1.1 Phytoplankton in the Baltic Sea

Phytoplankton grow photosynthetically (by using light as an energy source). Growth is therefore limited to roughly the upper 20 m 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 /150//159//160//162//163/:

- 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 /150/. 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 /162/. One of the bloom-forming cyanobacteria, *Nitzschia spumigena*, can produce nodularin, a hepatotoxic toxin that can result in liver damage.

- 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.

7.7.1.2 Phytoplankton biomass in the Danish section

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

Figure 7-27 shows the annual variation in the chlorophyll-*a* content of the surface water of the Danish section of the Baltic Sea in 2016, based on satellite measurements /160/.

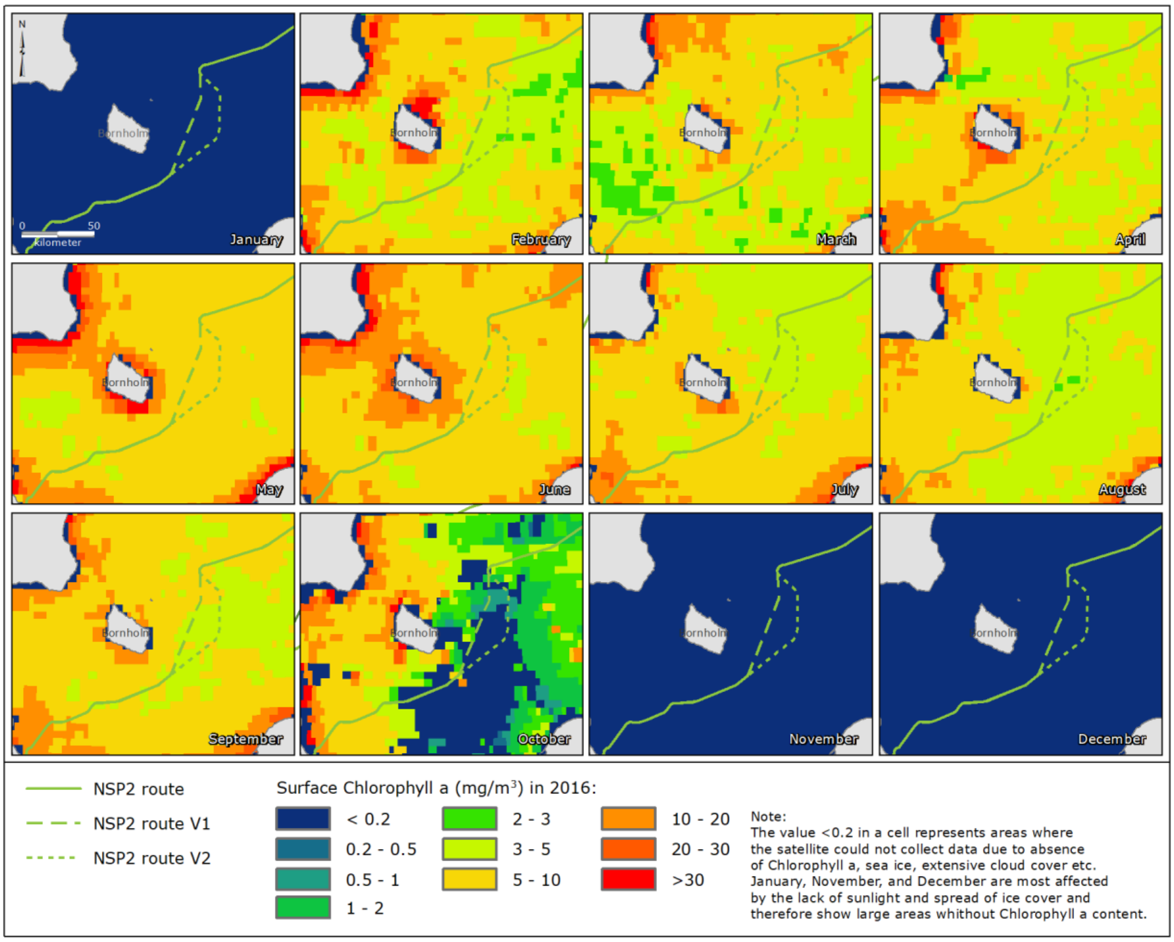


Figure 7-27 Annual variation in the chlorophyll-*a* content of the surface water in the Danish section of the Baltic Sea, based on satellite measurements from 2016 /160/.

Long-term trends in the summer biomass of phytoplankton are shown for the Bornholm Basin in Figure 7-28.

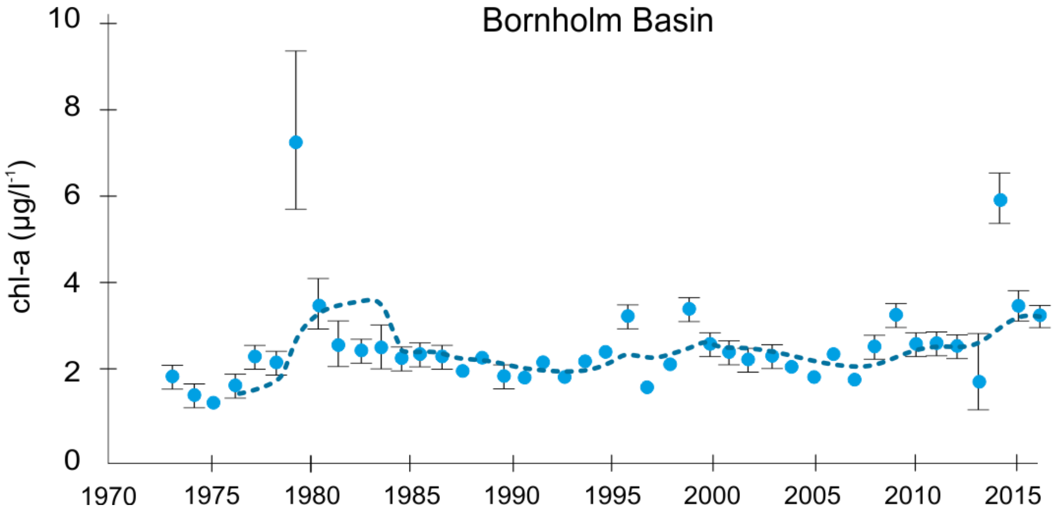


Figure 7-28 Long-term trends in *in-situ* chlorophyll-*a* concentrations in summer (Jun-Sep) in the Bornholm Basin, 1970-2015. Dashed lines indicate the 5-year moving average and error bars represent the standard error /161/.

For the Bornholm Sea (north and east of Bornholm), the concentrations of surface chlorophyll-*a* pigments for the periods 1979-1989, 1990-1999 and 2000-2005 are shown in Figure 7-29 /160/. The data series from 1979-1989 shows a pattern with two peaks in spring and autumn, with 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 time series data from the Bornholm Basin for 2007-2011 /147/ and from 2010-2016 /164/ show chlorophyll-*a* concentrations of up to 5 µg/l, which are comparable to the values presented in Figure 7-29 /159/.

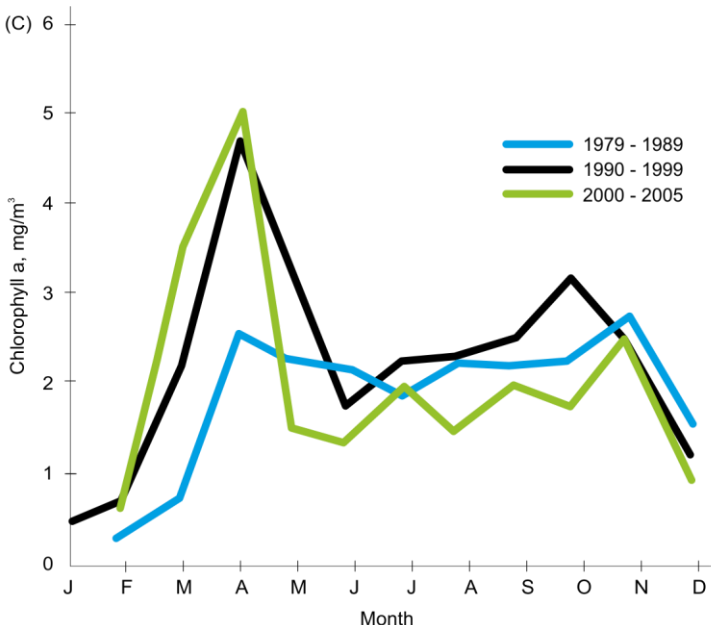


Figure 7-29 Seasonal patterns of chlorophyll-*a* (mg/m^3, monthly mean) for 1979-1989, 1990-1999 and 2000-2005 in the Bornholm Sea east of Bornholm, based on measurements of 0-10 m depth. Figure re-drawn from /159/.

In the Arkona Basin (west of Bornholm), the chlorophyll-*a* concentration has been measured as part of a long-term monitoring programme from the Danish environmental authorities /165/. The chlorophyll *a* concentration typically varies in a similar pattern as described above, with three peaks in spring, summer and autumn, with a maximum of 6 mg/m^3 /165/.

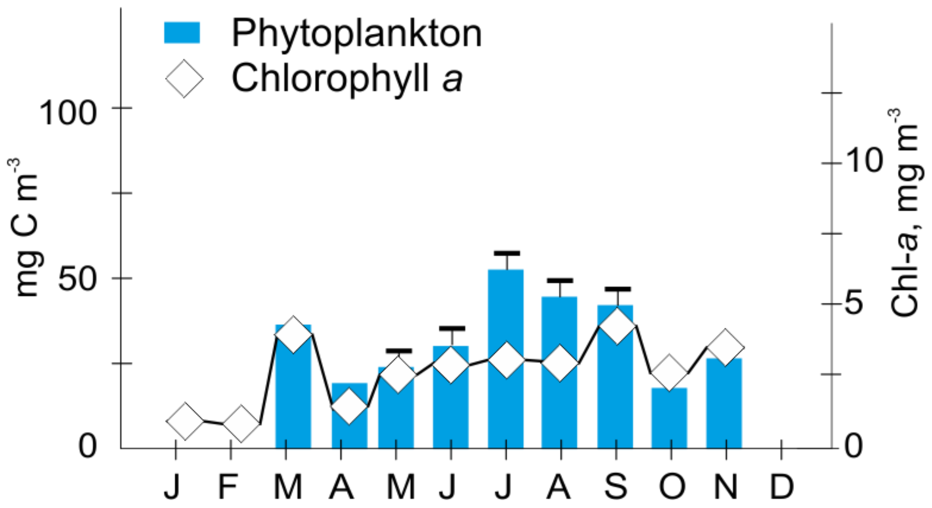


Figure 7-30 Biomass of phytoplankton (shown as carbon (C) and chlorophyll-*a*) in the surface layer of the open water monitoring stations in Arkona Basin. Figure redrawn from /165/.

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. 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 areas near the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 (Bornholm Basin), the GES level for chlorophyll-*a* is 1.8-2.0 µg/l (c. 1.8-2.0 mg/m^3) /147//161/. The current conditions (chlorophyll-*a* concentrations as described above) are thus higher than the GES threshold.

7.7.1.3 Phytoplankton composition in the Danish section

Phytoplankton in the Baltic Sea belongs primarily to the following taxonomic groups: Cyanobacteria, Cryptopheceae, Dinophyceae (dinoflagellates), Bacillariophyceae (diatoms), Chryosphyceae, and *Mesodiunium rubrum* (a protozoan capable of photosynthesis). Though interannual variation is high, there is some consistency in the species composition /159/.

The composition of the phytoplankton biomass in the Bornholm Sea east of Bornholm (2004 data), split into main taxonomical groups, is shown in Figure 7-31 /159/. In early February, the biomass is low and consists primarily of Cryptophyceae. Later in the month, *M. rubrum* starts to form a larger part of the population. The spring bloom (March-May) in the Bornholm Sea consists primarily of *Mesodiunium rubrum*. There is no dominance by typical spring bloom groups of the southern Baltic Sea (diatoms and/or dinoflagellates) in 2004 /159/. The species composition during the summer bloom varies, and in 2004 consisted of Cryptophyceae (*Plagioselmis prolonga*), cyanobacteria (*Aphanotece* sp.), dinoflagellates, and other (*Phacus* sp.). The autumn bloom in 2004 was dominated by diatoms (*Coscinodiscus granii*) /159/.

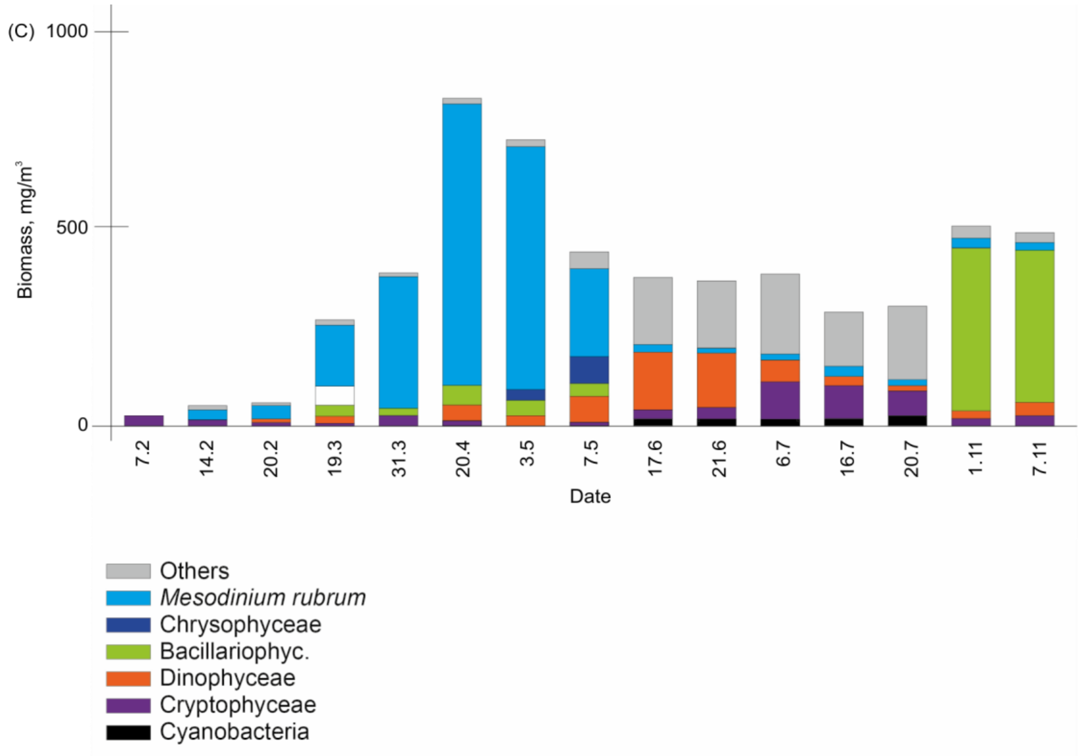


Figure 7-31 Seasonal variation of phytoplankton biomass (mg chl *a*/m³) in the Bornholm Sea east of Bornholm in 2004, split into the main taxonomical groups. Figure redrawn from /159/.

7.7.1.4 Phytoplankton along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2

The Peter Gaz surveys in 2005 and 2006 found that the *Bacillariophyta* algae were the most abundant at the stations located along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. The sampling was carried out in October 2005 and April/May 2006. The station numbers changed between sampling years, but are grouped in the below figure according to location.

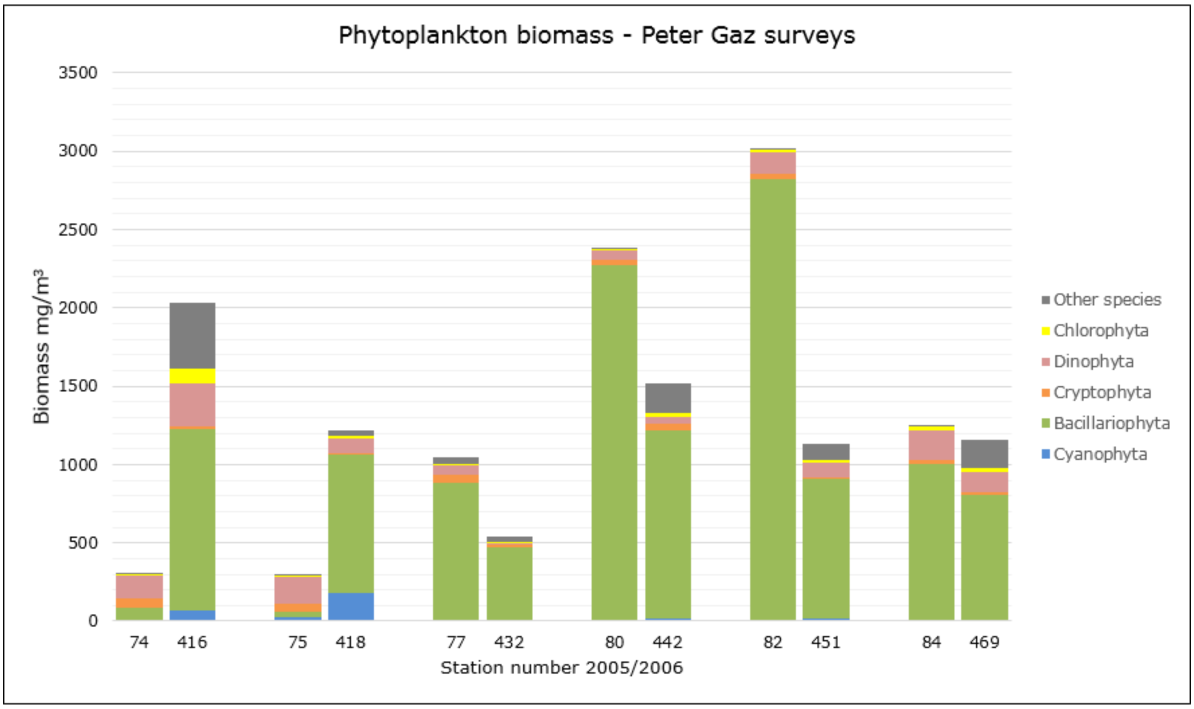


Figure 7-32 Phytoplankton biomass at the Peter Gaz sampling stations. The lower station numbers correspond to the general area of the NSP2 route V1 and the NSP2 route V2, whilst station 84/469 corresponds to the southern-most part of the proposed NSP2 route, see section 7.1.1.2.

7.7.1.5 Biodiversity status

In 2017, HELCOM released the integrated biodiversity status assessment for the pelagic habitats using the core indicators "Cyanobacterial bloom index" and "Chlorophyll-*a*" /111/. This assessment shows that in the Arkona Basin and Bornholm Basin, the integrated biodiversity status assessment for pelagic habitats is "not good" /111/.

7.7.1.6 Conservation status

The Danish Red List /166/, HELCOM Red List /167/ and EU Habitats Directive do not include phytoplankton.

7.7.2 Zooplankton

Zooplankton play 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 /161/.

7.7.2.1 Zooplankton in the Baltic Sea

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 /150//168/.

The zooplankton of the Baltic Sea are generally dominated by calanoid copepods and cladocerans. 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 coastal waters, e.g. *Acartia* spp. Occasionally, species of crustaceans from the North Sea, e.g. *Paracalanus parvus* and *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

/169//170/. Within the meso- and macrozooplankton, copepods *Pseudocalanus* spp., *Temora longicornis*, *Acartia* spp., and cladocerans *Evadne nordmanni* are the most important taxa in the open Baltic Sea in biomass and production /150/.

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.

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 /150//168/. 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 long-term significant trends in overall biomass development of zooplankton were found over this period /150/.

7.7.2.2 Zooplankton in the Danish section

In the Bornholm Basin, the most common zooplankton are cladocera, copepods and rotifers, with a study from 2002-2003 showing that each of five taxa (*Bosmina coregoni maritima*, *Acartia* spp., *Pseudocalanus* spp., *Temora longicornis*, *Synchaeta* spp.) contributed >10% to the zooplankton community composition /169/.

7.7.2.3 Zooplankton along the NSP2 route, the NSP2 route V1 and the NSP2 route V2

The Peter Gaz surveys in 2005 identified six species of copepod, with samples dominated by *Pseudocalanus elongatus* and *Temora longicornis*. There was no clear pattern in abundance of any of the six species. Sampling during the Peter Gaz surveys, see section 7.1.1.2, only identified two eggs (at station 74) at all Danish sampling stations, and no fish larvae.

7.7.2.4 Biodiversity status

In 2017, HELCOM released its integrated biodiversity status assessment of the pelagic habitats using the core indicator “Zooplankton mean size and total stock”, but this assessment did not cover the Arkona Basin or Bornholm Basin /111/.

7.7.2.5 Conservation status

The Danish Red List /166/, HELCOM Red List /167/ and EU Habitats Directive do not include zooplankton.

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 of the Baltic Sea, often playing the role of “habitat builders”. Therefore, although no species that are listed as near threatened, endangered or vulnerable in the HELCOM Red List are expected along the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2, benthic flora and fauna are considered an important receptor.

7.8.1 Benthic flora

7.8.1.1 Benthic flora in the Baltic Sea

The benthic flora in the Baltic Sea encompasses species-rich seagrass meadows and macroalgae in shallow areas.

Benthic flora is primarily dependant on the availability of light at the seabed. The photic zone is defined as the depth at which 1% of the surface irradiance remains, and typically 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 /150/.

In the places where light permits benthic flora, a number of other factors influence the biomass and composition, e.g. substrate type, salinity and oxygen concentrations /150/. The marine flora in the Baltic Sea comprise primarily macroalgae and a few species of sea grass and water moss species. Salinity influences the species richness, and the number of marine macroalgae decreases from south-west to north-east in the Baltic Sea with decreasing salinity level.

Hard substrates such a rocks are dominated by brown and red seaweeds, while shallow sandy bottoms can be inhabited by seagrass.

7.8.1.2 Benthic flora in the Danish section

The photic zone is shown in Figure 7-33. It can be seen that the potential for benthic flora in Danish waters exists nearshore around Bornholm and on Rønne Banke south-west of Bornholm.

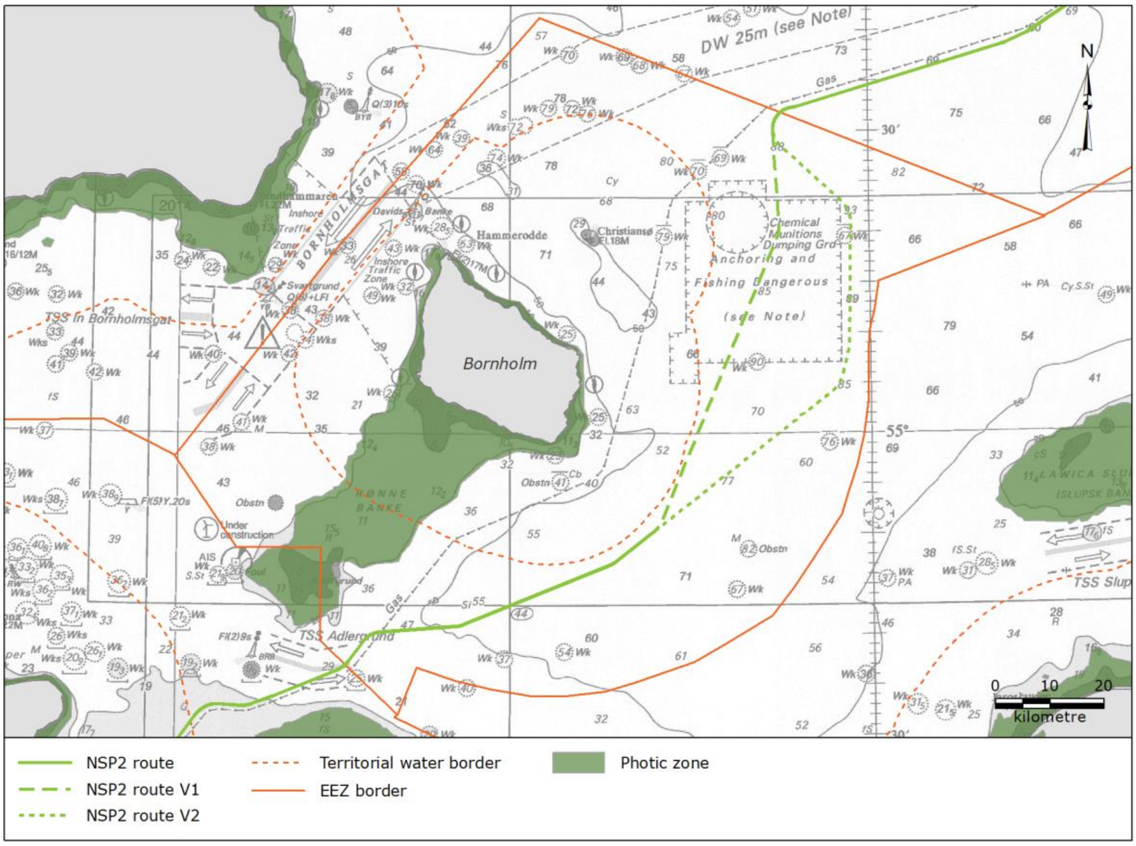


Figure 7-33 Map showing photic zone, and thus the potential for benthic flora.

Hard-bottom communities consist mainly of macroalgae: typically green, brown and red algae. Green algae tend to be the most abundant in shallower waters, brown algae (e.g. *Fucus* spp. *Laminaria* spp.), are found in both shallow and deeper parts and red algae (e.g. *Furcellaria*, *Ceramium*) in deeper parts. Soft bottom communities in shallow waters are often dominated by vascular plants or water moss (charophytes). Vascular plants rarely occur at depths greater than 6-8 m. Typical species include eelgrass (e.g. *Zostera marina*) and pondweeds (e.g. *Potamogeton* spp.).

7.8.1.3 Benthic flora along the NSP2 route, the NSP2 route V1 and the NSP2 route V2

The Danish section of the proposed NSP2 route, as well as the NSP2 route V1 and the NSP2 route V2, are situated at water depths below 20 m, which is below the photic zone; hence, no benthic flora is expected.

7.8.1.4 Biodiversity

In 2017, HELCOM assessed the integrated biodiversity status for benthic flora, but this assessment did not cover the Arkona Basin or the Bornholm Basin /111/.

7.8.1.5 Conservation status

The Danish Red List /166/ does not include benthic marine flora.

The HELCOM Red List for the Baltic Sea /167/ includes seven benthic flora species which are considered threatened (Critically Endangered, Endangered or Vulnerable). Three species were assigned to the category Endangered: one charophyte, *Lamprothamium papulosum*, and two vascular plants, *Persicaria foliosa* and *Hippuris tetraphylla*. Four species were categorised as Vulnerable: charophytes *Chara braunii* and *Nitella hyalina* and the vascular plants *Alisma wahlenbergii* and *Zostera noltii*. Four species were assessed as Near Threatened: two charophytes *Chara horrida* and *Nitellopsis obtusa* and two vascular plants *Crassula aquatica* and *Potamogeton friesii*. All Threatened and Near Threatened species are characteristic for soft-bottom, sheltered environments. No species identified along the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2 are listed as Near Threatened, Endangered or Vulnerable on the HELCOM Red List.

7.8.2 Benthic fauna

7.8.2.1 Benthic fauna in the Baltic Sea

The benthic fauna in the open Baltic Sea are primarily affected by salinity and oxygen supply.

Salinity (see sections 7.4 and 7.5) has an impact on the biodiversity of benthic fauna /171/. As illustrated in Figure 7-34, species richness in the open waters 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. The species richness of marine species such as polychaetes, molluscs and echinoderms is thus dramatically reduced from west to east /150/. Conversely, the diversity of freshwater benthic species increases towards the inner reaches of the Gulf of Finland and the Gulf of Bothnia /150//171/. The geographical trend in species richness in the Baltic Sea largely holds 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 /150/.

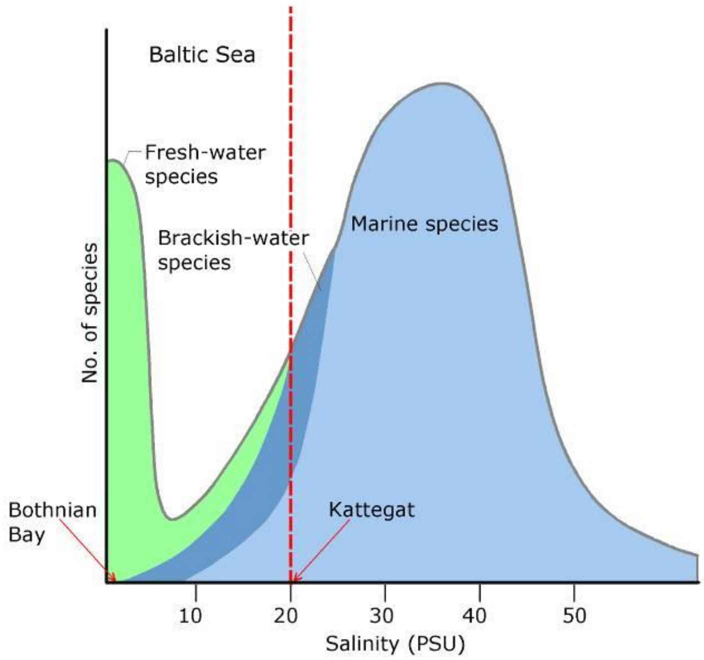


Figure 7-34 Number (arbitrary scale) of marine, brackish and freshwater species in open waters, correlated with salinity. The range of salinity in the Baltic Sea is indicated as the mean surface water salinity between the Bothnian Bay and the Kattegat. PSU stands for practical salinity units.

Oxygen conditions are crucial for benthic fauna, and benthic habitats in the Baltic Proper are, in general, strongly affected by the prevailing low-oxygen concentrations (see sections 7.4 and 7.5). Even occasional oxygen depletion will inhibit the usual successional pattern and prevent the development of a mature benthic community. Recurring low-oxygen concentrations lead to a diminished benthic diversity and dominance by opportunistic species. 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 /172/. Mobile species will show a behavioural response at oxygen concentrations below 4 mg O_2/l, while concentrations below 2 mg O_2/l are critical for organisms and typically result in the deaths of a number of organisms. The response is highly species-specific, with some species able to survive complete anoxia for weeks to months. The development of permanent anoxic conditions and subsequent release of toxic hydrogen sulphide will directly impact the survival of zoobenthos.

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 NSP2 route, the NSP2 route V1 and the NSP2 route V2 /150//171/. 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 /173/.

Furthermore, the composition of the benthic community and the species abundance are subject to a number of other factors, including light, seabed substrate conditions, water movement, water quality, food supply, trophic competition with invasive species, etc.

Generally, the benthic communities in the Baltic Sea all belong to the so-called Macoma community and are characterised by the bivalve *Limecola balthica* (formerly known as *Macoma balthica*) and a few other species, e.g. the common mussel *Mytilus edulis*. The small, brackish amphipod crustacean *Pontoporeia (Monoporeia) affinis*, the isopod crustacean *Saduria entomon* and the invasive polychaete *Marenzellaria* are likewise characteristic species in the Baltic Sea. In the basins of the open part af the Baltic Proper, benthic communities are often characterised by the amphipod crustacean *Pontoporeia femorata* and the Polynoidae *Bylgides sarsi* /171/. The aforementioned crustaceans are all considered ice age relicts of the Baltic Sea.

7.8.2.2 Benthic fauna in the Danish section

The benthic fauna communities in the Danish section are shown in Figure 7-35. In the benthic areas east of Bornholm, recurring low oxygen concentrations in the deeper waters lead to a benthic community dominated by opportunistic species, e.g. the Polynoidae *Bylgides sarsi*. South and south-west of Bornholm, towards Rønne Banke, the benthic fauna are characterised by the bivalve *Limecola balthica*, the small crustacean *Pontoporeia (Monoporeia) affinis*, and the polychaete *Marenzellaria* /171/.

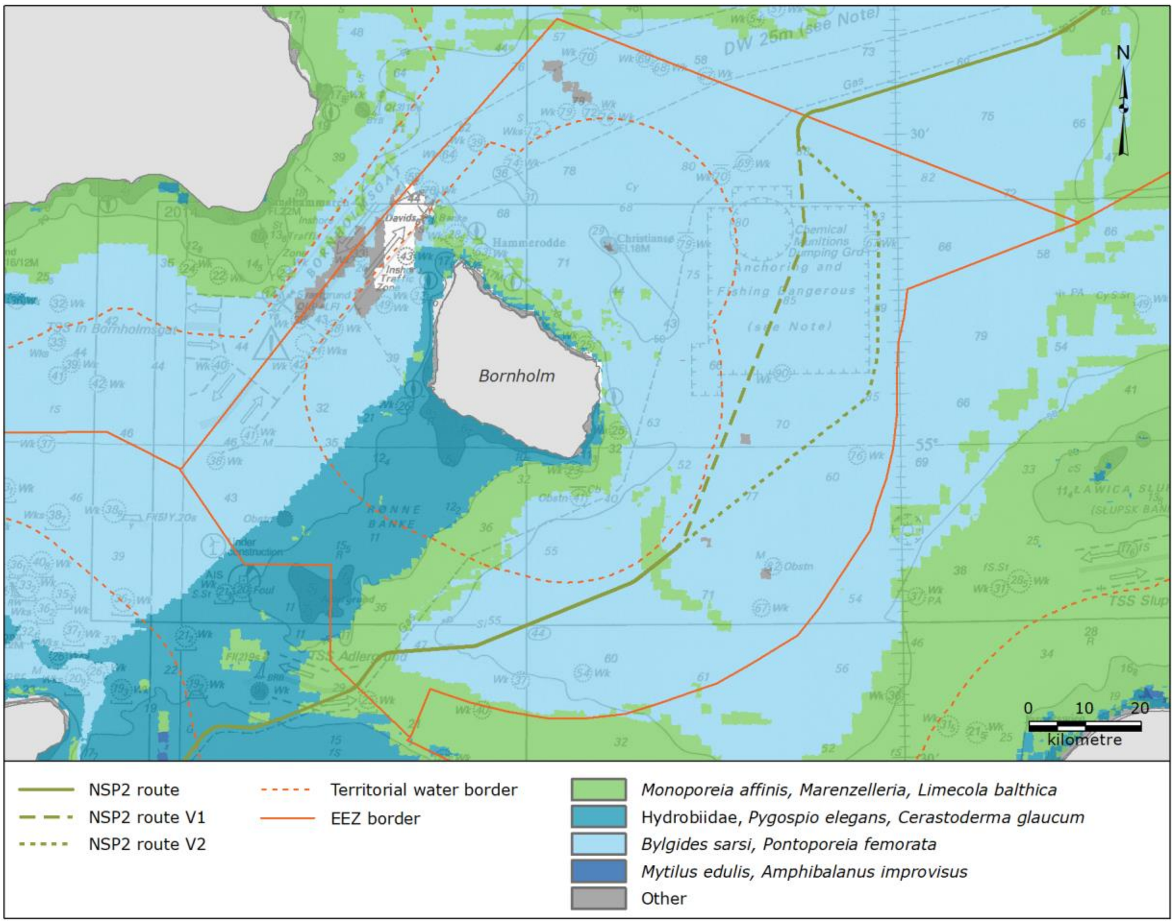


Figure 7-35 Regional distribution of benthic fauna in the Danish section of the Baltic Sea /171/.

7.8.2.3 Benthic fauna along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2

As described in section 7.4, poor oxygen conditions prevail along most of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2, which limit the presence of higher trophic levels. The depth profiles along each route alternative in Danish waters and general sediment types are shown in Figure 7-36.

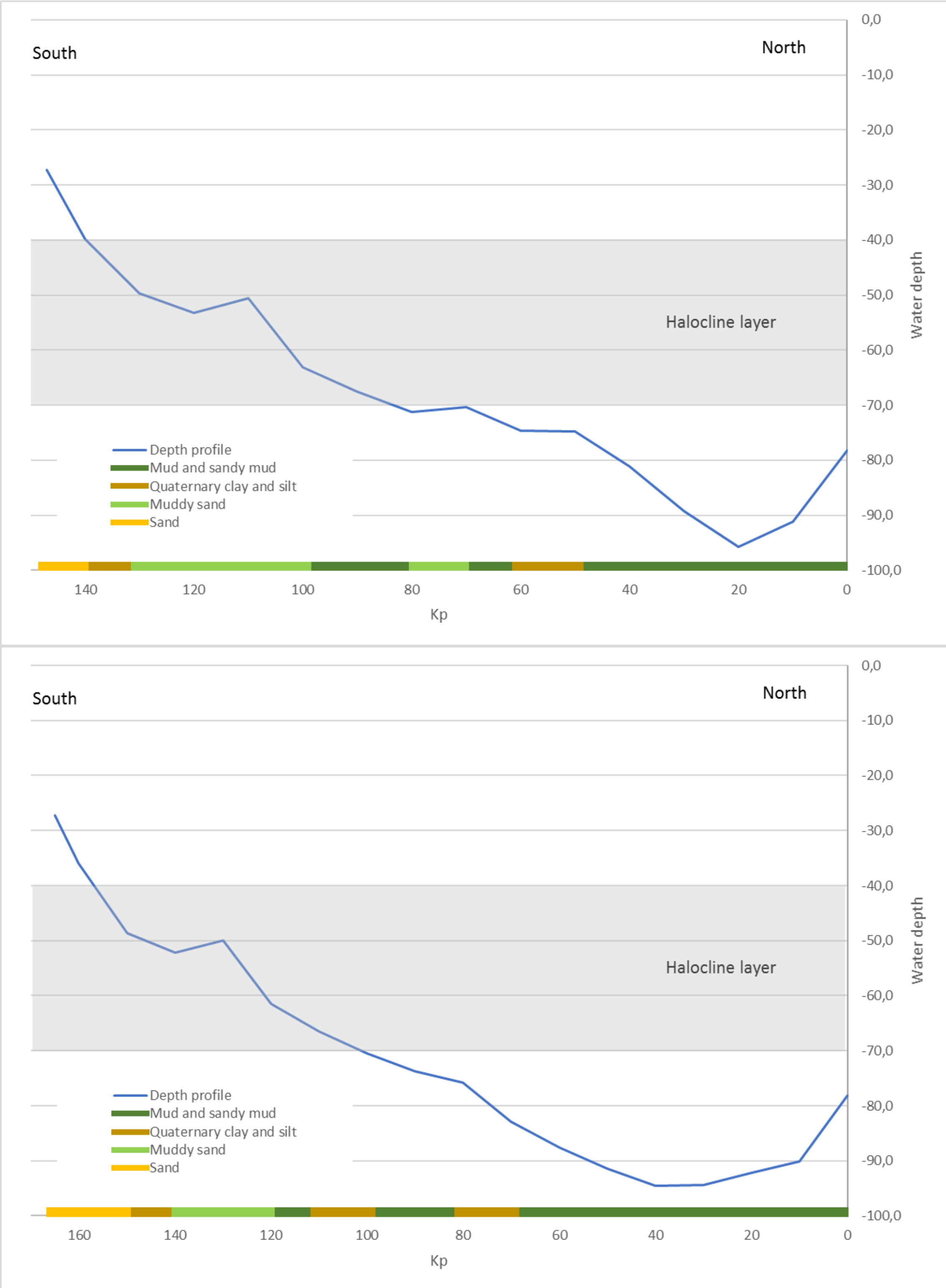


Figure 7-36 Depth profile and overall substrate type along the pipeline transect through the Danish section based on bathymetry data and general sediment data from GEUS /104/ (see section 7.3.2, Figure 7-17) . The combination of the proposed NSP2 route with V1 is shown at the top and the combination of the proposed NSP2 route with V2 is shown at the bottom. Mud consists mainly of clay and silt (<0.1 mm diameter), while sand mainly consists of mineral particles between 0.1 and 2 mm diameter. The depth curve is based on the bathymetry sea chart. The halocline layer is at a water depth of between 40 and 70 m, see section 7.4.

The water depth is 60-90 m along most of the combination of the proposed NSP2 route with V1 and along the combination of the proposed NSP2 route with V2. In these deep parts, the seabed consists of fine sediments, mainly silt and clay (<0.1 mm), and the water has a salinity of 15-20 psu (see sections 7.3.2 and 7.4). It is within the depth range of the halocline and therefore this habitat type experiences regular hypoxia/anoxia. The southern part of the proposed NSP2 route has a water depth of approximately 40-60 m, with fine sediment consisting mainly of sand (0.06-0.2 mm diameter) and with a salinity of 8-15 psu. This habitat experiences semi-frequent occurrences of low-oxygen or hypoxic conditions. The southern-most 5-km stretch of the proposed NSP2 route, closest to the German EEZ, crosses a shallower area with a depth of between 25 and 40 m. This habitat is above the halocline.

Due to the great water depths along most of the route, the soft muddy sediments and recurring hypoxia, the numbers of benthic fauna species along the route are small /88/.

Baseline surveys of benthic fauna were performed along the proposed NSP2 route and the NSP2 route V2 in August-September 2018 and along the NSP2 route V1 in January 2019, as described in section 7.1.2. The results of the 2018 surveys are presented below and the results of the 2019 surveys will be presented in separate reports.

During the August-September 2018 baseline surveys, sampling was undertaken along a transect that follows the proposed NSP2 route and the NSP2 route V2 /87/. Infauna were identified in nine of the 19 stations sampled. The results are shown in Table 7-27. The positions of the stations are shown in Figure 7-8.

Table 7-27 Depth, oxygen and occurrence of infauna along the proposed NSP2 route and the NSP2 route V2 in August-September 2018 /87//88/.

Station	Depth (m)	Oxygen (mg/l)	Infauna species	Abundance (N/m^2)
MB-17	84	0.5	1	83
MB-18	88	0.5	0	0
MB-19	88	0.5	0	0
MB-3	88	0.5	0	0
MB-4	86	0.5	0	0
MB-5	85	0.6	0	0
MB-6	81	0.6	1	3
MB-7	80	0.5	0	0
MB-8	76	0.4	0	0
MB-9	72	0.9	1	3
MB-10	68	3.2	0	0
MB-11	65	2.7	1	3
MB-12	60	2.6	3	10
MB-13	55	3.3	1	7
MB-14	51	3.8	2	43
MB-15	44	6.0	9	1,247
MB-16	29	8.2	13	887

The results show that the highest diversity and abundance of benthic fauna are found at the two stations with the shallowest depth and the highest oxygen content. Specifically, at station MB-16, 13 species were identified at an abundance of 887 ind./m^2, and at station MB-15, 9 species were identified at an abundance of 1,247 ind./m^2. At all other stations, three or fewer species were identified at abundances of 83 ind./m^2 or lower. The results indicate a low overall diversity in the surveyed area, with dominance by a few species including the polychaete *Pygospio elegans* and the Priapulid *Halicryptus spinulosus*, both of which are known for having a very wide ecological range and an ability to withstand low oxygen conditions. Overall, the results indicate that very few species can survive at depths greater than 70 m.

Sampling of benthic fauna was also previously carried out further north in the Bornholm Basin during baseline studies for NSP in 2008, monitoring surveys for NSP in 2010-2014 and baseline studies for the NSP2 base case route in 2015 /90//174/. Data from these earlier studies show that at depths greater than 60 m, zoobenthos are present in very low numbers, and consist mainly of opportunistic and H_2S tolerant polychaete species *Trochocaeta nultisetosa* and *Scoloplos armiger.* At depths between 40 and 60 m, biodiversity is higher, and the biomass is dominated by mussels such as *Limecola 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.

7.8.2.4 Biodiversity

In 2017, HELCOM assessed the integrated biodiversity status for benthic habitats using the core indicator "State of the soft-bottom macrofauna community", but this assessment did not cover the Arkona Basin or the Bornholm Basin /111/.

Of relevance to benthic fauna is the eutrophication indicator "Oxygen debt", which is assessed as "not good" in the Bornholm Basin /111/.

The percentage of disturbed benthic habitat has been assessed by HELCOM. The disturbed area is estimated based on spatial information of the distribution of human activities connected to the pressures. In the Arkona Basin and the Bornholm Basin, the disturbed area is 80-100% /111/.

7.8.2.5 Conservation status

The Danish Red List /166/ does not include benthic marine fauna.

The HELCOM Red List Assessment for the Baltic Sea provides information on the status of benthic species. The Red List includes 19 species of macrofauna categorised as Threatened. One species, the amphipod *Haploops tenuis*, was categorised as Endangered (EN) and 18 species were categorised as Vulnerable (VU). The majority of these occur in the Kattegat or the western-most part of the Baltic Sea, some of them at the border of their distribution area with respect to salinity /167/. None of the benthic species along the proposed NSP2 route, NSP2 route V1 or the NSP2 route V2 are listed as Near Threatened, Endangered or Vulnerable on the HELCOM Red List. Two species that could occur at water depths between 25 and 40 m have a status of Least Concern (*Monoporeia affinis* and *Pontoporeia femorata*) /167/.

A HELCOM threat assessment for the Baltic Sea has also been prepared for the characteristic living environments for species, so-called biotopes and biotope complexes. The Red List includes 17 biotopes evaluated as threatened and one which is critically endangered /175/. None of the benthic habitats along the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2 are listed as Near Threatened, Endangered or Vulnerable on the HELCOM Red List.

Ten biotope complexes recognised in HELCOM HUB /175/ are also listed in the EU Habitats Directive. A description of the habitat types as part of Natura 2000 is presented in section 7.13.

7.9 Fish

Fish are an important component of the marine food chain and the ecosystem of the Baltic Sea; they are also a valuable component of the Danish economy (commercial fishery and the value of fish are described in section 7.16). Given this, in combination with the fact that a number of fish species present along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 have protected status under national/international legislation, fish are considered an important receptor.

7.9.1 Fish in the Baltic Sea

Fish are a human food source, but are also prey for marine mammals and seabirds. Fish themselves feed on benthic species, zooplankton, and smaller fish, and are thereby a link between various parts of the food web. When migrating, they also play an ecological role in connecting different sea areas /111//177/.

Fish include both bony fish, a diverse taxonomic group of fish that have skeletons primarily composed of bone tissue, and cartilaginous fish, which have a skeleton made from cartilage (e.g. sharks).

The distribution of fish species is mainly determined by salinity levels, and marine fish species dominate the Baltic Proper, while freshwater species occur in the coastal areas and innermost parts of the Baltic Sea. Furthermore, the composition of fish communities varies between different regions of the sea in relation to different habitat characteristics and differences in salinity, water temperature, oxygen content and nutrient availability. The Baltic Sea fish populations are also affected by fishing, eutrophication, oxygen depletion, high levels of hazardous substances, as well as natural factors such as cold winters and varying salinity levels /111//177//178/.

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 /111//176//177//178/. Fish are subject to a number of anthropogenic impacts, as described above, 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 and increased fishing pressure. Climate-driven changes in the salinity, temperature and oxygen content of the water can also affect recruitment and growth. Hydrophysical-climatic variability (i.e. low frequency of inflows of saline oxygenated water 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 (i.e. herring, sprat) /176/. This shift is explained by a weakened cod recruitment and subsequent favourable recruitment conditions for sprat /176/.

Approximately 230 fish species are known in the Baltic Sea, of which 70 are marine species (including lampreys) /111//177/. The number of marine species is low compared with more saline waters.

Marine species are well-adapted to the Baltic Sea conditions and occur in high population densities. Cod (*Gadus morhua*), Baltic herring (*Clupea harengus*), and sprat (*Sprattus sprattus*) comprise the large majority of the Baltic Sea fish communities in terms of biomass and numbers. These three species are also the most important commercially-exploited species, and comprise the majority of the commercial catches in the Baltic Sea. Marine fish species such as cod, sprat, flounder (*Platichthys flesus*), plaice (*Pleuronectes platessa*), dab (*Limanda limanda*), turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*) prefer more saline areas and are therefore more abundant in the southern Baltic Sea and/or the Baltic Proper. Other marine species migrate from time to time from the North Sea into the Baltic Sea. Such species include whiting (*Merlangus merlangus*), European anchovy (*Engraulis encrasicolus*), mackerel (*Scomber scombrus*) and grey mullet (*Liza ramada*). Due to unfavourably low salinity conditions, these marine species are unable to form self-sustaining populations in the Baltic Sea.

Demersal marine fish species, such as flounder, plaice and turbot, live in the central and south-western parts of the Baltic Sea. In the deeper waters, demersal fish are not common due to the low oxygen content and limited presence of benthic fauna. Conversely, shallower waters with high levels of oxygen encourage a more diverse and abundant community of benthic invertebrates as well as small- and medium-sized bottom-dwelling fish species (i.e. gobies, juvenile cod and flatfish). Top predators such as cod and salmon strongly depend on this food chain.

Freshwater species inhabiting the Baltic Sea include e.g. perch (*Perca fluviatilis*), pike (*Esox lucius*), pikeperch (*Sander lucioperca*), bream (*Abramis brama*), roach (*Rutilus rutilus*) and burbot (*Lota lota*). These freshwater species naturally prefer the less saline areas and so they colonize mostly the coastal areas, especially in the northern Baltic Sea, where the salinity level is lower.

Migratory fish are species that undergo periodical migrations. Fish that migrate to spawn can be divided to anadromous and catadromous species. Anadromous species live and feed mostly in the sea and migrate to freshwater to breed, whereas catadromous species live mostly in lakes or rivers and migrate to sea to breed. In the Baltic Sea, anadromous fish include Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), whitefish (Coregonus species), vimba bream (*Vimba vimba*), river lamprey (*Lampetra fluviatilis*), grayling (*Thymallus thymallus*) and smelt (*Osmerus eperlanus*). The catadromous European eel (*Anguilla anguilla*) migrates a long way from the Sargasso Sea in the north-west Atlantic Ocean into Baltic Sea area rivers and lakes as a juvenile and back as an adult.

Lastly, species of sharks, rays and chimaeras (cartilaginous fish) have been recorded in the Baltic Sea and Kattegat. Some of the most common include: spiny dogfish (*Squalus acanthias*), thorny skate (*Amblyraja radiata*) and small-spotted catshark (*Scyliorhinus canicula*).

7.9.2 Fish in the Danish section

In the southern part of the Baltic Sea (i.e. covering the Danish section), the most important commercially exploited species are cod, sprat and herring, which comprise 90% of the commercial catches in the Baltic Sea. Other commercially important species, especially in the southern part of the Baltic Sea, include flounder, plaice, turbot, eel and salmon /177//179/.

The most important commercially exploited pelagic and benthic fish species in the southern part of the Baltic Sea also happen to be the most common in the Danish section. These species and their spawning periods are listed in Table 7-28 and described below in more detail.

Table 7-28 Spawning periods for commercially important fish stocks in the Baltic Sea. The acronyms N, S, E and W refer to the spawning population – see 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 Sea: March-May;
- Central Baltic Sea: 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 /180/.

[2]: The spawning period for salmon depends on latitude and the geographical locations of the breeding rivers. Demersal eggs are buried in river-gravel bottoms /181/.

[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 /182//183/.

[4]: Turbot eggs are demersal at the low salinities occurring in the Baltic Sea /184/.

[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 /185//186/.

[6]: Spawning in Dec-May /182/.

[7]: Two populations in the Baltic Sea: eastern (E) and western (W) Baltic cod. There are significant inter-annual variations in spawning time of eastern Baltic cod, and in the 1990s, a remarkable shift in the timing of spawning from April-June to June-August was observed. The spawning period for western Baltic cod (also known as the Belt Sea cod) is Jan-April /176//187//188//189/.

In the following sections, a description is provided for each fish species that is considered important in the Danish section. Importance is given based on commercial value and conservation status (see section 7.9.4). The descriptions are based on peer-reviewed literature as well as scientific knowledge from e.g. HELCOM and ICES.

7.9.2.1 Baltic cod

Baltic cod (*Gadus morhua*) is a demersal, marine species, which mainly feeds on molluscs, crabs, sea stars, worms and small fish (i.e. herring and sprat, but also juvenile cod and eggs).

Distribution

The abundance and distribution of Baltic cod has varied considerably over time owing to natural as well as anthropogenic factors.

Two populations are present in the area: The western Baltic cod stock (*Gadus morhua morhua*) and the eastern Baltic cod stock (*Gadus morhua calarias*). These stocks have different morphological characteristics and population genetics. The eastern cod stock occurs in the central, eastern and northern Baltic Sea, while the western cod stock inhabits the areas west of Bornholm, including the Danish straits. The two stocks overlap in the area around Bornholm.

The eastern population is the largest, accounting for approximately 90% of the cod stocks in the Baltic Sea; however, the subpopulation of the Gdansk and Gotland Deep is considered seriously reduced and has not spawned since the 1980s /187/. The eastern Baltic cod stock declined from its historically highest level in 1982-1983 to the lowest level on record in 2004-2005 /187/. The decline is attributed to reduced reproductive success in combination with increasing fishing pressure. ICES reports that the eastern Baltic cod stock is still at historically low levels, even though the stock has increased continuously since 2005 /187//190/.

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. ICES classifies the stock as being at risk of reduced reproductive capacity, suffering from too high fishing pressure /190/. While the abundance of smaller individuals has increased in recent years, the number of larger individuals has decreased. The reason for the reduced number of larger cod is unclear, but may be associated with either increased mortality of older cod and/or low individual growth. Studies indicate that size-specific trawl fishing, in which small cod are released from the trawl, thereby only catching large cod, could further hamper growth, since the result is a large biomass of small cod with high intraspecific feeding competition and hence a lower growth rate /191/.

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 or no oxygen content.

Spawning

Female cod spawn in batches, and as the time between releases of batches varies, there are no fixed periods for various spawning phases. Egg fertilisation, development and larvae periods are completed in parallel to one another throughout the spawning period. 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 /192/.

The spawning grounds and nursery areas for Baltic cod are shown in Figure 7-37 /190/. Cod undertake migrations between spawning and feeding areas and have a strong homing behaviour. Spawning and nursery areas in the Baltic Sea include the deeper regions of the Bornholm Basin, Arkona Basin, Kiel Bay, Fehmarn Belt and Mecklenburg Bay. The Arkona Basin is used by both western and eastern stocks for spawning, whilst the Bornholm Basin is only used by the eastern Baltic cod stock /193/.

In order to enable undisturbed spawning, the cod fishery is regulated by a seasonal closure from 1 May to 31 August in the areas shown in Figure 7-37. 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 /187//190/. The area closed for fisheries covers 4,406 km^2 of which 1,940 km^2 is in the Danish section. The combination of the proposed NSP2 route with V1 crosses this closure area in both Danish and Swedish waters, over a total stretch of 82.8 km, of which 32.6 km are within the Danish EEZ. The combination of the proposed NSP2 route with V2 crosses this closure area in both Danish and Swedish waters, over a total stretch of 87.8 km, 37.6 km of which are within the Danish EEZ. It should be noted that the total spawning area is larger than the closure area as shown in Figure 7-37.

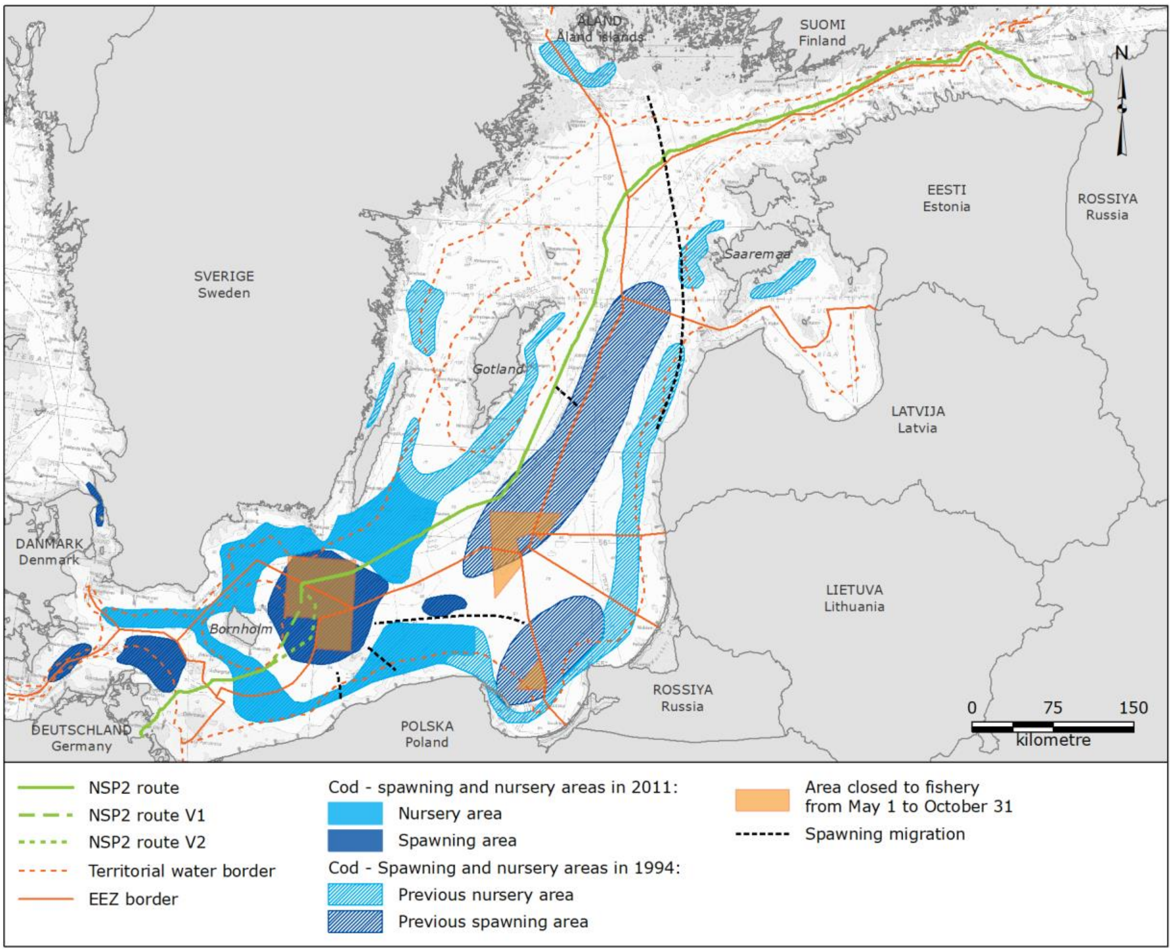


Figure 7-37 Traditional spawning grounds and nursery areas for Baltic cod. During recent decades, cod spawning has taken place only in the southern parts of the Bornholm Deep and in Slupsk Furrow (the small area east of the Bornholm Deep) /197/. Since the late 1980s, spawning in the Gdansk Deep and the Gotland Deep was almost eliminated /190/ (a larger version of this figure can be seen in Atlas Map FI-01). The figure also shows the general migration routes to and from spawning areas and areas that are closed to fishery due to spawning activity.

Data from 2014 and 2016 show that spawning occurs in most of the Bornholm Deep in areas following the 60 m isobath, as seen in Figure 7-38. The area closed for fisheries is shown on Figure 7-38..

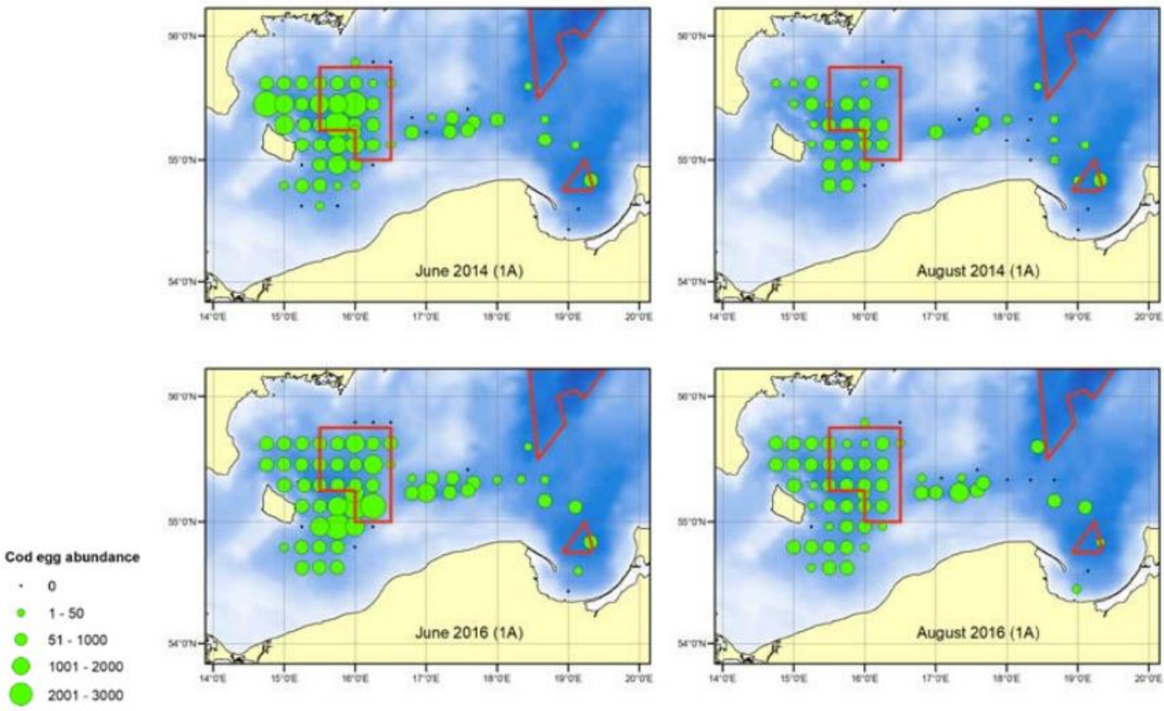


Figure 7-38 Cod egg abundance in the Bornholm Deep in June 2014 (top left), August 2014 (top right), June 2016 (bottom left) and August 2016 (bottom right). The area of fisheries closure is shown with a red box /195/.

Successful egg development requires a minimum oxygen level of approximately 3 mg/l (2 ml/l) seawater and salinity higher than 11 psu in the reproductive volume, at which the buoyancy of cod eggs is neutral /194/. The volume of water where this is fulfilled is called the "reproductive volume", and the location of this differs due to external factors affecting salinity and oxygen levels (e.g. storms and inflow of marine water). In periods without major inflows, oxygen depletion of the saline water affects the survival of the eggs. The spawning of the eastern Baltic cod is generally confined to areas of 40-75 m water depth, e.g. in the waters of the Bornholm Deep and previously in the Gdansk Deep and Gotland Deep. 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 /196//197/. Since the mid-1980s, cod reproduction of the eastern stock has only been successful in the southern spawning areas, mainly in the Bornholm Basin /190/. The Arkona Basin is used for spawning by both the western and eastern cod stocks.

In the mid-1990s, despite improved hydrographical conditions for egg development, there was a lack of recovery in recruitment related to poor larval survival, apparently due to a 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 /176/.

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 western Baltic cod spawns in the period of January-April, whilst the eastern Baltic cod spawns in the period April-September. The spawning time of the eastern Baltic cod is subject to inter-annual variations in the Bornholm Basin, and has been thoroughly studied /188/. During the 1970s and late 1980s, peak spawning took place between the end of April and mid-June, and in the 1990s, a shift in the spawning time to the end of July was observed.

Figure 7-39 shows the reproductive volume for the eastern Baltic cod stock in the Bornholm Deep from 2010 to 2018. In the Bornholm Deep, the depth of the 11 psu isohaline varies between 42–68 m without any trend. The 2.0 ml/l (around 3 mg/l) concentration critical for egg development fluctuates more regularly between 65 m and the bottom (more than 90 m). The total reproductive volume during 2010–2013 in the Bornholm Deep was around 75–150 km^3 during the peak spawning time, but was up to 350 km^3 during 2015–2016 due to a major 2014/2015 inflow. The reproductive volume subsequently decreased, and in the first half of 2018 it was below 50 km^3 /195/.

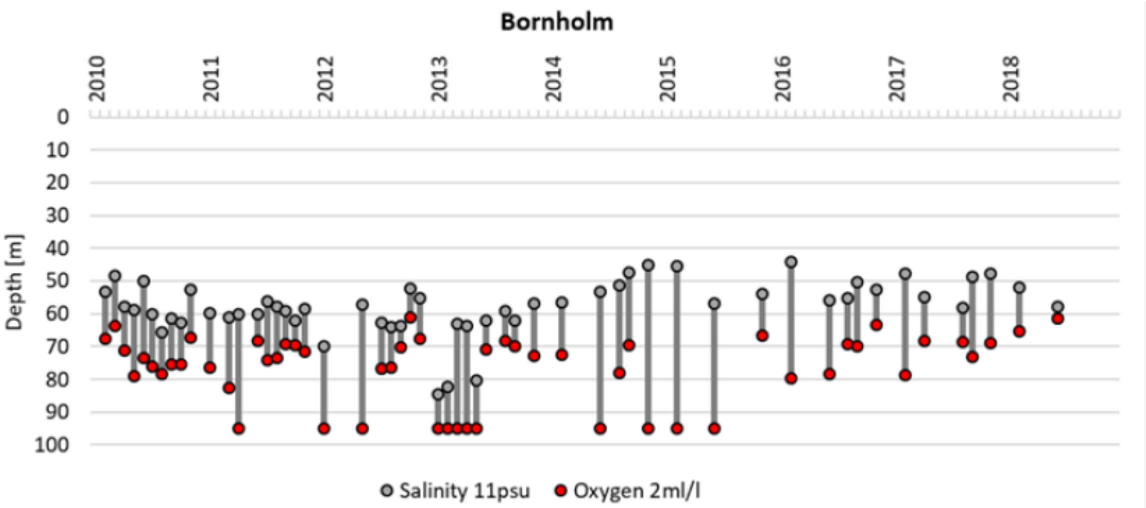


Figure 7-39 Reproductive volume in the Bornholm Deep between 2010 and 2018, shown as grey bars between the 11 psu isohaline (light grey dot) and the 2 ml/l critical oxygen concentration (red dot) /195/.

Conservation status

Cod is classified as vulnerable on the HELCOM Red List (see section 7.9.4).

7.9.2.2 Herring

The Baltic herring (*Clupea harengus membras*) is a subspecies of the Atlantic herring (*Clupea harengus*). Herring feed primarily on zooplankton, although older herring may also feed on fish eggs and fry.

Distribution

Herring occur in large schools throughout the entire 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 the 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. The abundance and biomass of Baltic herring generally has decreased during the last 40 years owing to changes in the amount and composition of zooplankton and overfishing /177//198/. However, the general trend has been reversed, albeit slowly, since the beginning of the year 2000 /190/.

Spawning

Different herring stocks have different spawning periods, and herring populations in the Baltic Sea 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, with spawning from March-June (Table 7-28). Herring spawn in coastal areas in most parts of the Baltic Sea /198/, see Figure 7-40.

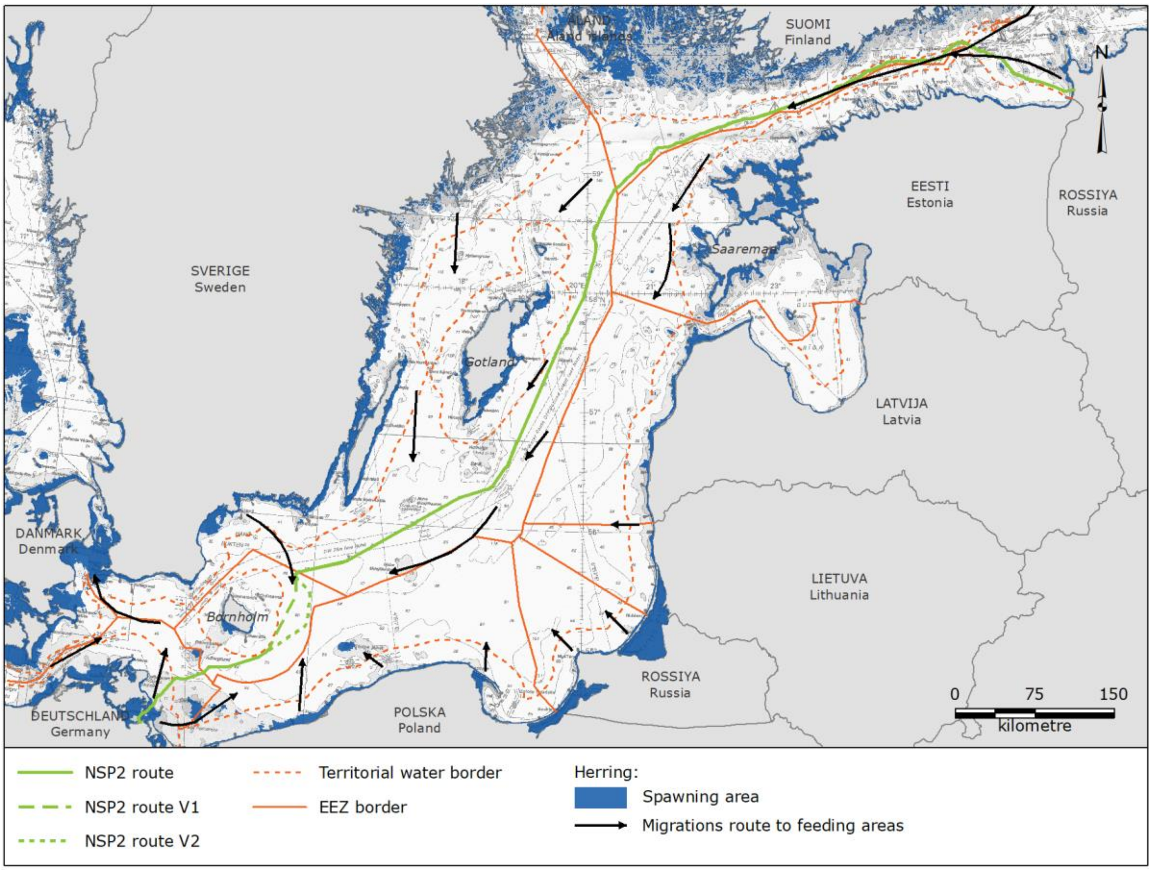


Figure 7-40 Herring spawning areas and migration routes in the Baltic Sea /198/ (a larger version of this figure can be seen in Atlas Map FI-01).

Conservation status
Herring is not classified as threatened on the HELCOM Red List (see section 7.9.4).

7.9.2.3 Sprat

Sprat (*Sprattus sprattus*) eat zooplankton as well as cod eggs and fry /198/, and sprat larvae have a strong preference for the copepod *Acartia* spp. as their main food source.

Distribution
Sprat live in schools throughout the Baltic Sea. Sprat is an open-sea species that is rarely found along the coast. Sprat migrate to open water areas, seeking out warmer water layers during different seasons and avoiding areas where 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 /198/.

Spawning
Figure 7-41 shows the spawning area for 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 Sea, with the highest concentration in the upper part of the halocline, typically at a water depth of 45-55 m. Spawning occurs from April-July or November-January, depending on the geographical area (Table 7-28). Winter spawning (Nov-Jan) of sprat is observed following 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. Years of strong larval displacement towards the southern and eastern Baltic Sea coasts indicates weak recruitment conditions, while years of retention within the deep basins are associated with relative recruitment success /185/.

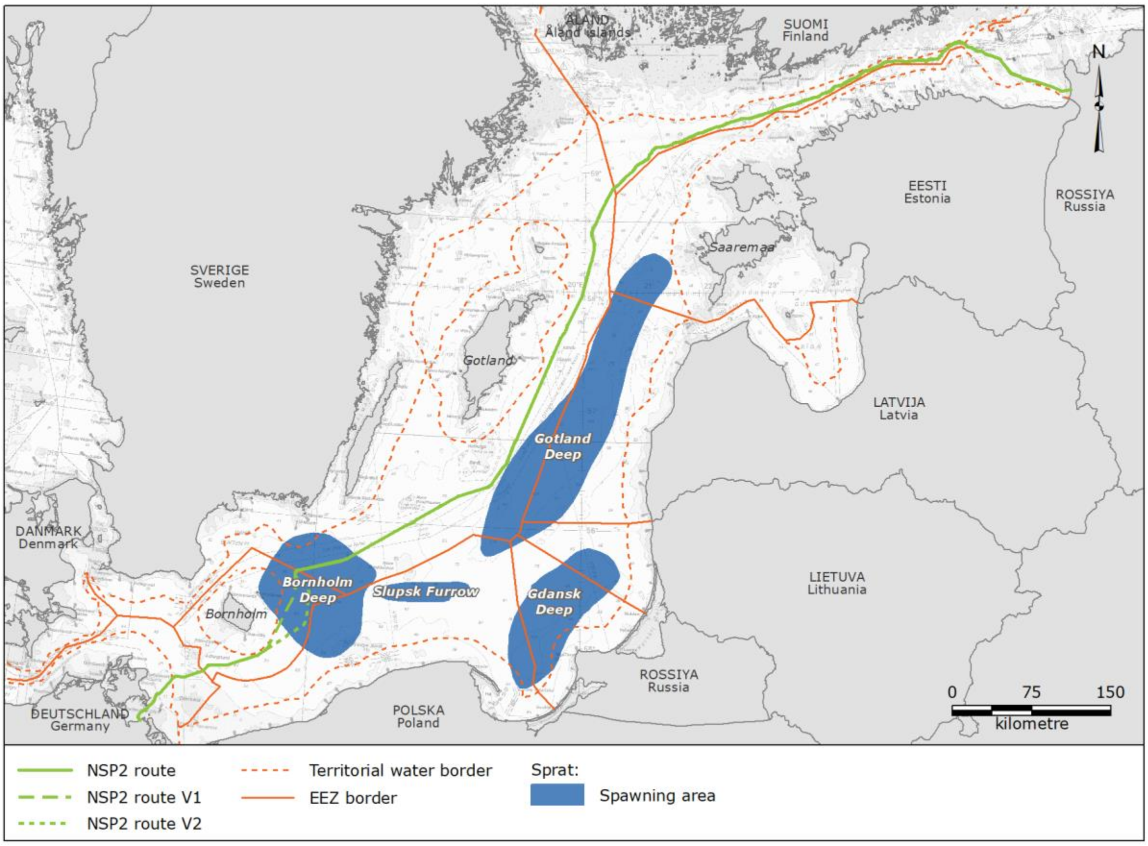


Figure 7-41 Spawning areas of sprat /199/ (a larger version of this figure can be seen in Atlas Map FI-01).

The Bornholm Basin is an especially important spawning ground for sprat /199/. As egg-specific gravity changes during the season, there is accordingly a shift in vertical egg distribution in the Bornholm Basin, e.g. from 50-80 m in April to 25-65 m in May-June /200/.

The abundance of *Acartia* has drastically increased since the 1990s in parallel with an increase in temperature. This may have led to generally higher sprat larval survival /187/.

Conservation status
Sprat is not classified as threatened on the HELCOM Red List (see section 7.9.4).

7.9.2.4 Flounder

Flounder (*Platichthys flesus*) is a demersal flatfish, which feeds on bivalves (e.g. blue mussel), other benthic invertebrates (e.g. polychaete worms, gastropod molluscs) and small fish.

Distribution
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. 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 /190/.

Spawning
There are two ecological types of flounder in the Baltic Sea: one southern, with pelagic eggs, and one northern, with demersal eggs.

In the southern Baltic Sea, flounder migrate between coastal feeding areas and spawning areas in the deep basins (spawning in March-July, see Table 7-28). They have larger, pelagic eggs adapted to floating, in spite of the 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. An oxygen content of at least 1 ml/l is critical for egg survival /183/.

The other ecological type of flounder occurs in the northern Baltic Sea, where flounder are more stationary and spawn in shallow banks or coastal areas. Their eggs are smaller, thicker-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 /183/.

The onset of spawning in the spring is influenced by rising temperatures. Consequently, the spawning period varies across different areas in the Baltic Sea; for example, in the Kattegat, spawning starts in February-April, while in the Gotland Basin, spawning occurs in April-May /183/.

Conservation status
Flounder is not classified as threatened on the HELCOM Red List (see section 7.9.4).

7.9.2.5 Plaice

Plaice (*Pleuronectes platessa*) is a demersal flatfish that feeds on molluscs and polychaete worms.

Distribution
Plaice inhabit the western Baltic Sea and are rarely found east of the Bornholm Basin. Plaice are less tolerant to low salinity and low oxygen content than flounder are, which affects their distribution patterns.

Spawning
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 /190/. Plaice spawn in December-April (Table 7-28).

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.

Conservation status
Plaice are not classified as threatened on the HELCOM Red List (see section 7.9.4).

7.9.2.6 Atlantic salmon

Salmon (*Salmo salar*) make long feeding migrations in the Baltic Sea, where they prey on herring and sprat.

Distribution
The most important feeding grounds for Baltic salmon stocks are in the southern part of the Baltic Sea /181/. The management of salmon in the Baltic Sea is subject to the Salmon Action Plan adopted by the International Baltic Sea Fishery Commission in 1997. Fishing for salmon is banned during the summer (1 June-15 September) throughout most of the Baltic Sea.

Spawning
Salmon show a strong homing behaviour and return to their natal river to spawn, resulting in the development of genetically differentiated stocks. Salmon spawning in the Baltic Sea takes place in July-November (Table 7-28).

Conservation status
Atlantic salmon is classified as vulnerable on the HELCOM Red List (see section 7.9.4).

7.9.2.7 Sea trout

Sea trout carry out feeding migrations in the Baltic Sea, where they are top predatory fish with a diverse diet.

Distribution
Sea trout is widely distributed in northern and western Europe, including in the entire Baltic Sea area.

Although still numerous, 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; however, in general, the Danish sea trout populations have developed positively during the last couple of decades, showing a steady increase in population size /201/.

Spawning
Spawning occurs in freshwater, and there are in total approximately 1,000 trout rivers in the Baltic Sea area. Conditions are improving in many Danish streams, including those on the island of Bornholm /201/.

Conservation status
Sea trout is classified as vulnerable on the HELCOM Red List (see section 7.9.4).

7.9.2.8 Turbot

Turbot (*Scophthalmus maximus*) feed mainly on demersal fish, bivalves and crustaceans.

Distribution
Turbot occur in large parts of the Baltic Proper, but their abundance is rather low. After spawning, turbot reside in shallow areas during the summer and return to deeper waters in the autumn /202/.

Spawning
Successful spawning is possible in waters with a salinity of 6-7 psu or higher. Spawning takes place in shallow water at depths of 5-40 m. Spawning of turbot in the Baltic Sea typically takes place in June-July (Table 7-28). Eggs and larvae are planktonic, but the low salinity of the Baltic Sea inhibits flotation of the eggs. As a result, the eggs of Baltic Sea turbot are demersal instead of pelagic /203/.

Conservation status
Turbot is not classified as threatened on the HELCOM Red List (see section 7.9.4).

7.9.2.9 European eel

The European eel (*Anguilla anguilla)* is a migratory species.

Distribution
The European eel is known to migrate from the northern part of the Baltic Proper along the Swedish coast, as well as from the eastern part of the Baltic Sea into the open sea areas, including the

waters around Bornholm /204/. Feeding usually takes place in shallow waters, but they may also dive to deeper waters at night /205/.

Eel reproduction is seriously impaired, and the stock is likely to be severely depleted. ICES recommends that eel fishing be reduced to a level as close to zero as possible in order for the stock to recover.

Spawning
Eel does not spawn in the Baltic Sea.

Conservation status
The European eel is classified as critically endangered on the HELCOM Red List (see section 7.9.4).

7.9.2.10 Sea lamprey

Sea lamprey (*Petromyzon marinus*) in marine waters feed off the blood and tissue of other fish.

Distribution
Sea lamprey is an anadromous, long-distance migrating species. Adults are found in the Kattegat and in the southern Baltic Sea along the coasts, including the waters around Bornholm. Sea lamprey is a very rare species in the Baltic Sea, and is occasionally observed in the southern Baltic Sea /206/.

Spawning
Adults enter freshwater habitats in late winter or spring and migrate upstream to their spawning sites. The spawning habitat consists of gravel bottoms with isolated larger pebbles or rocks and adjacent clean sandy areas, where sea lamprey spawn from June to July. After spawning, the adults normally die. Spawning occurs in freshwater, particularly along the coast in the Kattegat /206/.

Sea lamprey has two stages in its life cycle. During the larval stage, it is buried at the bottom of a stream and feeds on small zooplankton and particles filtered from the water. After six to eight years, it goes through a metamorphosis during which its characteristic mouth with sharp teeth and a circular suction disc evolves. The sea lamprey then migrates downstream to sea. Once in marine waters, it attaches itself to increasingly larger fish such as cod and salmon, and feeds off their blood and tissue /206/.

Conservation status
The sea lamprey is classified as vulnerable on the HELCOM Red List and is listed in Annex II of the EU Habitats Directive (see section 7.9.4).

7.9.3 Biodiversity status

In 2017, HELCOM assessed the integrated biodiversity status for fish /111/. The open sea assessment was based on results for internationally assessed commercial fish stocks, using information on spawning stock biomass and fishing mortality from ICES. For the Arkona Basin and Bornholm Basin, the biodiversity status for both pelagic and demersal fish was assessed as "not good" /111/.

Also of relevance to demersal fish is the eutrophication indicator "Oxygen debt", which is assessed as "not good" in the Bornholm Basin and Arkona Basin /111/.

7.9.4 Conservation status

The Danish Red List /166/ does not include marine fish.

According to the HELCOM Red List for the Baltic Sea /167/, among the fish and lamprey species assessed, 14 were evaluated as threatened (i.e. Critically Endangered, Endangered or Vulnerable).

Four species were categorised as Critically Endangered: grayling, eel and two shark species (porbeagle and spurdog), all of which have experienced dramatic population declines in the HELCOM area. Three species were assessed as Endangered: Atlantic wolf-fish, whitefish and ling, and seven species were assessed as Vulnerable: sea lamprey, tope shark, thornback ray, cod, whiting, salmon and trout.

Table 7-29 summarizes the fish and lamprey species present in the Danish waters around Bornholm that are identified as threatened (Critically Endangered, Endangered or Vulnerable) on the HELCOM Red List for the Baltic Sea /167/, the global International Union for Conservation of Nature (IUCN) Red List /207/ and/or are included in Annex II of the EU Habitats Directive.

Table 7-29 Species in the Baltic Sea that are on the HELCOM Red List /167/, IUCN Red List /207/ and/or listed in the EU Habitats Directive.

Species	Status on HELCOM Red List	Status on IUCN Red List	Included in EU Habitats Directive
Asp (*Aspius aspius*) [1]	Not threatened	Least concern	Annex II
Atlantic salmon (*Salmo salar*)*	Vulnerable	Lower Risk/Least concern	Not listed (only freshwater)
Atlantic wolf-fish (*Anarhichas lupus*)	Endangered	Not listed	No
Bullhead (*Cottus gobio*) [1]	Less concern	Least concern	Annex II
Cod (*Gadus morhua*)*	Vulnerable	Vulnerable	No
European eel (*Anguilla anguilla*)*	Critically endangered	Critically endangered	No
Grayling (*Thymallus thymallus*) [1]	Critically endangered	Least concern	No
Ling (*Molva molva*)	Endangered	Not listed	No
Porbeagle (*Lamna nasus*)	Critically endangered	Vulnerable	No
Razor-fish (*Pelecus cultratus*) [1]	Less concern	Least concern	Annex II
Sea lamprey (*Petromyzon marinus*)*	Vulnerable	Least concern	Annex II
Sea trout (*Salmo trutta*)*	Vulnerable	Least concern	No
Spined loach (*Cobitis taenia*) [1]	Less concern	Least concern	Annex II
Spurdog (*Squalus acanthias*)	Critically endangered	Vulnerable	No
Thornback ray (*Raja clavata*)	Vulnerable	Near threatened	No
Tope shark (*Galeorhinus galeus*)	Vulnerable	Vulnerable	No
Whitefish (*Coregonuc maraena*)[1]	Endangered	Not listed	No
Whiting (*Merlangius merlangus*)*	Vulnerable	Least concern	No

* Species that may occur (spawn, forage or migrate) in Danish waters.

[1] Freshwater species that are mainly distributed in the northern and eastern parts of the Baltic Sea where salinity is low, and may occur sporadically in the Danish waters around Bornholm.

Of the species listed in Table 7-29, only cod spawns in the waters around Bornholm. In accordance with the EU Habitats Directive, the Danish authorities have appointed Natura 2000 sites (see section 7.13) in which the species listed in the Habitats Directive should be protected. These, however, do not include the waters around Bornholm.

7.10 Marine mammals

Marine mammals are an important component of the marine food chain and ecosystem in the Baltic Sea. Furthermore, a number of marine mammal species have protected status under national/international legislation and are therefore considered an important receptor.

This section describing marine mammals is an extract of a report prepared by DCE, Aarhus University /210/.

7.10.1 Marine mammals in the Baltic Sea

Marine mammal species residing 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 frequent and these species are not native to Baltic waters /208/.

The following sections describe the biology, distribution and abundance of the three residential species in the Danish part of the Baltic Sea: harbour porpoise, harbour seal and grey seal.

7.10.2 Harbour porpoise

This section presents the Baltic Sea population of harbour porpoise, with information on population structure and size, distribution, behaviour, reproduction, echolocation, hearing, and protection.

7.10.2.1 Population structure and size

Several studies have sought to understand the population structure of harbour porpoises in the north-east Atlantic Ocean and particularly in the transition zone between the North Sea and the Baltic Sea. Studies on morphometric skull differences /211/ and genetics /212/ have found that three populations (or sub-populations) may exist in this area, namely (1) in the Baltic Proper (henceforth called the Baltic Sea population), (2) in the western Baltic Sea, the Belt Sea and the southern Kattegat (henceforth called the Belt Sea population) and (3) in the Skagerrak and North Sea.

These studies could not, however, determine the exact borders between the populations, perhaps due to some overlap in distribution in so-called transition zones. The proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 cross the Baltic Sea population management border and the majority of the route is located in the transition zone between the Baltic Sea and the Belt Sea populations. Individuals from both populations may therefore inhabit the area.

The Baltic Sea population has been studied by conducting visual surveys (albeit with low resolution in coverage) of population size in the Baltic Proper. 599 (95% confidence interval (CI): 200-3,300) individuals were observed in 1995 /213/, and 93 individuals (95% CI: 10-460) were observed in 2002 /214/. 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% CI: 80-1,100) /215/. The severe decline of the harbour porpoise population in the Baltic Sea makes it the smallest population of harbour porpoise in the world /216/.

The Belt Sea holds high densities of porpoises, especially in the Sound, Great Belt, Little Belt and Fehmarn Belt. Based on surveys performed in 1994, 2005, 2012 and 2016, the number of porpoises residing in this area was estimated to be 27,923 (95% CI: 11,916-65,432, 1994), 10,614 (95% CI: 6,218 - 18,117, 2005), 18,495 (95% CI: 10,892 - 31,406, 2012), and 42,324 animals (95% CI: 23,668 – 76,658, 2016), respectively /217//218/. Therefore, on the basis of the newest available data from 2016, the Belt Sea population is assessed to be stable.

For comparison, the total number of harbour porpoises in the continental shelf waters of the north-east Atlantic Ocean was estimated at 375,358 (95% CI: 256,304–549,713) /219/. 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.

7.10.2.2 Distribution

Harbour porpoises are widely, but unevenly, distributed throughout European waters. The distribution is presumably linked to the distribution of prey (e.g. /220/), which in turn is linked to parameters such as hydrography and bathymetry /221/.

The porpoise detections from the SAMBAH project /215/ were analysed as porpoise positive seconds (PPS) per day and divided into two seasons: summer and winter (see Figure 7-42 and Figure 7-43, respectively).

In Figure 7-42, 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 a white circle. In the summer period, the data points could be divided into the two population groups (i.e. east and west of the determined population border). Orange indicates the area inhabited by part of the Belt Sea porpoise 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 7-42). There is a clear drop in the density of harbour porpoises with distance from this area in all directions, which 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 the 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 /215/.

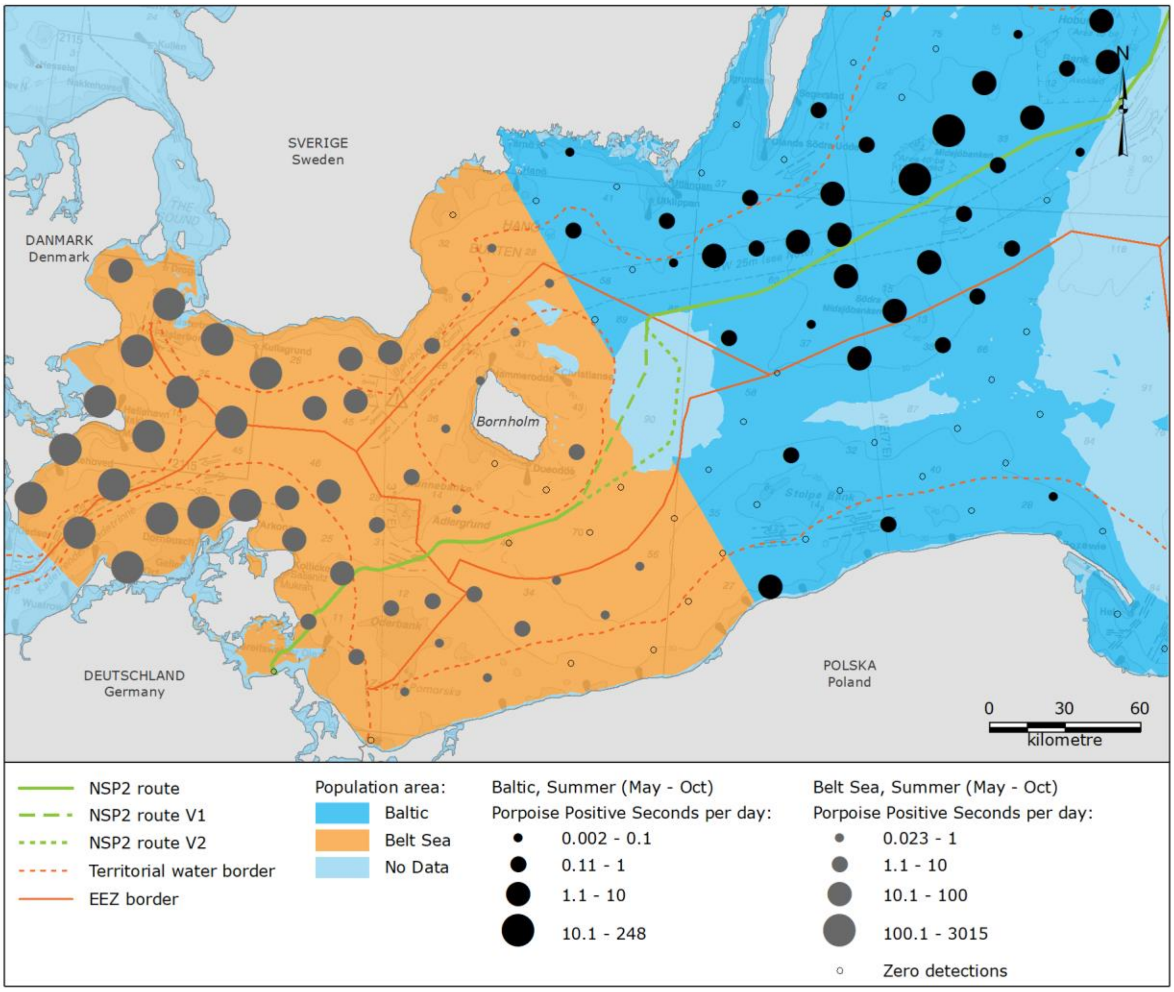


Figure 7-42 Summer distribution of porpoises in the southern part of the Baltic Sea. Source: SAMBAH /215/.

During winter, porpoises are more widespread in the northern part of the Baltic Sea (see Figure 7-43). 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 a white circle. In the winter, it is not possible to separate the two populations.

With respect to migration, there are no studies of current harbour porpoise migration routes in the Baltic Sea. However, in the adjacent waters of the Belt Seas, Kattegat, Skagerrak and the North Sea, satellite tracking of over 100 harbour porpoises have not indicated specific migration routes between sites or seasons.

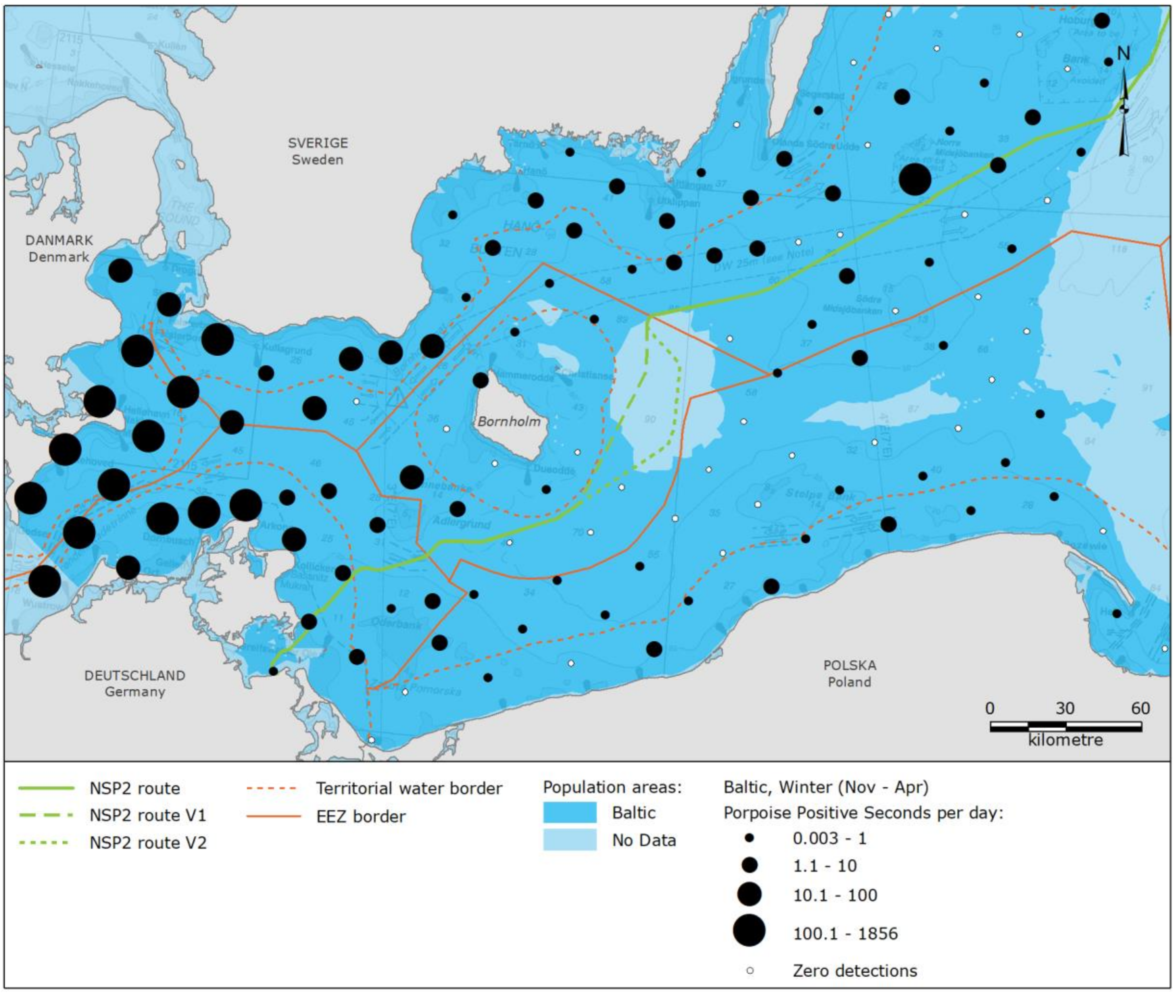


Figure 7-43 Winter distribution of porpoises in the southern part of the Baltic Sea. Source: SAMBAH /215/.

7.10.2.3 Behaviour and reproduction

In the Baltic Sea, 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 for Baltic harbour porpoises begins in mid-June and ends in late August. Ovulation and conception typically take place in late July and early August /222/, 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 /223//224/. No specific breeding areas for harbour porpoises have been identified in the Danish sector of the Baltic Sea.

7.10.2.4 Echolocation and hearing

Harbour porpoises have good underwater hearing and use sound actively (i.e. echolocation) for navigation and prey capture. Harbour porpoises produce short ultrasonic clicks (130 kHz peak frequency, 50-100 µs duration; /225//226/) and are able to orient and find prey in complete darkness. Data from porpoises tagged with acoustic data loggers indicate that they use echolocation almost continuously /227//228/. Their hearing sensitivity is extremely high and covers a vast frequency range (see Figure 7-44, /229//230//231//232/). The audiogram (see Figure 7-44) shows the hearing threshold; porpoises can only hear sound above the threshold for each frequency. Their best ability to detect sound is at frequencies with the lowest threshold (the highest sensitivity).

Marine 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.

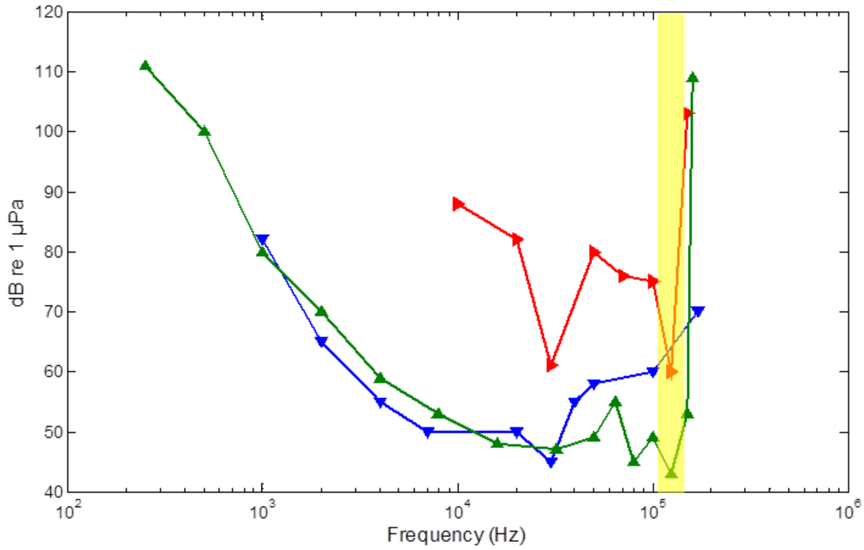


Figure 7-44 Audiograms for harbour porpoises modified from /232/ (green), /229/ (blue) and /230/ (red). The audiogram also shows the frequency range of harbour porpoise vocalisation (yellow).

7.10.2.5 Biodiversity status

In 2017, HELCOM assessed the integrated biodiversity status of the Baltic Sea /111/. Harbour porpoise is not assessed in this report.

7.10.2.6 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 Annex 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 Administrative Order 867 of 27/06/2016 /233/.

In the regional assessment for Europe, the harbour porpoise is listed as "Vulnerable", while the sub-population of the Baltic Sea harbour porpoise is listed as "Critically Endangered" on the IUCN Red List.

Protected areas for marine mammals are described in sections 7.12 and 7.13.

7.10.3 Harbour seal

This section presents the Baltic Sea population of harbour seal, with information on population structure and size, distribution, behaviour, reproduction, hearing and protection.

7.10.3.1 Population structure and size

Based on genetic data and satellite telemetry, harbour seals in the Baltic Sea 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 /234//235/. The Kalmarsund population comprises approximately 1,000 individuals /236/, the south-western Baltic population comprises approximately 1,500 individuals, and the Kattegat population comprises approximately 7,800 individuals /237/. The proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are located in the transition zone between the Kalmarsund population and the south-western Baltic population.

7.10.3.2 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 conducted during the moult in August. Knowledge of seal abundance and density is extensive with respect to the locations of the haul-out sites, which are shown in Figure 7-45. A tagging study showed that 10 tagged harbour seals travelled with a mean travel range of below 25 km /242/ and the zone of regular occurrence 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 Sea, concentrated around the Rødsand sandbar (7 km west of Gedser in Denmark) and Falsterbo and Saltholm in the Sound.

The Danish section of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 do not cross any areas with colonies or regular occurrence of harbour seals. However, foraging harbour seals may potentially be present at all depths within their range in the areas surrounding the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2.

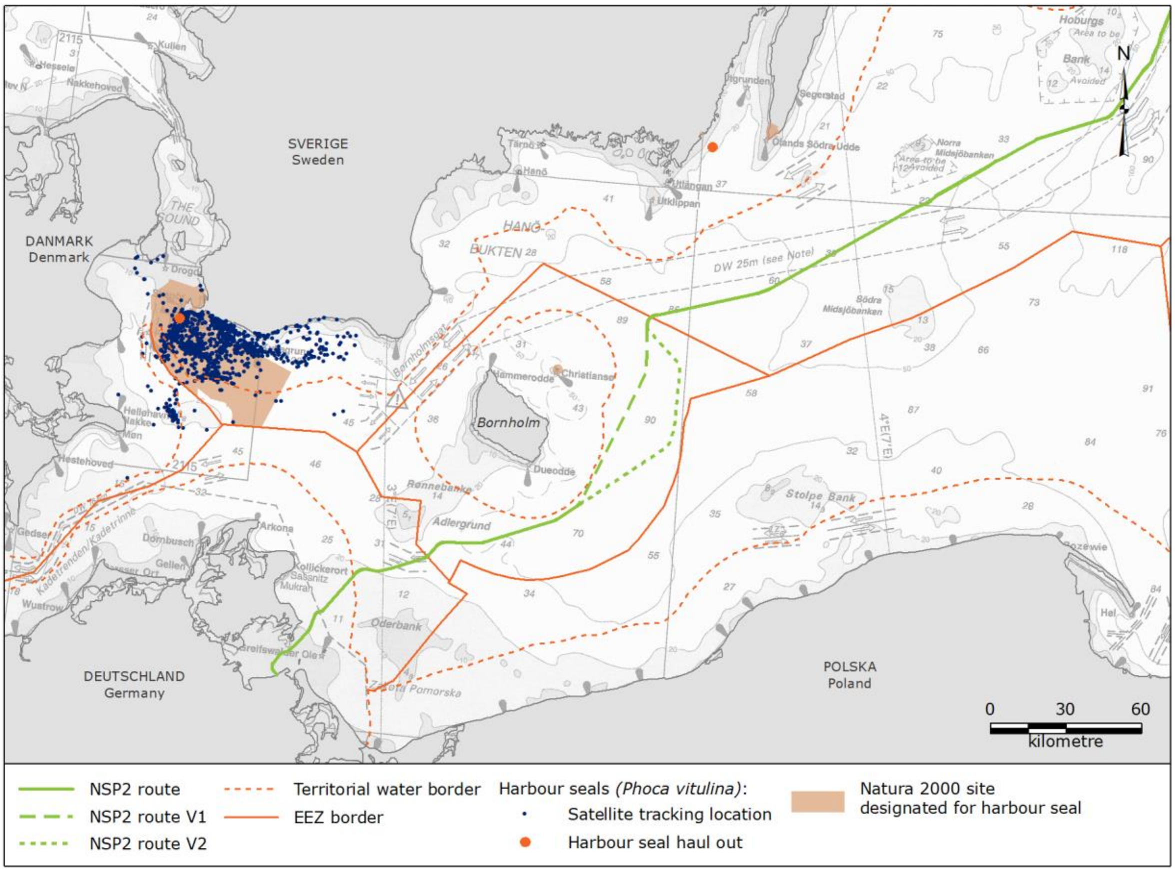


Figure 7-45 Haul-out sites (colonies) in the Baltic Sea used by harbour seals for resting, breeding and moulting. Global positioning system (GPS) tracking of harbour seals in the Danish sector is indicated by blue dots. No satellite tracking has been undertaken in the Swedish colonies. Source: HELCOM Seal Database /243/.

7.10.3.3 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, after 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 7-45).

7.10.3.4 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 /244/.

Figure 7-46 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.

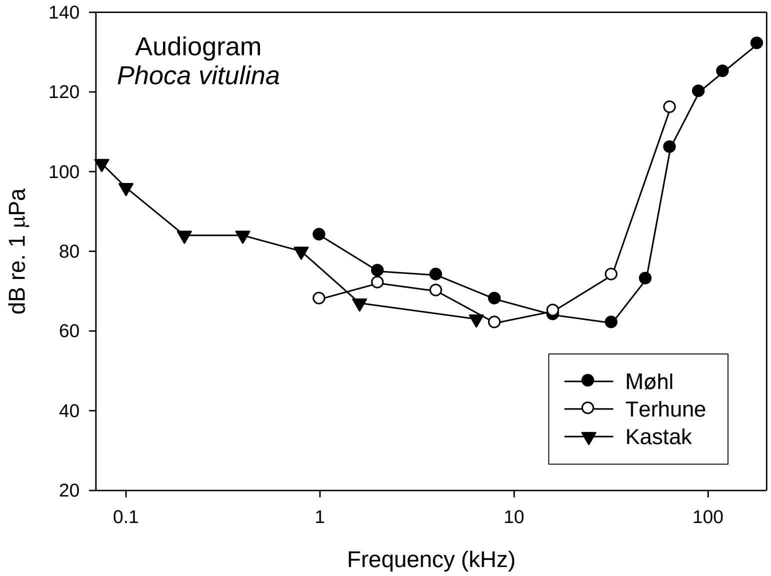


Figure 7-46 Audiograms of three harbour seals, showing the threshold of hearing under quiet conditions at frequencies in the range from 80 Hz to 150 kHz. The names Møhl, Terhune and Kastak in the legend refer to results from references /245/, /246/ and /247/, respectively.

7.10.3.5 Biodiversity status

In 2017, HELCOM assessed the integrated biodiversity status of the Baltic Sea /111/. The proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are located in the zone between the Kalmarsund population and the south-western Baltic population. Under the most recent assessment of biodiversity under HELCOM, the Kalmarsund population falls below the threshold for 'Good Status', based on the low abundance, while the growth rate of the stock is satisfactory. The south-western Baltic population falls below the threshold based on a positive growth rate lower than the threshold.

7.10.3.6 Protection

Harbour seals are protected under the EU Habitats Directive and the Bonn Convention. In addition, they are fully protected under national legislation. Furthermore, 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 designated in connection with important haul-out areas on land. In Denmark, the species is furthermore protected under Administrative Order 867 of 27/06/2016 /233/.

Protected areas for marine mammals are described in sections 7.12 and 7.13.

7.10.4 Grey seal

This section presents the Baltic Sea population of grey seal, with information on population structure and size, distribution, behaviour, reproduction and protection.

7.10.4.1 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 Ocean, respectively.

One hundred years ago, the grey seal population in the Baltic Sea comprised 80,000-100,000 individuals, but by the 1970s it had decreased to approximately 4,000 due to hunting and reproductive disorders that have been connected to pollution by organochlorides /248/. 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 /249/. Studies have counted 30,000 grey seals in the Baltic Sea /236/, and it is estimated that the total population in the Baltic Sea was up to 40,000.

7.10.4.2 Distribution

Baltic grey seals are distributed from the northern-most part of the Bothnian Bay to the south-western waters of the Baltic Proper (Figure 7-47). 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 Sea. As is the case with harbour seals, haul-out sites/colonies are land localities occupied by grey seals. The locations of these sites are shown in Figure 7-47.

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 species requirements for feeding and suitable breeding habitats /242/. Typically, however, the animals feed locally, foraging just offshore and adopting a regular pattern of travelling between local feeding sites and preferred haul-out sites /250//251/.

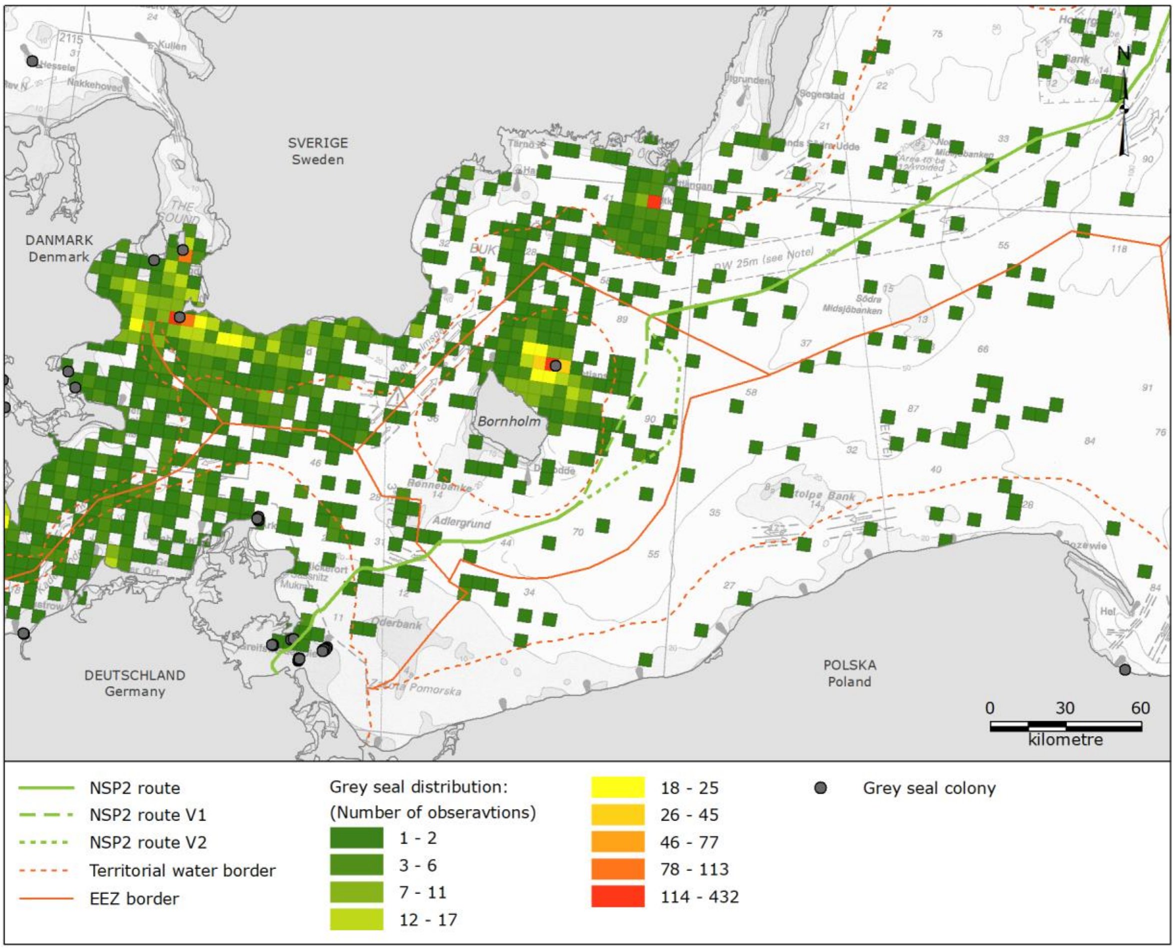


Figure 7-47 Haul-out sites (colonies) used by grey seals for resting, breeding and moulting. GPS tracking of grey seals is indicated by blue dots. Source: HELCOM Seal Database /243/.

In the Danish part of the Baltic Sea, the number of grey seals has increased drastically over the last decade (see Figure 7-48). The grey seal colony in closest vicinity to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 is at Christiansø (part of Ertholmene), north-east of Bornholm, more than 29 km from the combination of the proposed NSP2 route with V1, and more than 35 km from the combination of the NSP2 route with V2. This colony is, at present, the largest Danish grey seal colony. Up to 600 grey seals have been counted here, and in 2011-

2014, 33-99% of all observed grey seals in Danish waters were detected here /237/. In recent years, grey seals have also been observed at the colony of Rødsand, south of Zealand (not on map).

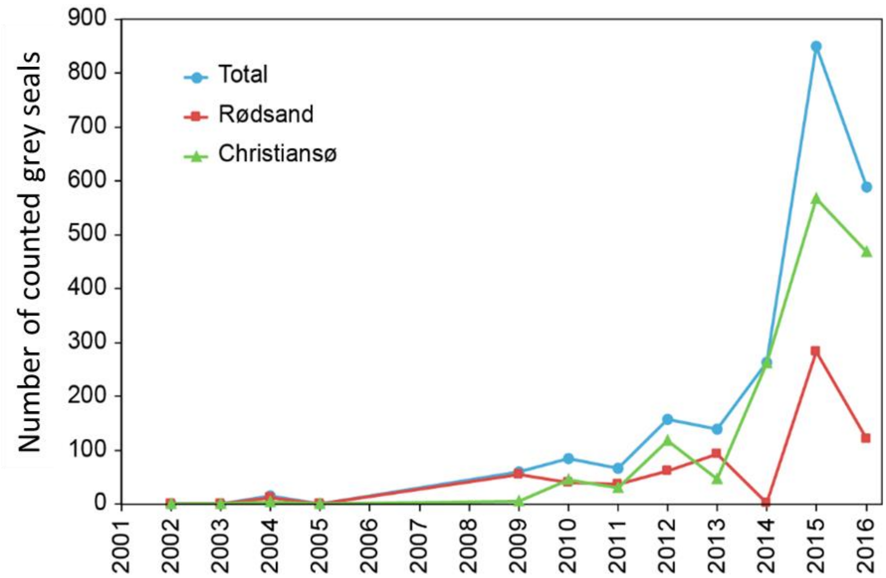


Figure 7-48 Number of grey seals counted during their moulting period (May-June) in the Danish part of the Baltic Sea in the years 2002-2016 /238/.

7.10.4.3 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 /239/. 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 their pup fur, grow dense waterproof adult fur, and leave for the sea /240//241/.

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 /240/.

7.10.4.4 Biodiversity status

In 2017, HELCOM assessed the integrated biodiversity status of the Baltic Sea /111/. The Baltic grey seal population falls below the threshold for 'Good Status', based on inadequate reproductive and nutritional status, while the abundance and population growth rate are above the evaluation thresholds.

7.10.4.5 Protection

The grey seal is a protected species listed in Annex II and Annex V of the EU Habitats Directive and Annex III of the Bonn Convention. The Baltic Sea population of grey seal is also listed as endangered by the IUCN.

In Denmark, the species is furthermore protected under Administrative Order 867 of 27/06/2016 /233/. However, Denmark has recently opened small quotas for hunting grey seal in order to protect fisheries /252/.

Protected areas for marine mammals are described in sections 7.12 and 7.13.

7.10.5 Overview of critical periods for Baltic Sea mammals

The most vulnerable periods for seals in the Baltic Sea are 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 mothers. Table 7-30 summarises the most critical periods for Baltic Sea marine mammals.

Table 7-30 Critical periods for marine mammals and countries around the Baltic Sea. Countries are defined as "countries in which the species distribution overlaps with the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2 and potential impact area" /210/.

Species	Period		Country
	Breeding and lactation	Moulting	
Harbour porpoise	All year (nursing persists throughout the following year)	-	Sweden, Denmark, Germany, Finland, Poland
Harbour seal	May-July	August	Sweden
Grey seal	February-March/April	May-June	Finland, Estonia, Sweden, Denmark, Poland, Russia, Germany

7.11 Seabirds

Seabirds are an important component of the marine food chain and the ecosystem of the Baltic Sea. Furthermore, a number of seabird species have protected status under national/international legislation and seabirds are therefore considered an important receptor.

7.11.1 Seabirds in the Baltic Sea

The Baltic Sea is an important area for numerous seabird species, especially staging seabirds. Seabird species encompass many different feeding types. Many are predators of fish, mussels and shellfish, but other types include scavengers and grazers of coastal vegetation. Whereas some species occur over the entire Baltic Sea region, such as breeding common terns and wintering long-tailed ducks, others are restricted to smaller parts of the Baltic Sea or only selected sites.

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*)) /253//255/. 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 /253/. 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 seabirds congregate for moulting in particular areas with easy access to optimal feeding grounds. During this moulting period, the birds are generally unable to fly /255/.

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 forages in the more open and deeper parts of the Baltic Sea. 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*) /253//255/.

7.11.2 Seabird populations in Danish marine areas

The Danish marine areas are of significant international importance for seabirds, and hold significant numbers of birds during all times of the year, with the highest numbers being found during the winter and migration periods. Danish marine areas lie at the heart of the major flyway for migratory birds, comprising some of the most important staging and wintering areas for many species, especially divers, seaducks and alcids. The shallow marine areas are of particular importance to a number of diving duck species.

A report from 2011 provided national abundance estimates and modelled the distributions of selected species of waterbirds in Danish waters on the basis of aerial surveys. These estimates are presented in Table 7-31, based on /254/. The estimates cover all Danish waters, i.e. the Baltic Sea, the North Sea and inner Danish waters.

Table 7-31 National abundance estimates for six waterbird species/types in Danish waters during the winter, spring and summer based on surveys in the summer of 2006, the winter of 2008 and the spring of 2008 and 2009 /254/. "-" indicates no estimate is available.

Waterbird species	Winter	Spring	Summer
Divers	10-15,000	20,000	-
Common Eider	503,000	-	-
Common Scoter	600,000	-	55,000
Long-tailed Duck	28,000	-	0
Red-breasted Merganser	55,000	-	-
Razorbill/Guillemot	76,000	-	-

7.11.3 Seabirds in the Danish section of the Baltic Sea

Ertholmene, located north-east of Bornholm, holds some of the largest breeding populations of common eider (*Somateria mollissima*) and herring gull in Denmark, while the shallow areas of Rønne Banke west of Bornholm provide foraging habitat for the birds, and higher densities are thus found here.

Based on a census of seabirds and knowledge of biology and ecology, wintering grounds have been identified /255/. These wintering grounds are shown in Figure 7-49.

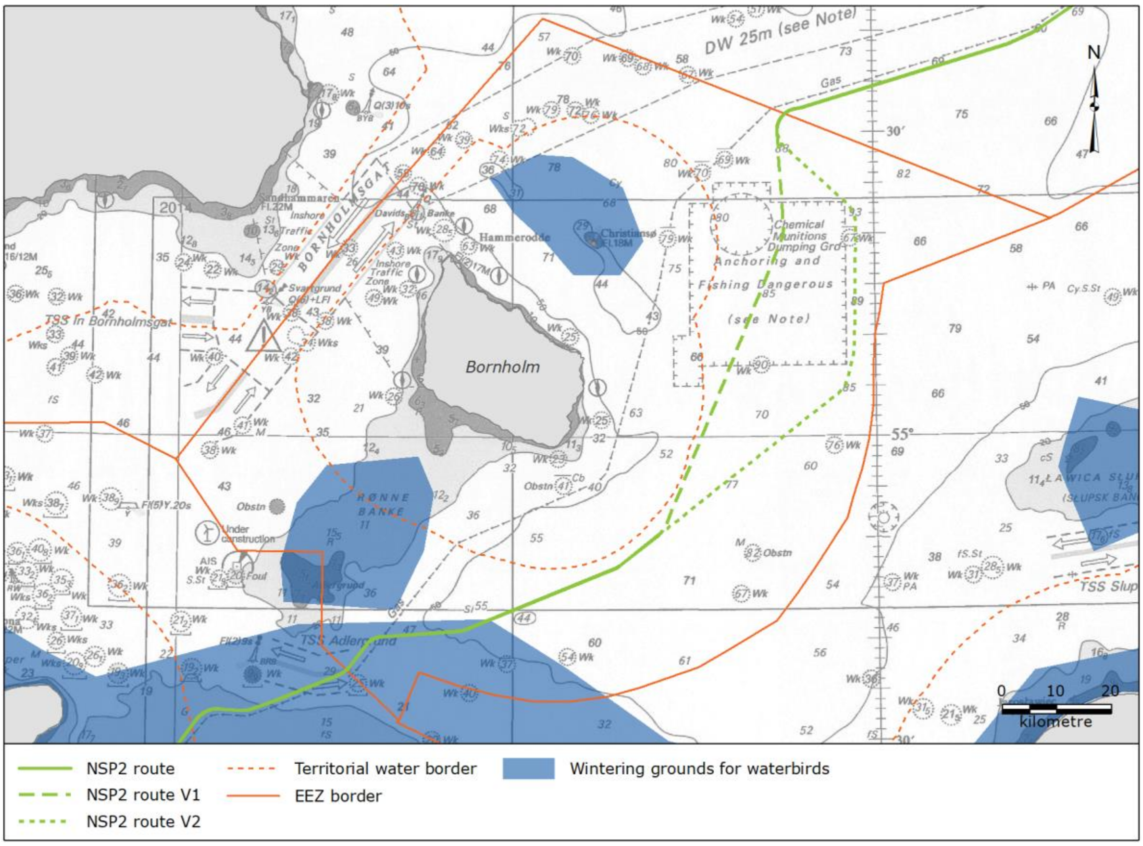


Figure 7-49 Wintering grounds for waterbirds /255/.

Based on the 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 Banke and near the coasts of Bornholm) /255/. The abundance of all species observed in the Danish EEZ represented less than 1% of the Baltic Sea populations. The most abundant species by far was the long-tailed duck (*Clangula hyemalis*), observed mainly at Rønne Banke. Information on observed species, abundance and conservation status is presented in Table 7-32 /255/.

Table 7-32 The abundance of seabirds observed in the Danish sector during winter surveys in 2007-2009 /255/.

Species	Average number of wintering birds 2007-2009*	Relative proportion of the Baltic Sea population (%)
Common coot (*Fulica atra*)	241	0.01
Common goldeneye (*Bucephala clangula*)	73	0.04
Common pochard (*Aythya ferina*)	42	0.14
Goosander (*Mergus merganser*)	24	0.04
Great cormorant (*Phalacrocorax carbo*)	138	0.26
Greater scaup (*Aythya marila*)	3	0.00
Long-tailed duck (*Clangula hyemalis*)	12	0.81
Mallard (*Anas platyrhynchos*)	2,472	0.97
Mute swan (*Cygnus olor*)	70	0.05
Red breasted merganser (*Mergus serrator*)	21	0.13
Red-throated diver (*Gavia stellata*) and black-throated diver (*Gavia arctica*)	50	0.58
Smew (*Mergus albellus*)	2	0.02
Tufted duck (*Aythya fuligula*)	1,334	0.28
* Wintering birds includes staging and migrating (passage) birds.		

It should be noted that not all of the seabird species present in the Danish part of the project area are included in the study summarized in Table 7-32 /255/. Only birds observed at the defined survey transects have been included.

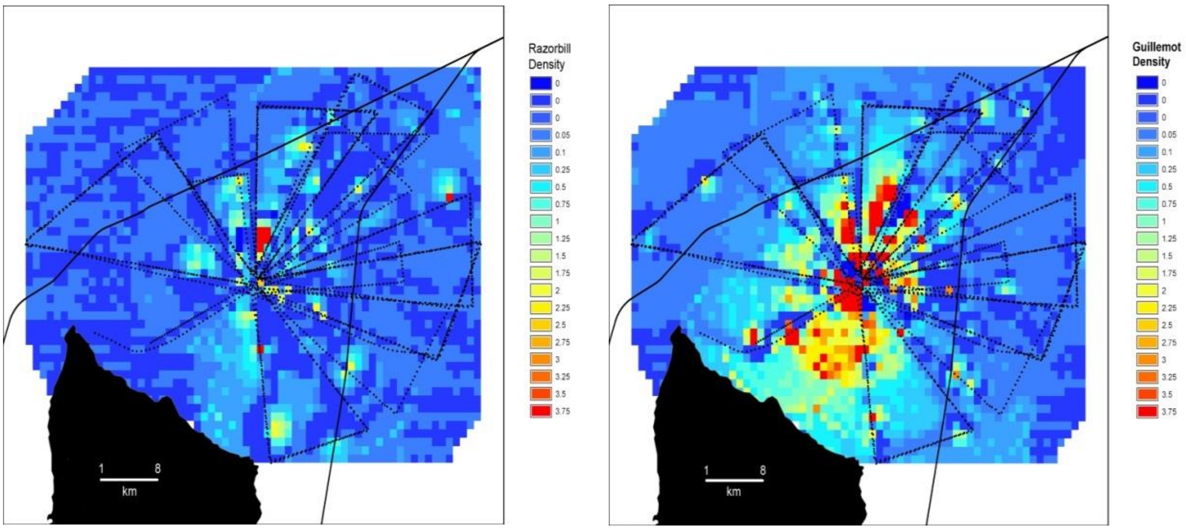
Other species are presented in the following sections, based on information from the IBAs, and species designated as protected under Natura 2000 are presented in section 7.13.

7.11.4 Seabird studies from NSP

During NSP, surveys of seabirds were undertaken in Danish and German waters. Transect studies were undertaken at Rønne Banke and Oder Bank in 2006-2007 and at Ertholmene in 2008. Furthermore, studies were undertaken in the German part of Rønne Banke in 2010-2012.

7.11.4.1 Foraging distribution of two seabird species at Ertholmene

Baseline studies of the foraging distribution of the two species razorbill and guillemot, designated as protected under Natura 2000, were carried out as part of the NSP baseline studies between May and July 2008 /256/. 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 7-50) during seven individual field trips.



A Density of foraging razorbills **B** Density of foraging guillemots

Figure 7-50 Density of foraging razorbills (Left, A) and guillemots (Right, B) 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 /256/.

Results from the study revealed a high-density foraging area 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 of 6 km) and large for guillemots (radius of 20 km) /256/.

7.11.4.2 Winter and summer abundances between Rønne Banke and Oder Bank

The abundance and distribution of seabirds were also investigated as part of the NSP baseline studies in Rønne Banke and Oder Bank (see Figure 7-51) in the winter (February and March 2007) and in the summer (July and September 2006). Birds were counted in transects from ships (winter surveys) or aircraft (summer surveys) /257/.

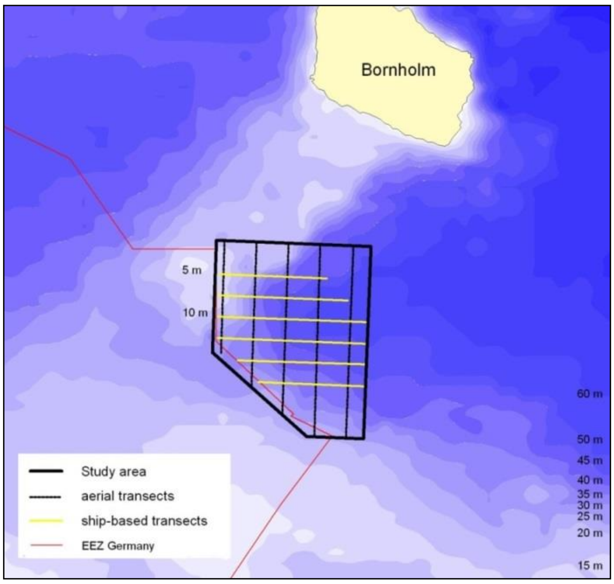


Figure 7-51 Study area of winter and summer abundances of waterbirds south of Bornholm /257/.

Winter numbers (ship-based surveys)

The densities and the total estimated numbers of the observed bird species during the winter are summarised in Table 7-33.

Table 7-33 Densities and estimated total numbers of seabirds during the winter of 2007 /257/.

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 were observed in the shallow parts of Rønne Banke at <20 m water depth. Lower densities were observed on the adjacent slopes. The numbers were significantly lower in March than in February, indicating an early start of spring migration or movements to other habitats. The same development was observed for guillemot (*Uria aalge*).

The 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 guillemots during the summer are summarised in Table 7-34.

Table 7-34 Densities and estimated total numbers of seabirds during the summer of 2006 /257/.

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	2,428	0.91	723

German aerial surveys revealed that in the summer, adult chicks of guillemots (possibly also razorbills) from the colony near Christiansø (Ertholmene) congregate in the southern part of Rønne Banke /257/. 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 7.11.4.1 and /256/. Besides the main moulting and post-fledging areas, both species are believed to be found offshore outside the study area /256/.

7.11.4.3 Other surveys at Rønne Banke

Ship and airplane surveys were performed in October and December 2010, January 2011 and March 2012 /258//259/, with the aim of defining the prevalence of bird species within the German EEZ. The survey area also overlapped with a minor part of the Danish EEZ and the south-western part of Rønne Banke. The surveys generally revealed high numbers and high densities of seabirds in the German EEZ, with seasonal fluctuations in all species. Very low numbers of seabird species were recorded in Danish waters, with auks (common guillemots and razorbills) and long-tailed ducks being the most frequent, with numbers of up to 150 birds. Velvet scoter, common scoter and divers were mainly present in March (2012), but in low numbers (<50 individuals per species).

7.11.5 Seabird studies from the NSP2 base case route

No specific surveys along the NSP2 base case route were undertaken in the Danish sector.

In the German sector, vessel-based seabird surveys (covering an area of 2,250 km^2) were undertaken in the Pomeranian Bay (September 2015-August 2016), which covered most of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in this area of importance for seabirds. In addition, two aerial digital image surveys were conducted in order to evaluate the "reef effect" of the operating NSP pipeline during the winter season. The highest numbers counted in the aerial survey area along the NSP/NSP2 route in a corridor of approx. 2 km width (covering an area of 167 km^2) were 6,000 long-tailed ducks, 15,000 common and velvet scoters as well as 300 red-throated and arctic divers and 50 auks during spring migration in April 2016, outside of the construction period for NSP2. Benthophagous sea ducks were evenly distributed within the survey corridor with long-tailed ducks aggregating in significantly higher concentrations above the NSP pipeline, indicating no adverse effects.

Further information on the number and distribution of seabirds can be found in the German EIA /260/.

7.11.6 Important Bird and Biodiversity Areas

The NGO Birdlife has appointed IBAs, which are sites of international significance for the conservation of birds and other nature. An IBA does not provide legal protection; however, it is considered an area of international importance that generally supports significant numbers of birds or a particular species.

To be appointed 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.

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" /261/.

IBAs within the Danish part of the project area are presented in Figure 7-52.

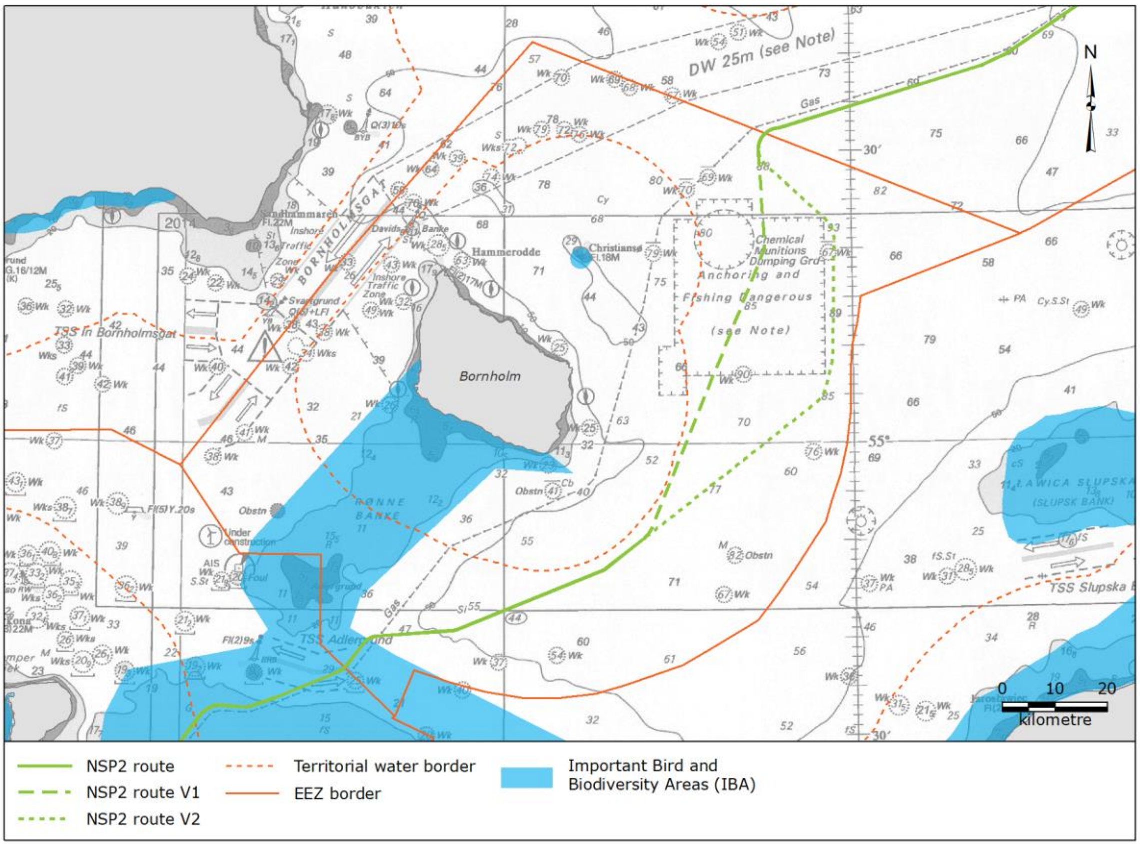


Figure 7-52 IBAs present in Danish section of the Baltic Sea.

Two IBAs are located within the Danish section of the Baltic Sea: DK079 Ertholmene north-east of Bornholm and DK120 Rønne Banke south of Bornholm. Ertholmene and part of Rønne Banke are also designated Natura 2000 sites (see section 7.13) and Ertholmene is furthermore a designated Ramsar site (see section 7.12.2).

Key bird species, season of stay and criteria for the two IBAs in Danish waters are summarised in Table 7-35.

Table 7-35 The Danish IBAs DK120 Rønne Banke and DK79 Ertholmene in the vicinity of the project area with key bird species, season of stay and distance to the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2 /261//262/.

IBA	Species	Season	IBA criteria	Minimum distance to proposed NSP2 route with V1 / proposed NSP2 route with V2
DK120: Rønne Banke	Common scoter (*Melanitta nigra*)	P	A4i, B1i, C3	Crossing for 7.1 km in Danish waters (both the proposed NSP2 route with V1 and the proposed NSP2 route wit V2)
	Velvet scoter (*Melanitta fusca*)	p	A4i, B1i, C3	
	Long-tailed duck (*Clangula hyemalis*)	P	A4i, B1i, C3	
	Red-breasted merganser (*Mergus serrator*)	P	A4i, B1i, C3	
	Red-necked grebe (*Podiceps grisegena*)	P	A4i, B1i, C3	
	Great crested grebe (*Podiceps cristatus*)	P	A4i, B1i, C3	
	Horned grebe (*Podiceps auritus*)	P	A4i, B1i, C3	
	Black guillemot (*Cepphus grille*)	P	A4ii, B1i, C3	
DK079: Ertholmene northeast of Bornholm	Guillemot (*Uria aalge*)	B, W	C7	29.6 km (proposed NSP2 route with V1) 37 km (proposed NSP2 route with V2)
	Razorbill (*Alca torda*)	B, W	C7	

Season: B: breeding, W: wintering, P: permanent

IBA criteria: Global (A level criteria), regional or continental (B level criteria), sub-regional and/or national (C level criteria)

A4i: Sites that are known or thought to hold, on a regular basis, 1% or more of a biogeographic population of a congregatory waterbird species
A4ii: Sites are known or thought to hold, on a regular basis, 1% or more of the global population of a congregatory seabird or terrestrial species
B1i: Sites that are known or thought to hold ≥ 1% of a flyway or other distinct population of a waterbird species
C3: Sites that are known to regularly hold at least 1% of a flyway population of a migratory species not considered threatened at the EU level
C7: Other ornithological criteria, e.g. areas that have been designated as a SPA prior to the IBA designation

Note: The sites have been assessed using older assessment criteria; the new categories are similar, but not available for the two listed sites.

Ertholmene is designated as a SPA because it is the only known Danish site with breeding *Alca torda* (570 pairs) and *Uria aalge* (2,000 pairs), although the numbers do not reach C3 thresholds. It is also important for breeding *Somateria mollissima* (3,000 pairs), but the numbers are below the C3 threshold /262/.

7.11.7 Biodiversity status

In 2017, HELCOM assessed the integrated biodiversity status for seabirds /111/. Two core indicators were used to assess the status of 42 bird species divided between the breeding and the wintering season. The species were chosen in order to represent the overall bird species composition as well as different species groups. The core indicators, "Abundance of waterbirds in the breeding season" and "Abundance of waterbirds in the wintering season", assess status by comparing to an abundance index. The HELCOM assessment is carried out on a regional scale, covering the whole Baltic Sea, in order to assess the overall population status /111/.

The two core indicators for abundance of waterbirds during the breeding and the wintering season did not achieve "good" status. Benthic feeding birds exhibited "not good" status during both seasons. Grazing feeders achieved "good" status only in the breeding season, and surface feeders only in the wintering season. Pelagic feeders as a group achieved "good" status in both seasons /111/.

7.11.8 Conservation status

Table 7-36 summarises the important seabird species present in the Danish waters around Bornholm, with importance defined by whether the species is listed in an IBA or designated in a bird protection area. The species are listed along with their status on the Danish Red List /166/, HELCOM Red List for the Baltic Sea /167/, the global IUCN Red List /207/ and/or are included in the EU Birds Directive.

The HELCOM Red List Assessment /167/ is divided into breeding birds and wintering birds. For the breeding populations, 23 species were red-listed, while for the wintering populations, 16 species were red-listed.

Table 7-36 Species occurring in the Danish section of Baltic Sea (i.e. listed in Danish IBA or designated as bird protection area) or that are on the HELCOM Red List /167/, IUCN Red List /207/ and/or listed in the EU Birds Directive.

Species	Status on the Danish Red List	Status on the HELCOM Red List*	Status on the IUCN Red List	Status in the Birds Directive
Black guillemot (*Cepphus grille*)	LC	LC-VU	-	M
Common scoter (*Melanitta nigra*)	-	EN (W)	LC	M
Great crested grebe (*Podiceps cristatus*)	LC	-	LC	Annex I
Guillemot (*Uria aalge*)	NT	-	LC	M
Horned grebe (*Podiceps auritus*)	RE	VU (B), NT (W)	VU	Annex I
Long-tailed duck (*Clangula hyemalis*)	-	EN (W)	VU	M
Razorbill (*Alca torda*)	NT	-	NT	M
Red breasted merganser (*Mergus serrator*)	LC	VU (W)	LC	M
Red-necked grebe (*Podiceps grisegena*)	LC	EN (W)	LC	M
Velvet scoter (*Melanitta fusca*)	-	VI (B), EN (W)	VU	M

Red List
LC: Least concern
EN: Endangered
VU: Vulnerable
NT: Near threatened
NA: Not applicable
-: Not listed.
* For HELCOM Red List, distinction is made between listings for breeding (B) or wintering (W) species

Birds Directive
M: Migratory species.

7.12 Protected areas

Protected areas in the Baltic Sea comprise marine and coastal biotopes, including habitats and species. Their protection ranges 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 as well as their role in providing a wide range of environmental, social and economic benefits, protected areas are considered an important receptor.

Protected areas are shown in Figure 7-53. UNESCO sites and shellfish waters are not designated in the Danish EEZ near the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2. IBAs are described in section 7.11.

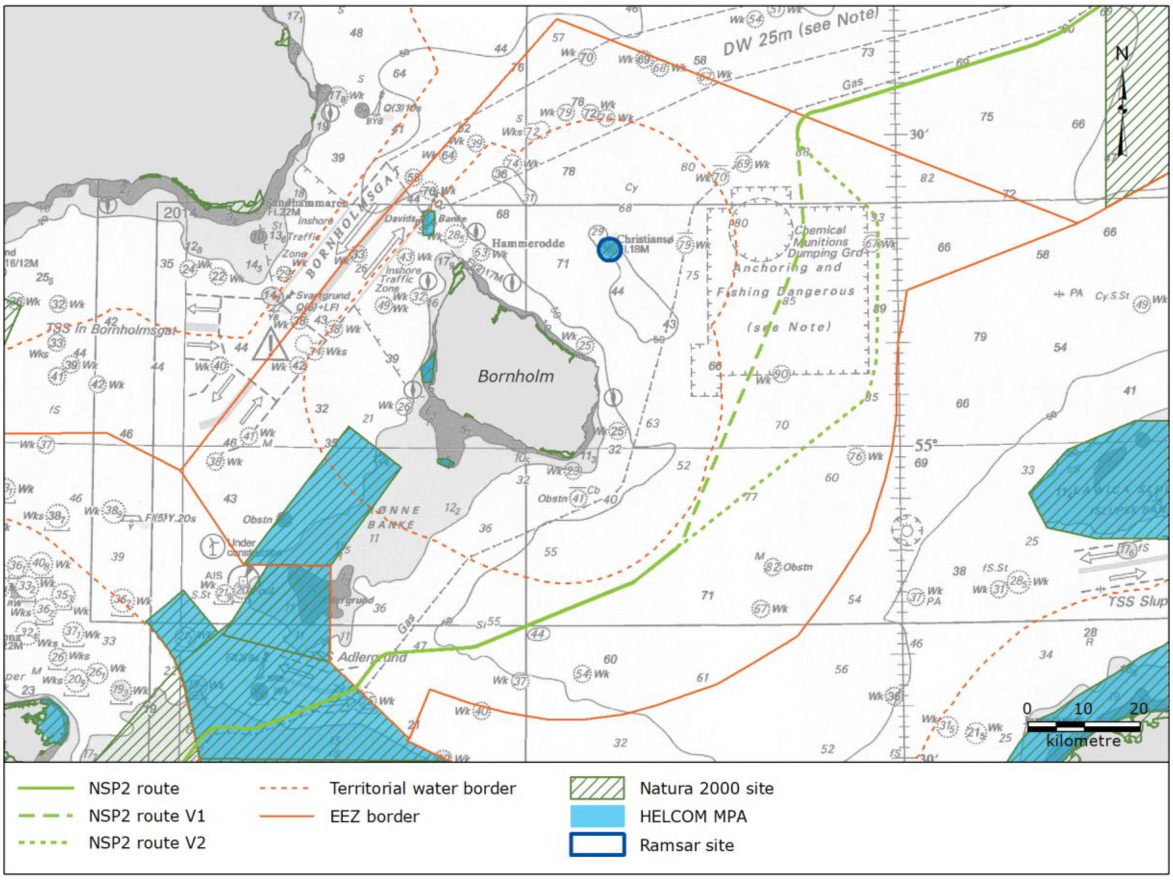


Figure 7-53 Protected areas in the proximity of the proposed NSP2 route, NSP2 route V1 and/or NSP2 route V2 within Danish waters. Protected areas include Natura 2000 sites, HELCOM MPAs and Ramsar sites.

7.12.1 Natura 2000

Natura 2000 is an EU network of protected areas. A description of these areas is presented in section 7.13 and an assessment of potential impacts is presented in section 9.12.

7.12.2 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 territories /263/.

The Ramsar contracting parties have committed to designating suitable wetlands for the List of Wetlands of International Importance and to ensuring their effective management.

In Denmark, Ramsar sites are integrated into Natura 2000 sites, see section 7.13. Ramsar sites in the proximity of the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2 in Danish waters are shown in Figure 7-53 whilst further details are provided in Table 7-37.

Table 7-37 Ramsar sites closest to the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2 within Danish waters /264/.

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.	29.6 km (NSP2 route with V1) 37 km (NSP2 route with V2)

7.12.3 HELCOM Marine Protected Areas

HELCOM is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea. Through intergovernmental cooperation, HELCOM works to protect the marine environment of the Baltic Sea from all sources of pollution.

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 /265/.

HELCOM and the OSPAR Commission have adopted a joint Work Programme on MPAs to ensure that the implementation of the HELCOM/OSPAR Ministerial Declaration is consistent across marine areas /266/.

The HELCOM MPAs are shown in Figure 7-53 whilst Table 7-38 provides details of the HELCOM MPAs within 20 km of the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2 in Danish waters. The Danish HELCOM MPAs are identical to EU Natura 2000 sites.

Table 7-38 HELCOM MPAs closest to the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2 within the Danish waters /267/.

HELCOM MPA name	Description	Listed pressures to site	Distance to pipelines (minimum)
#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.	18.4 km (NSP2 route with V1 and NSP2 route with V2)

7.12.4 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 the sovereign jurisdiction of the states in which 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 /268/.

7.12.5 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 /269/.

7.12.6 Shellfish waters

Shellfish waters have been designated in accordance with Administrative Order 840 of 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 EU 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 /19/ 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 DEPA 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 the 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 Danish section of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are shown in Figure 7-54. Additional details on the marine Natura 2000 sites located within 20 km of the Danish section of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are provided in Table 7-39. A distance of 20 km was selected based on professional judgement and experience from NSP regarding the potential for impact on Natura 2000 sites from construction and operational activities.

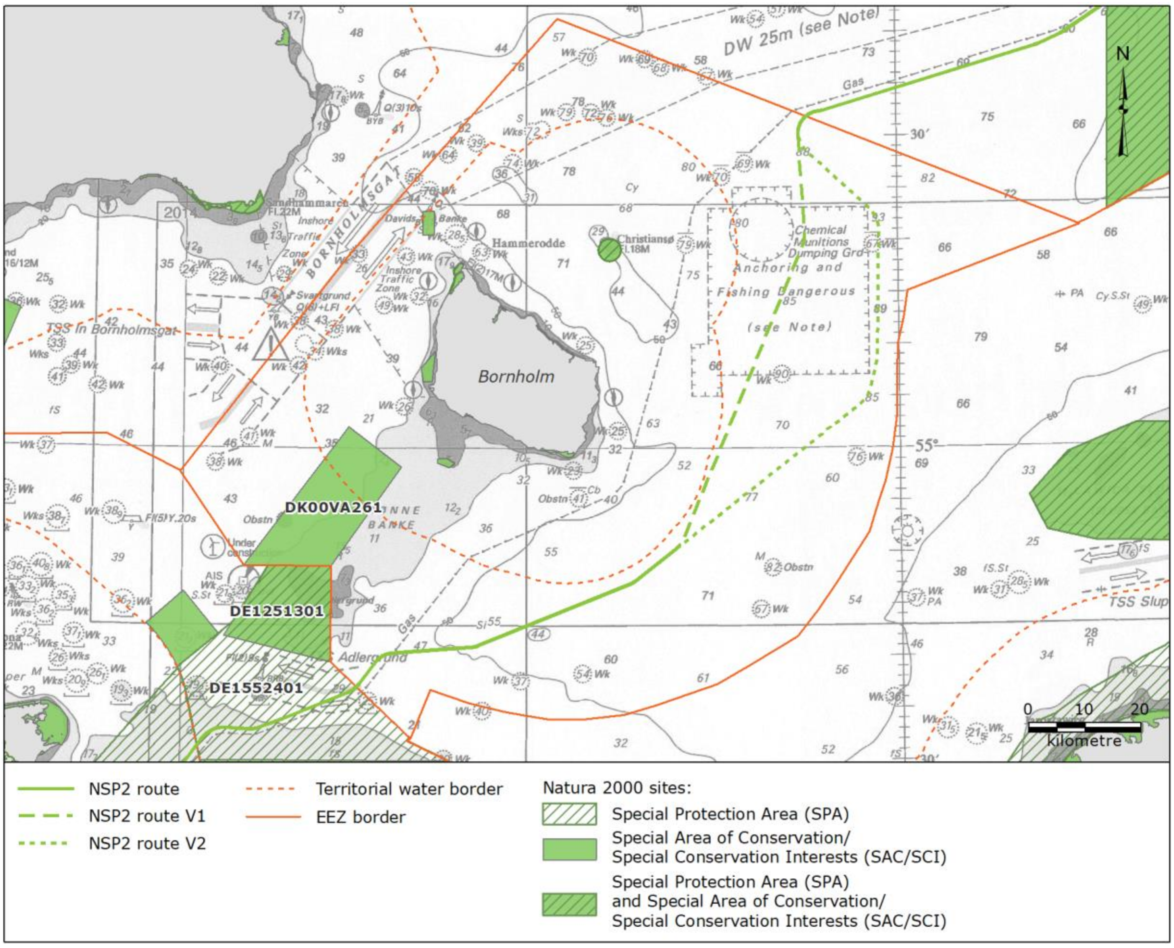


Figure 7-54 Natura 2000 sites (a larger version of this figure can be seen in Atlas Map PA-01-D).

Table 7-39 Selected Natura 2000 sites (comprising marine designations*) within approximately 20 km of the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2.

Natura 2000 site	Distance to proposed NSP2 route with V1/NSP2 route with V2	SPA and/or SAC	Designated marine species	Designated marine habitat types
N252 Adler Grund and Rønne Banke (DK00VA261)	Approximately 18 km (NSP2 route with V1 and NSP2 route with V2)	SAC 261	-	1110 sandbanks 1170 reefs
Adler Grund* (DE1251301)	Approximately 6 km (NSP2 route with V1 and NSP2 route with V2)	SAC	1351 Harbour porpoise (*Phocoena phocoena*) 1364 Grey seal (*Halichoerus grypus*)	1110 sandbanks 1170 reefs
Pommersche Bucht* (DE1552401)	0 km (NSP2 route with V1 and NSP2 route with V2)	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 Habitats 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 Habitats Directive (sites that have been adopted by the European Commission but not yet formally designated by the government of each country)

* Only marine Natura 2000 areas are discussed in this section; the coastal and terrestrial Natura 2000 sites around Bornholm are not considered a relevant receptor since the NSP2 activities in the Danish sector occur entirely offshore and the distance to the coast of Bornholm is at least 20 km.
** Designated Natura 2000 site in Germany. Due to the proximity of the site to the Danish EEZ, it has been included in this description.

In addition, Ławica Słupska (PLC990001), a marine Natura 2000 site located in Polish waters approximately 35 km south-east of the combination of the proposed NSP2 route with V1 and the combination of the NSP2 route with V2 at its closest point, see Figure 7-54.

The designated marine habitat types have been mapped as part of Natura 2000 planning and are presented in Figure 7-55. The habitat types in the Danish Natura 2000 site N252 include reefs and sandbanks.

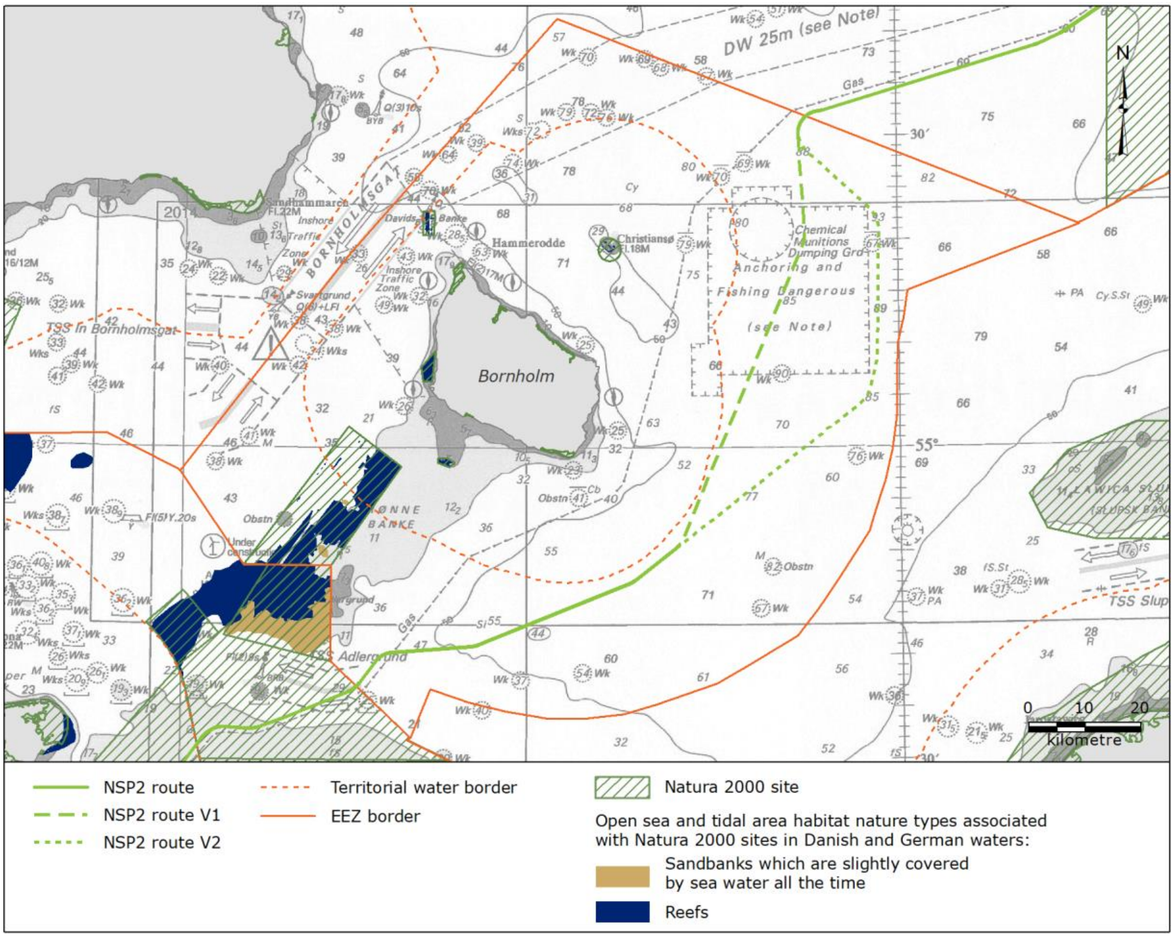


Figure 7-55 Habitat types designated under Natura 2000 within Danish and German waters, as mapped by the authorities /270/ (a larger version of this figure can be seen in Atlas Map PA-01-D).

Each Natura 2000 site identified in Table 7-39 is described in detail in the following sections. In particular, the conservation status and main threats are listed for each species and habitat type.

7.13.1 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 ha. The SAC is designated on the basis of two habitat types ("reefs" and "sandbanks"). Reefs cover approximately 40% of the total area.

The Natura 2000 site was 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, since there is no formal system to assess the status of marine habitats. The main threats have been identified as eutrophication, contaminants and bottom trawling fishery, but the threats and their environmental impacts have not been assessed /271//272/.

Table 7-40 Summary of conservation objectives, status and main threats for the designated marine species and habitats /271/.

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

7.13.2 German Natura 2000 sites DE1552401 Pommersche Bucht and DE1251301 Adlergrund

The Pommersche Bucht and Adlergrund Natura 2000 sites cover areas 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 have been described in detail 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 /273/. The status of the site is assessed as "average or partially degraded structure" /273/. The main threats to the area include sailing, sand/gravel removal, disturbance, underwater noise and eutrophication /273/. The conservation status of the site is characterised as "good" for eight of the bird species and "average or reduced" for 11 species /273/.

The SAC Adlergrund encompasses the shallowest parts of 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 7-39. Shallow reef ridges are colonised by macroalgae (*F. serratus, H. tomentosus, L. saccharina, F. lumbricina*), whilst deeper boulder fields are colonised by blue mussels. At the outer edges of the reef, the site is dominated by sandbanks formed from glacial sands. 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"* (see section 4.3.3.6). 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 /274/.

Biodiversity is considered important due to its role in providing ecosystem services[8] such as sources of 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).

[8] Ecosystem services are the benefits people obtain from ecosystems.

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 (MSFD), 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 sections 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 that were used in the assessments include macrophytes, benthic animals and fish, as well as, in a limited number of 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 /274/.

Within 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 (Figure 7-56).

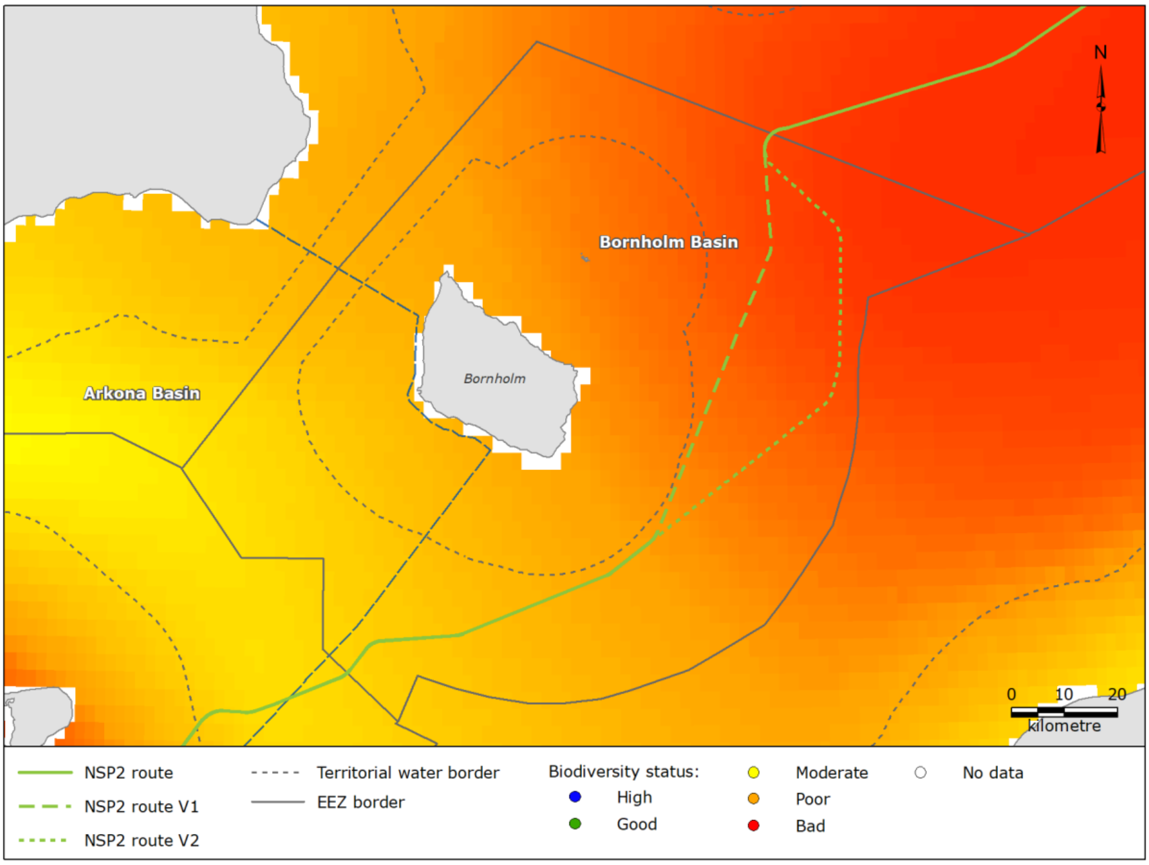


Figure 7-56 Biodiversity status of the Arkona and Bornholm Basins within Danish waters.

An updated assessment of the "State of the Baltic Sea" was prepared in 2018 /275/. The biodiversity assessment showed that many species and habitats in the Baltic Sea have inadequate status. Only a few biodiversity core indicators achieved the threshold values in at least part of the Baltic Sea, and none of them achieved the threshold values in all assessed areas /275/.

7.14.2 Species

Due to the young geological 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 /274/.

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 sections 7.7-7.11 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. These studies are therefore of less relevance for NSP2.

7.14.3 Habitats

The landscape and abiotic conditions provide the basis for the biotic conditions within the Danish section of the Baltic Sea. Together these determine the habitats that are present and subsequently the species that inhabit them. A summary of the abiotic conditions is provided in sections 7.2-7.6, whereas detailed descriptions of pelagic and benthic habitats can be found in sections 7.7 and 7.8, respectively.

Certain benthic communities within 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 most commonly found in coastal zones; however, a few habitat builders are present along the proposed NSP2 route in the 5-km stretch close to the German EEZ, where it crosses a shallower area (depth of 25-40 m), e.g. the Baltic tellin (*Limecola balthica*), blue mussel (*Mytilus edulis*) and various polychaetes, including the bristleworm and the invasive species *Marenzelleria 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. These can 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 7.2-7.6, 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 (see Figure 7-56) 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).

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, the NSP2 route V1 and the NSP2 route V2 in Denmark, a naturally lower diversity is found. This is mainly due to the limiting conditions defined by abiotic parameters (e.g. oxygen, see above) /150/.

Within the Bornholm Basin, anoxic conditions are frequent and in some instances, permanent. Along deeper sections of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2, anoxic areas create barriers to colonisation by habitat builders, which limits species richness and results in biological deserts (see section 7.8). The species that are present are often short-lived, opportunistic or hypoxia-tolerant species. Therefore, detritus-feeding polychaetes and bivalves form the basis of the biotic features of the habitats.

Light conditions also influence the colonisation of habitat builders along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. The seabed along the route is below the photic zone in Danish waters, and therefore there are no floral habitat builders present.

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 that 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 the Danish waters around the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2, the ecosystem is generally referred to as the Macoma community, due to the presence of the bivalve *Limecola balthica*. The Macoma community is normally dominant at water depths down to 15-30 m, but in the Baltic Sea the species is also frequent also at deeper waters. The open basins of the Baltic Sea, however, are more often characterised by the relict amphipod *Pontoporeia femorata* and the scaled worm *Bylgides sarsi*. Likewise, the brackish genus Hydrobiidae, the polychaete *Pygispio elegans* and the brackish cockle *Cerastoderma glaucum* frequently occur in the shallower, sandy parts of the Baltic Sea.

Despite its overall low diversity, the Baltic Sea ecosystem is considered to have an intrinsic biological value, and provides a variety of goods and ecosystem services. Nutrient cycling, 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 /274//278/. 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 /277//278/.

7.14.4.1 Trophic interactions

Trophic interactions are the interactions between organisms that are producers and consumers. Figure 7-57 provides a summary of the trophic interactions within the Baltic Sea, which is also relevant to the Danish EEZ.

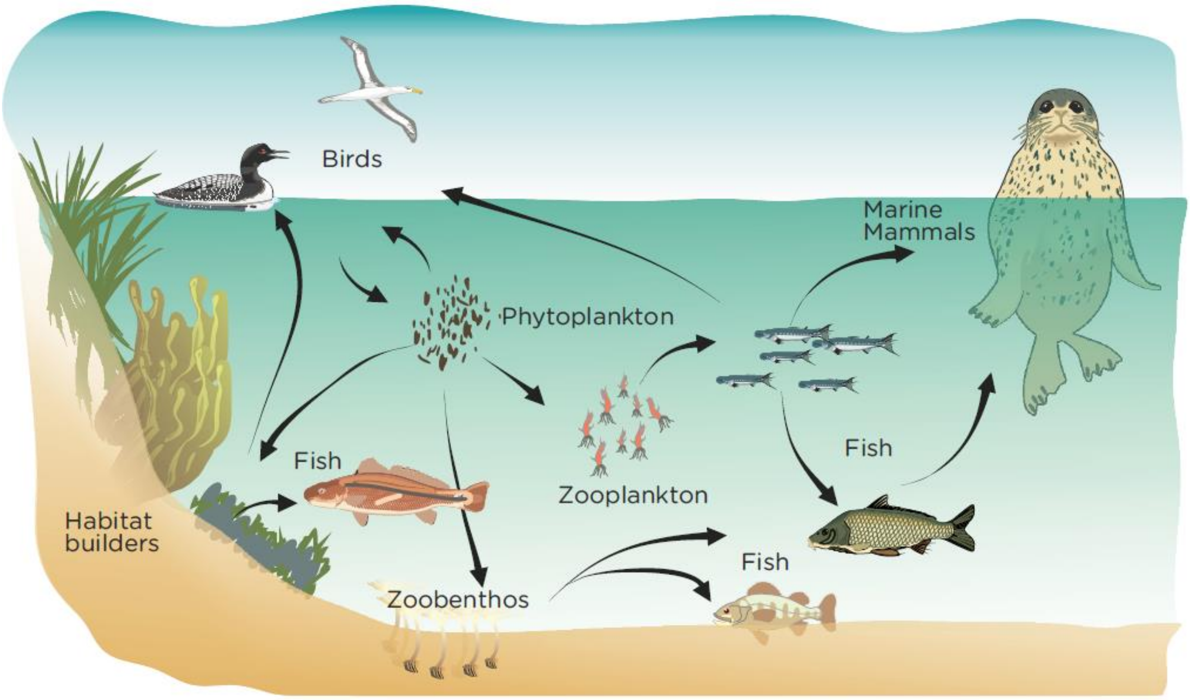


Figure 7-57 Schematic representation of the Baltic Sea trophic interactions. Adapted from /111/.

The first trophic level consists of different phytoplankton that form the functional group of primary producers, along with macroalgae /277/. 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.

The food web in the Baltic Sea is currently influenced by a general reduction in top predator populations (e.g. seabirds, 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. Therefore, the Baltic Sea food web can be categorised as bottom controlled.

As noted above, due to the anoxic conditions found in the Bornholm Basin, no zoobenthos or sessile fish (second and third trophic levels of the food web) are present in close proximity to the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2. As organic matter from the planktonic primary production accumulates in the basins, the decomposition in the Bornholm Basin relies on anaerobic microorganisms, which in relation to fish represent a dead end in the food web.

Along the western-most part of the proposed NSP2 route in Danish waters (characterised by reduced water depths such as on the slope of the Bornholm Basin), sufficient oxygen is available for zoobenthos and habitat builders. This will favour bottom-dwelling fish of small- and medium-sized species (i.e. gobies, juvenile cod and flatfish), which will then sustain larger predators. Hence, in this area, 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 within the Danish EEZ in particular) are considered to be:

- Eutrophication;
- Introduction of non-indigenous species (NIS);
- 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 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 due to fouling. Within the Danish part of the Baltic Sea, a total of 43 NIS species have been observed /276/. One NIS species of the *Marenzelleria* genus was reported during the NSP2 base case route survey at the western-most sampling stations south of Rønne Banke /90/.

Other anthropogenic activities taking place in the catchment area, coastal zone, and open sea (e.g. fisheries, maritime traffic, physical damage and disturbance, recreational activities, hunting, noise pollution and climate change) exert pressures on ecosystem interactions and biodiversity, particularly 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 is 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 7-58 shows the ship traffic intensity in the Baltic Sea, based on Automatic Identification System (AIS) registrations from 2014.

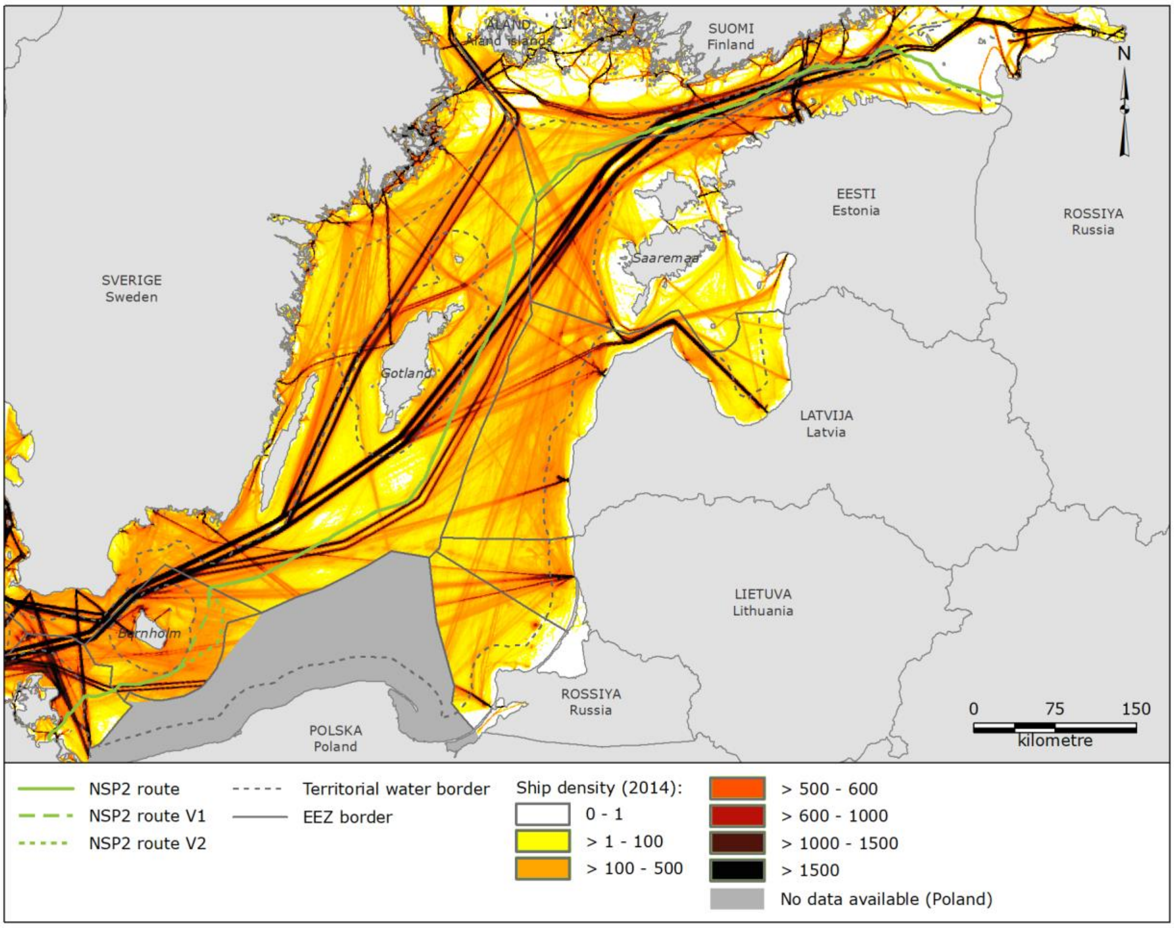


Figure 7-58 Ship intensity plot of the Baltic Sea, based on AIS registrations in 2014.

As shown in Figure 7-58, the majority of ships follow predesignated routes that are static and in accordance with existing traffic separation schemes (TSS).

7.15.1 Shipping lanes and ship traffic intensity in the Danish section of the Baltic Sea

In Danish waters, the combination of the proposed NSP2 route with V1 or the combination of the NSP2 route with V2 will run east and south of Bornholm, avoiding the heavily trafficked TSS Bornholmsgat. The only area with high ship traffic intensity is where NSP2 crosses the TSS Adlergrund, which has approximately 7,000 ship movements per year /279/.

The ship traffic density and primary ship traffic routes, including ferry routes, in Danish waters are shown in Figure 7-59.

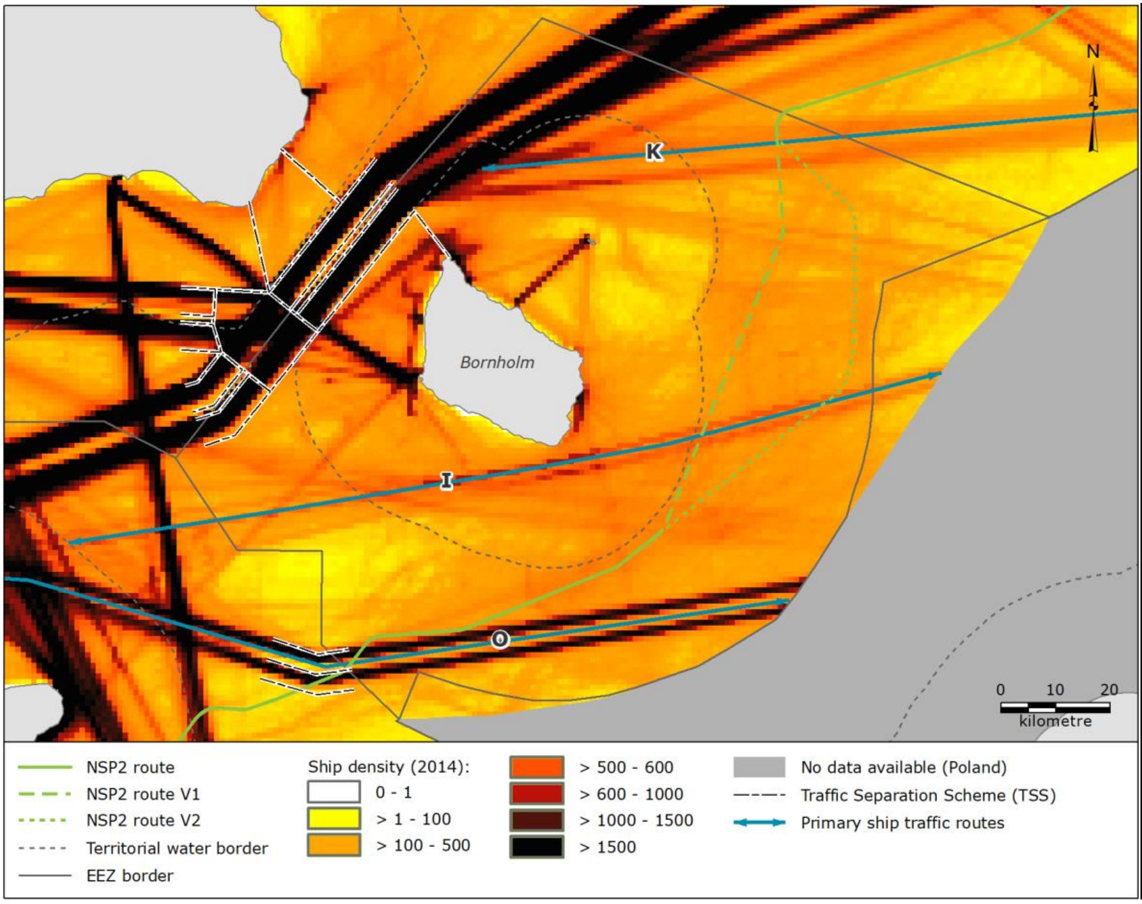


Figure 7-59 Ship traffic density in Danish waters. Please refer to annual crossings in Figure 7-63.

Three primary ship traffic routes have been identified as crossed by the Danish section of the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2. These include:

- Route K. The vessels using this route are sailing north of Bornholm to/from primarily Klaipeda Port. The ship traffic on this route is approximately 2,400 passages per year /279/.
- Route I. This route is used by ships passing the Natura 2000 area Adler Grund and 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. The ship traffic on this route is approximately 5,300 passages per year /279/.
- Route O. This route is used by ship traffic to and 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 at the border between Denmark and Germany. The ship traffic on this route is approximately 7,000 passages per year /279/.

The annual ship movements in 2014 and the forecasted ship movements for 2025 for the three primary ship routes in Danish waters are shown in Figure 7-60 /279/. The distribution of ship type on these routes in 2014 is shown in Figure 7-61, while the length distribution is shown in Figure 7-62.

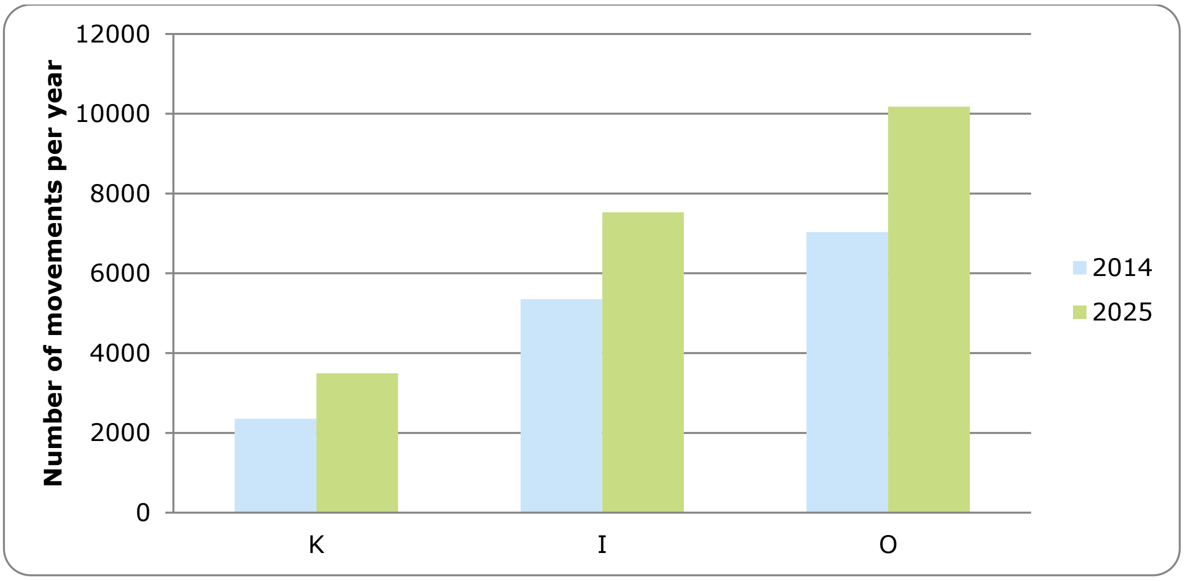


Figure 7-60 Annual ship movements on primary routes in Danish waters.

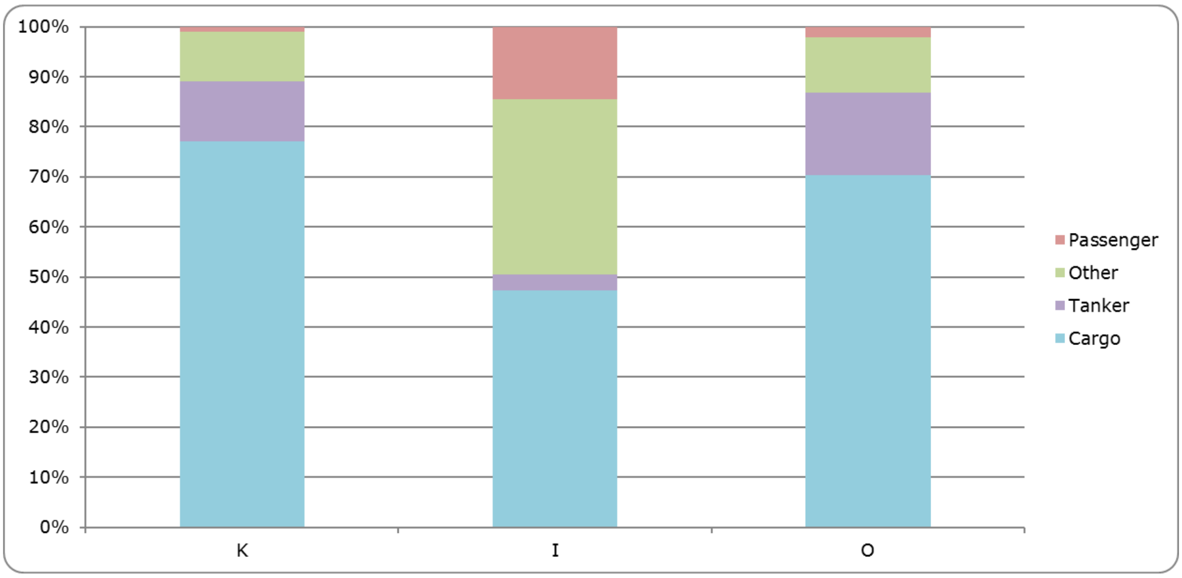


Figure 7-61 Ship type distribution in 2014 for primary routes in Danish waters.

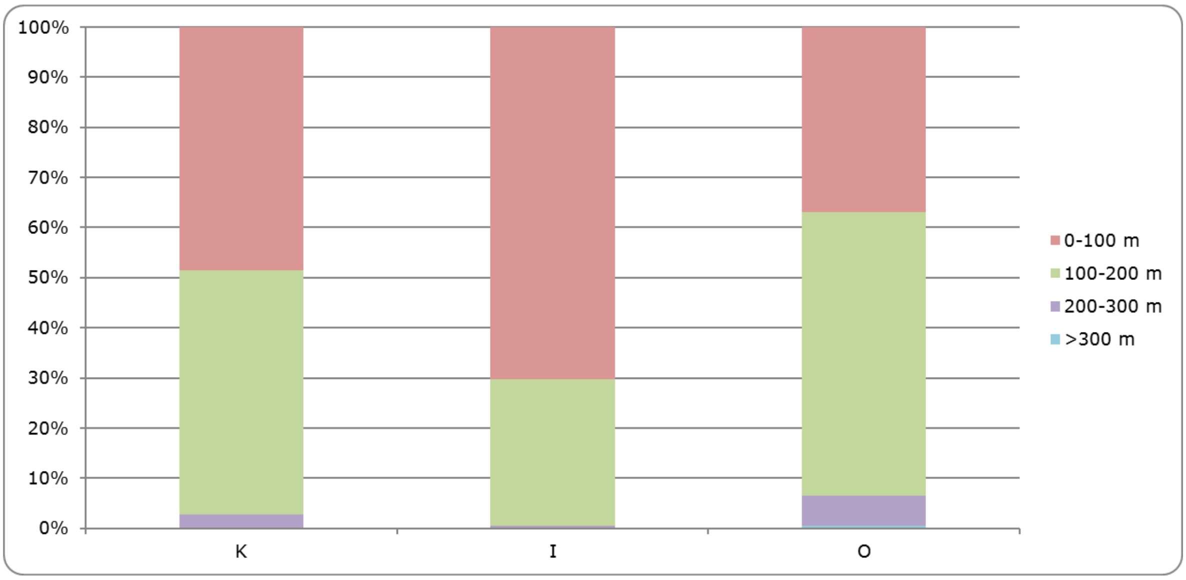


Figure 7-62 Ship length distribution on primary routes in 2014 in Danish waters.

Route I had approximately 5,300 movements in 2014. The annual ship movements are forecasted to increase to 7,500 (a 42% increase) 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.

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 forecasted to increase to 10,200 (a 46% increase) 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.

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; it 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.

The annual number of ship crossings along the combination of the proposed NSP2 route with V1 and the combination of the NSP2 route with V2 within Danish waters have been estimated for each KP and are shown in Figure 7-63 and Figure 7-64, respectively.

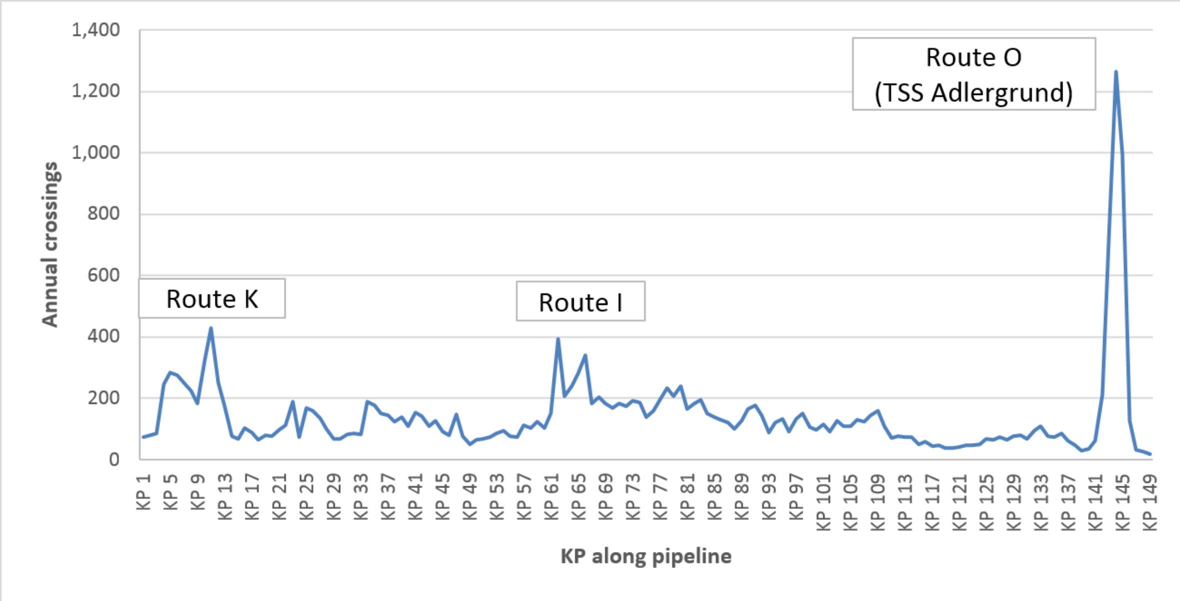


Figure 7-63 Annual crossings per KP-interval (e.g. 1 represents the interval between KP0 and KP1, see Figure 7-59) along the combination of the NSP2 route with V1 in Danish waters.

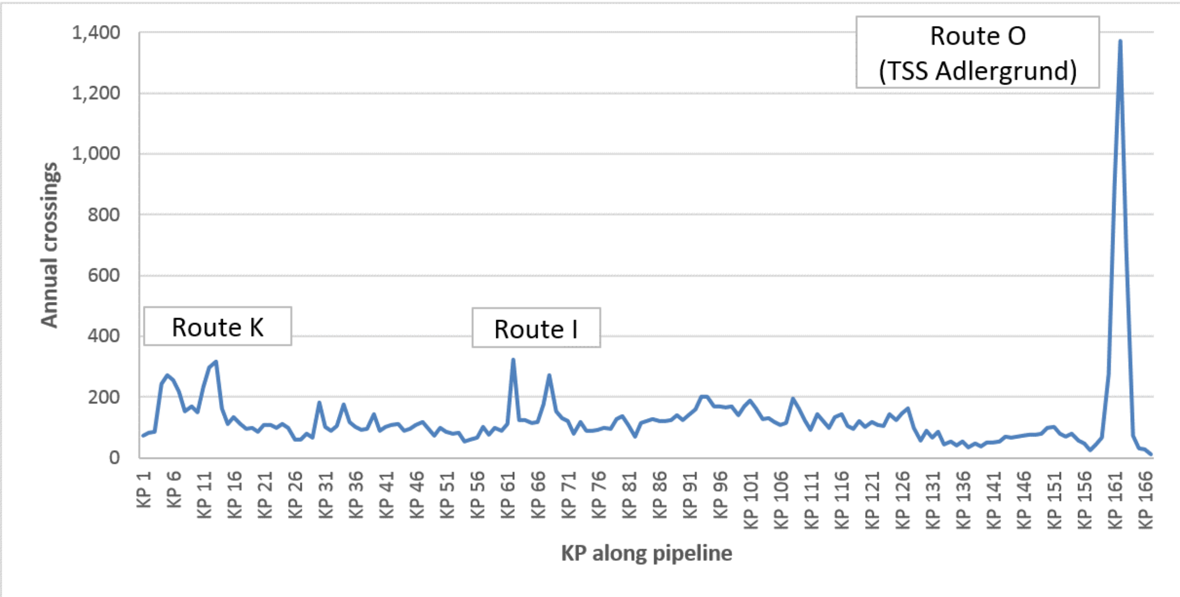


Figure 7-64 Annual crossings per KP-interval (e.g. 1 represents the interval between KP0 and KP1, see Figure 7-59) along the combination of the proposed NSP2 route with V2 in Danish waters.

The peak with the highest number of crossings (approximately 1,400) in Danish waters is associated with the westbound traffic at TSS Adlergrund before the proposed NSP2 route enters the German EEZ.

7.15.2 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 in the number of cargo ships 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.

The combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2 are considered similar with respect to the parameters discussed in this section, and the routes are therefore not discussed separately.

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 target 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). These fishing vessels can therefore cover large distances in a single haul. The Danish gill net fishery primarily targets cod and the most valuable flatfish species (plaice, turbot (*Psetta maxima),* 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 lines 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.

The 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 the 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, 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 (which measure approximately 30 x 30 nm, see Figure 7-65). 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 the 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 2010-2016 have been used to indicate the spatial distribution and density of 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[9]. By estimating the period of fishery activity according to vessel speed, VMS data can be used to indicate specific fishery distributions. However, because only large vessels (≥12 m vessels/≥15 m before 2012) are required to be equipped with VMS systems, it is possible that these data underestimate the distribution of smaller vessels. The proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are, however, located a considerable distance offshore, where vessels are generally >12 m in length and the predominant fishing gear is the trawl. Furthermore, because vessels using the same gear types generally utilise the same fishing areas, albeit the larger vessels often travel further, the distribution of the fishery exhibited by VMS data are considered to be representative of most of the fishery along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2.

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 2016. The data were obtained from the Danish AgriFish Agency. The catches and value for the other countries bordering the Baltic

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[9] Before 2012, VMS data included only vessels ≥15; after 2012 it included vessels ≥12 m.

Sea (with the exception of Russia where data could not be obtained) were derived from data obtained from the fishery authorities in each country.

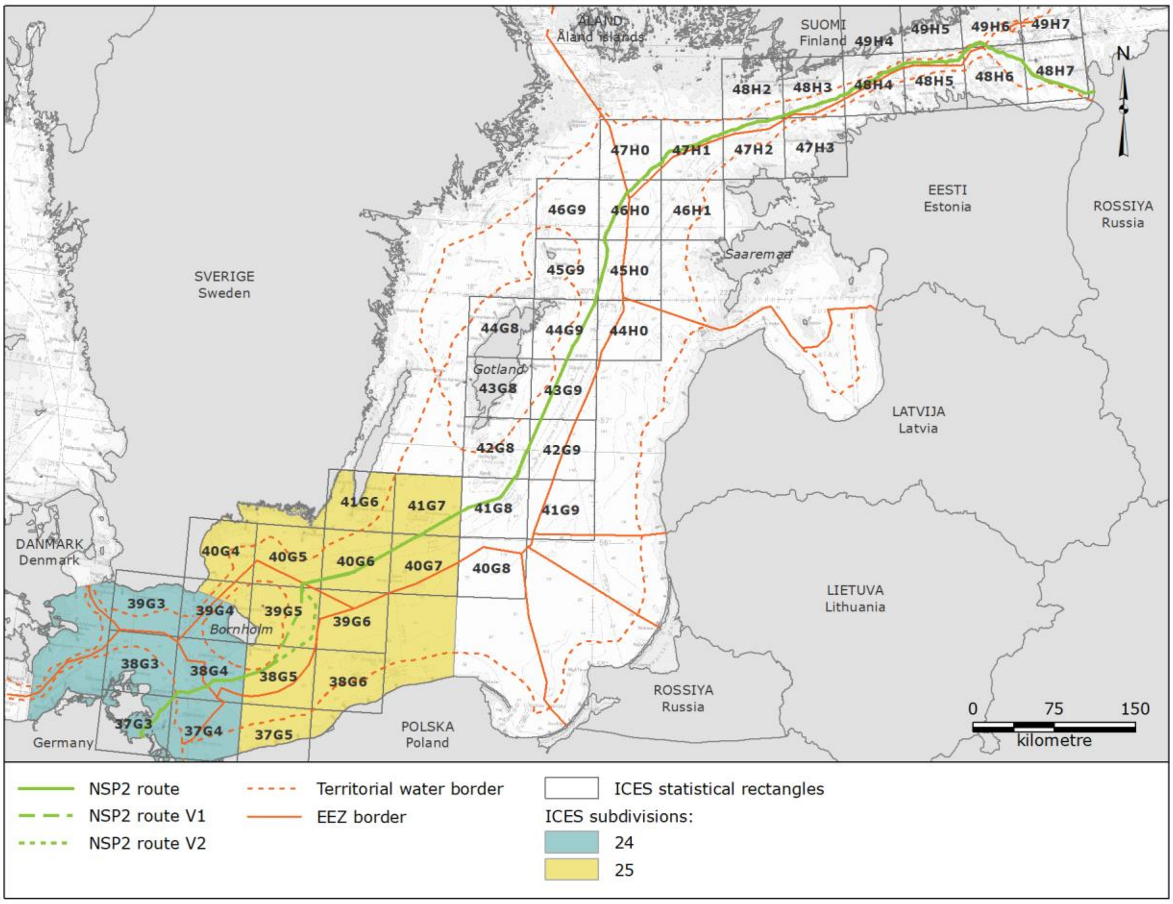

Figure 7-65 ICES rectangles and subdivisions along and adjacent to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2.

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 countries such as Germany, the state level.

Fishery for most fish stocks in the Baltic Sea is managed under the Common Fisheries Policy (CFP) of the European Commission, which includes input from the Regional Baltic Sea Fisheries Forum (BALTFISH) and the Baltic Sea Advisory Council, as well as Russian legislation. The main instruments of fishery management by the CFP are:

- Catch limits (Total Allowable Catch (TAC) allocated among countries, also referred to as "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 (see Figure 7-66). This restriction is primarily in place to conserve cod stocks by protecting aggregations of mature cod. Also, there is an area east of Bornholm in which bottom trawling is discouraged due to the fact that chemical munitions were dumped there following WWII (see section 7.18) (see Figure 7-66).

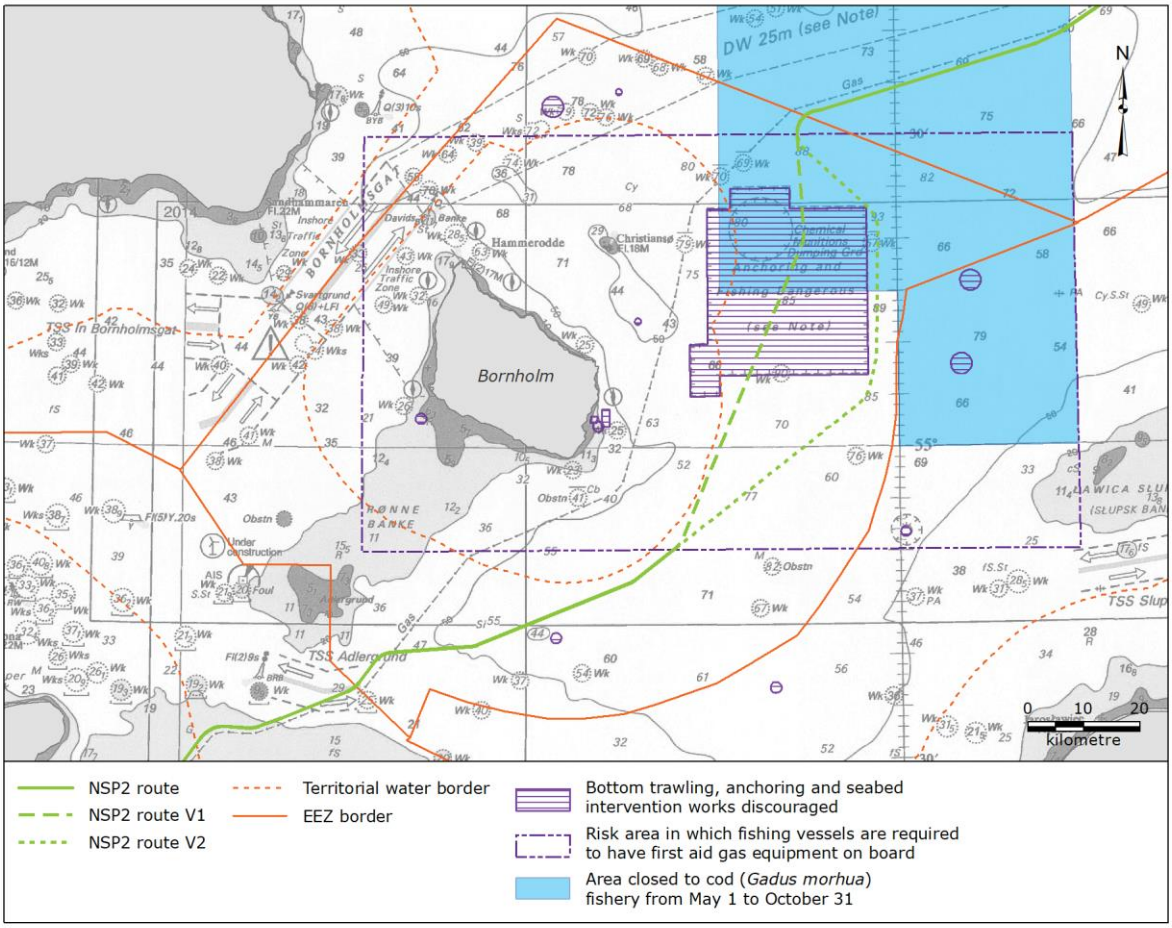

Figure 7-66 Area closed to fisheries from 1 May to 31 October and the area in which bottom trawling is discouraged.

Other general fishery restrictions regarding trawlers apply within Danish waters. In general, small trawlers (with motors of less than 175 horsepower) using trawls with mesh sizes less than 90 mm are allowed to fish within 3 nm from the coast (bordering at low tide levels) /280/.

There is a multilateral agreement between Denmark and Sweden that allows reciprocal access for fishing vessels to undertake their fisheries within each other's territorial waters (3-12 nm from the coastline) in the Baltic Sea /281/. Denmark and Germany have a similar agreement; however, unlike the agreement with Sweden, the agreement between Denmark and Germany only includes the commercial species cod, herring, sprat, eel, salmon, whiting, mackerel and all flatfish species /281/. Fishing vessels from Poland, Estonia, Latvia and Lithuania are only allowed to undertake fishery within the EEZ of Denmark /281/.

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 net, seine net and "other gear") that have fished (i.e. registered catches) in the ICES rectangles along the NSP2 route, the NSP2 route V1 and the NSP2 route V2 is presented in Table 7-41 (bottom trawl and pelagic trawl) and Table 7-42 (gill net, seine net, and other gear). ICES rectangles are shown in Figure 7-65.

Nationally, the total number of Danish fishing vessels has declined over the last 5-10 years. Within the Danish Baltic Sea fishing fleet, trawls are used more than any other gear type.

Data on the number of vessels fishing along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 indicate that Danish bottom trawlers operate almost exclusively in the southern part of the Baltic Sea. In the period 2010-2016, on average, 34-64 bottom trawlers have registered catches annually in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5) where the main part of the fishery takes place (Table 7-41 and Figure 7-65).

In contrast to bottom trawlers, vessels using pelagic trawls operate throughout much of the main Baltic Sea basin. Based on data from 2010 to 2016, an average of 3-12 pelagic trawlers have registered catches annually in the 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 at which they are based. According to data from 2010 to 2016, an average of 6-15 gill net vessels operated each year in the southern parts of the Baltic Sea, in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5). The most intensively fished area was the ICES rectangle (39G4) west of Bornholm, which is 28 km (at its closest point) from the NSP2 route V1.

There are only a few Danish seine vessels (3 to 6) that operate in the inner Baltic Sea. Based on data from 2010 to 2016, the majority of seine net fishing vessels have been operating in ICES rectangle 38G3, located west of the proposed NSP2 route, whereas 1-2 vessels have registered catches each year in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5).

Furthermore, based on data from 2010 to 2016, an average of 8-14 fishing vessels using hooks and lines, pound nets or various types of fish traps and other passive gear types have registered catches each year in the ICES rectangles around Bornholm (38G4, 38G5, 39G4 and 39G5). Vessels using these gear types fish along or near the coast and are often smaller in length than trawlers.

Table 7-41 Number of Danish commercial fishing vessels (≥8 m) according to gear (bottom trawl and pelagic trawl) that fished in the ICES rectangles along and adjacent to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in 2010-2016. 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 7-65. Source: Danish AgriFish Agency.

ICES rectangle	Bottom trawl							Pelagic trawl						
	2010	2011	2012	2013	2014	2015	2016	2010	2011	2012	2013	2014	2015	2016
48H3									1					
47H3												1		
47H2		1						4	5	1	2	5		2
47H1		1						2	8	1	4	5	1	3
47H0								2	9	2	5	4		3
46H1		1						2	6	2	2	1	2	
46H0								5	13	5	6	3	4	3
46G9								8	5	7	6	6	4	4
45H0								7	6	5	3	4	4	3
45G9								10	7	5	5	4	4	4
44H0								4	1	1	1	2	3	2
44G9							1	5	8	4	3	6	3	3
44G8											1			
43G9		1					1	10	9	5	2	3	2	1
43G8									2	1	1			2
42G9	1							10	3	5		1	4	3
42G8	1	1				1		7	7	4	3	4	4	
41G9							1	17	8	4	2	3	3	2
41G8	1							13	6	2	4	6	2	1
41G7	1	1						2	1					
40G8	6	4	8	7	4	6	8	15	4	2	4	5	4	1
40G7	4	5	5	4	4	3	5	1						
40G6	2	11	6	3	6	5	6		1					2
40G5	**3**	**6**	**7**	**4**	**11**	**11**	**9**	**1**	**2**			**2**		**1**
40G4	**5**	**4**	**2**	**4**	**2**	**7**	**2**	**4**	**5**	**3**	**2**	**2**	**2**	**3**
39G6	**11**	**18**	**20**	**14**	**20**	**16**	**15**	**1**	**1**			**1**		
39G5	**77**	**58**	**65**	**53**	**48**	**44**	**38**	**13**	**9**	**11**	**11**	**19**	**2**	**10**
39G4	**59**	**48**	**60**	**53**	**50**	**33**	**38**	**5**	**12**	**7**	**7**	**7**	**3**	**9**
39G3	**31**	**36**	**44**	**20**	**22**	**18**	**27**	**2**	**6**	**5**	**10**	**6**	**6**	**5**
38G6		**11**	**7**	**9**	**4**	**6**	**7**							
38G5	**61**	**58**	**66**	**53**	**44**	**47**	**37**	**11**	**7**	**6**	**7**	**14**	**3**	**6**
38G4	**57**	**40**	**47**	**43**	**41**	**27**	**24**	**2**	**1**	**4**	**7**	**9**	**5**	**6**
38G3	29	36	49	23	19	16	20			10	11	9	7	7
37G5				1		3								
37G4					1				2					
Total	349	341	386	291	276	243	239	163	155	102	109	132	72	86

Table 7-42 Number of Danish commercial fishing vessels (≥8 m) according to gear (gill net, seine net, other gear) that fished in the ICES rectangles along and adjacent to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in 2010-2016. 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 7-65. Source: Danish AgriFish Agency.

ICES rec-tangle	Gill net							Seine net							Other gear						
	2010	2011	2012	2013	2014	2015	2016	2010	2011	2012	2013	2014	2015	2016	2010	2011	2012	2013	2014	2015	2016
48H3																					
47H3																					
47H2																					
47H1																					
47H0																					
46H1																					
46H0																					
46G9																					
45H0																					
45G9																					
44H0																					
44G9																					
44G8																					
43G9																					
43G8																					
42G9																					
42G8										1											
41G9																					
41G8										1											
41G7																					
40G8			1							1										1	1
40G7			1																		
40G6			1						1	1											1
40G5																					**1**
40G4										**1**										**1**	**2**
39G6									**1**	**1**					**1**	**1**			**1**		**1**
39G5	**22**	**13**	**14**	**7**	**7**	**7**	**8**	**1**	**1**	**2**					**20**	**14**	**14**	**10**	**12**	**6**	**8**
39G4	**23**	**15**	**18**	**18**	**16**	**13**	**13**								**15**	**16**	**16**	**17**	**15**	**14**	**10**
39G3	**3**	**1**													**2**		**1**		**1**	**2**	**1**
38G6		**1**		**1**											**2**	**1**		**1**			**1**
38G5	**9**	**8**	**6**	**6**	**7**	**3**	**3**	**1**	**1**						**13**	**10**	**7**	**8**	**8**	**7**	**7**
38G4	**7**	**5**	**4**	**7**	**6**	**2**	**3**	**1**		**2**	**1**				**9**	**8**	**8**	**7**	**9**	**6**	**6**
38G3	2					1	4	6	3	5	4	3	4	2						2	1
37G5																				1	
37G4																					
Total	66	43	45	39	36	26	31	9	7	15	5	3	4	2	62	50	46	43	46	40	40

7.16.4 Harbours

To operate commercially, all Danish fishing vessels are required to register their vessel information with the DMA and the Danish AgriFish Agency. In addition to other data, this registration includes the owner(s) of the vessel, primary gear types, vessel length and home harbour.

In the seven-year period between 2010 and 2016, fishing vessels from over 51 different Danish harbours have fished in one or more of the ICES rectangles along the proposed NSP2 route, the

NSP2 route V1 and the NSP2 route V2. The home harbours of the vessels that have landed the largest catches by species, weight and value are shown in Table 7-43.

Fishing vessels from the distant harbours of Skagen, Grenå, Hanstholm, Hirtshals and Gilleleje caught between 3.4% and 25.7% (1,006-9,005 t) of the total annual catches by weight along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2, between 2010 and 2016. With the exception of vessels from Hirtshals harbour, the vast majority of the catches from vessels of distant harbours are comprised of herring and sprat (industrial fish) from pelagic trawlers. Because the value of these species is considerably lower than that of the species caught for human consumption (cod and flatfish species, etc.), the total value of the catches of vessels from distant harbours only comprises 2.4-11.6% (€0.5-2.4 mio.) of the total annual value of catches along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2, in the period 2010-2016.

Of the harbours on Bornholm, fishing vessels from Nexø harbour caught the majority of commercial fish (17.6% of the total annual catch in weight) in the ICES rectangles along the entire proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. The second and third most important Bornholm harbours were Tejn and Hasle, averaging 3.4% (1,198 t) and 2.93% (1,006 t) of the annual catches from 2010-2016, 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. Vessels from Nexø caught 31.8% of the total annual value caught by Danish fishermen in the ICES rectangles along the entire proposed NSP2 route, including the NSP2 route V1 and the NSP2 route V2 (corresponding to €6.5 mio.).

Table 7-43 Primary base harbours and mean annual catch (t and value in x€1000) of species in 2010-2016 by Danish vessels in the ICES rectangles along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in the Baltic Sea. "Other" harbours include 42 nearby and distant harbours. Harbours on Bornholm are shown in bold. Source: Danish AgriFish Agency.

Mean annual catch (t) according to base harbours (2010-2016)										
Species	Skagen	**Nexø**	Grenå	Hans-tholm	Thy-borøn	Hirt-shals	**Tejn**	Gil-leleje	**Hasle**	Other
Cod	0	4,855	58	834	105	295	784	113	192	3,038
Sprat	8,387	973	4,787	1,713	1,696	274	3	22	338	1,578
Herring	617	25	216	24	0	0	269	1,065	416	386
Flounder	0	130	0	33	10	568	52	4	12	207
Plaice	0	37	0	14	3	36	76	1	24	177
Whiting	1	31	0	34	5	6	6	2	0	50
Salmon	0	15	0	0	1	0	6	0	23	47
Saithe	0	3	0	6	0	0	0	0	0	2
Turbot	0	1	0	0	0	0	1	0	0	3
Other	0	87	0	1	1	0	0	1	1	201
Total	9,005	6,158	5,062	2,659	1,821	1,180	1,198	1,207	1,006	5,690
% of total	25.7	17.6	14.5	7.6	5.2	3.4	3.4	3.4	2.9	16.3

Mean annual value (x €1000) of catches according to base harbours (2010-2016)										
Species	Skagen	**Nexø**	Grenå	Hans-tholm	Thy-borøn	Hirt-shals	**Tejn**	Gil-leleje	**Hasle**	Other
Cod	0	6,015	70	1,054	128	359	970	141	236	3,759
Sprat	2,101	223	1,216	394	349	71	1	5	75	370
Herring	253	11	79	9	0	0	123	444	179	172
Flounder	0	66	0	17	5	284	27	2	6	107
Plaice	0	37	0	14	3	35	77	1	25	179
Whiting	1	33	0	38	5	5	7	1	0	47
Salmon	0	70	0	0	6	0	27	0	103	216
Saithe	0	3	0	9	0	0	0	0	0	3
Turbot	0	4	0	1	0	1	5	0	1	18
Other	0	21	0	2	1	1	1	1	1	58
Total	2,355	6,483	1,366	1,537	497	755	1,238	595	627	4,928
% of total	11.6	31.8	6.7	7.5	2.4	3.7	6.1	2.9	3.1	24.2

7.16.5 Number of fishing vessels from Bornholm

From 2010 to 2016, the number of registered fishing vessels associated with Bornholm harbours, including Christiansø and all very small harbours, decreased from 121 to 88 vessels (Table 7-44). Of the 17 harbours throughout Bornholm, 16 harbours had registered fishing vessels in 2016. The harbour of Nexø on the eastern side of Bornholm had the largest number of fishing vessels (30 vessels in 2016), which were dominated by trawlers and vessels using gill nets as well as vessels switching 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 8 and 14 fishing vessels, primarily using trawls and gill nets together with secondary gear (i.e. hooks and lines) (Table 7-44).

Table 7-44 Number of fishing vessels according to gear, from Bornholm harbours in the period 2010-2016. (Source: Danish AgriFish Agency vessel registrations.)

Harbour	Gear	2010	2011	2012	2013	2014	2015	2016
Nexø	**Total**	**34**	**33**	**36**	**37**	**37**	**3.4**	**30**
	Trawler	18	17	18	19	18	17	14
	Gill nets / trawler	3	4	4	3	4	4	4
	Gill nets	5	5	6	7	7	6	6
	Gill nets / hook and lines	7	6	6	6	6	5	4
	Small boat - undetermined	1	1	2	2	2	2	2
Tejn	**Total**	**17**	**17**	**18**	**15**	**11**	**9**	**8**
	Trawler	3	3	2	2	2	2	2
	Gill nets	3	3	4	3	2	2	2
	Gill nets / hook and lines	9	9	9	7	5	3	2
	Seine nets	1	1	1	1	1	1	1
	Small boat - undetermined	1	1	2	2	1	1	1
Hasle	**Total**	**14**	**12**	**12**	**12**	**12**	**12**	**9**
	Trawler	1	1	1	1	1	1	1
	Gill nets / trawler	1	1	0	0	0	0	0
	Gill nets	2	2	3	3	3	3	3
	Gill nets / hook and lines	6	6	6	6	6	6	3
	Small boat - undetermined	4	2	2	2	2	2	2
Rønne	**Total**	**15**	**15**	**15**	**14**	**13**	**14**	**14**
	Trawler	3	3	3	3	3	3	3
	Gill nets / trawler	1	1	1	1	1	1	1
	Gill nets	1	1	1	1	1	1	2
	Gill nets / hook and lines	5	5	5	4	4	5	5
	Small boat - undetermined	5	5	5	5	4	4	3
Årsdale	**Total**	**8**	**8**	**8**	**6**	**6**	**7**	**7**
	Gill nets / trawler	2	2	3	2	2	2	2
	Gill nets	4	4	3	2	2	2	2
	Gill nets / hook and lines	1	1	1	1	1	2	2
	Hook and lines	1	1	1	1	1	1	1
Sømarken	**Total**	**5**	**4**	**4**	**4**	**4**	**3**	**3**
	Gill nets / trawler	1	1	1	1	1	1	1
	Gill nets	1	1	1	1	1	1	1
	Gill nets / hook and lines	2	2	2	2	2	1	1
	Small boat - undetermined	1	0	0	0	0	0	0
Listed	**Total**	**6**	**6**	**6**	**5**	**4**	**4**	**3**
	Trawler	1	1	1	1	1	1	0
	Gill nets / trawler	1	1	1	1	1	1	1
	Gill nets	1	1	1	1	0	0	0
	Gill nets / hook and lines	1	1	1	0	0	0	0
	Small boat - undetermined	2	2	2	2	2	2	2
Christiansø	**Total**	**5**	**5**	**3**	**4**	**4**	**4**	**4**
	Trawler	1	1	1	1	1	1	1
	Gill nets / trawler	0	0	0	1	1	1	1
	Gill nets / hook and lines	4	4	2	2	2	2	2
Snogebæk	**Total**	**5**	**5**	**4**	**3**	**2**	**2**	**2**
	Gill nets	1	1	0	0	0	0	0
	Gill nets / hook and lines	2	2	2	2	2	2	2
	Small boat - undetermined	2	2	2	1	0	0	0
Gudhjem	**Total**	**2**	**2**	**2**	**2**	**1**	**2**	**1**
	Gill nets	1	1	1	1	0	0	0
	Gill nets / hook and lines	1	1	1	1	1	1	0

Harbour	Gear	2010	2011	2012	2013	2014	2015	2016
	Hook and lines	1	1	1	1	1	1	1
Allinge	**Total**	**1**	**0**	**0**	**0**	**0**	**0**	**1**
	Trawler	1	0	0	0	0	0	0
	Gill nets / hook and lines	0	0	0	0	0	0	1
Bølshavn	**Total**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	Small boat - undetermined	1	1	1	1	1	1	1
Svaneke	**Total**	**2**	**2**	**1**	**1**	**1**	**1**	**1**
	Gill nets / trawler	1	1	1	1	1	1	1
	Gill nets	1	1	0	0	0	0	0
Pedersker	**Total**	**1**	**1**	**0**	**1**	**1**	**1**	**1**
	Gill nets / hook and lines	0	0	0	0	0	1	1
	Small boat - undetermined	1	1	0	0	0	0	0
Arnager	**Total**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
	Gill nets	1	1	1	1	0	0	0
	Gill nets / hook and lines	1	1	1	1	1	1	1
	Small boat – undetermined	0	0	0	0	1	1	1
Hammerhavn	**Total**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
	Gill nets / hook and lines	1	1	0	0	0	0	0
Melsted	**Total**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	Gill nets / hook and lines	1	1	1	1	1	1	1
Total		**121**	**116**	**114**	**109**	**101**	**97**	**88**

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 96.9% of the catches by weight and 93.3% of the value of catches between 2010 and 2016 (see Figure 7-67).

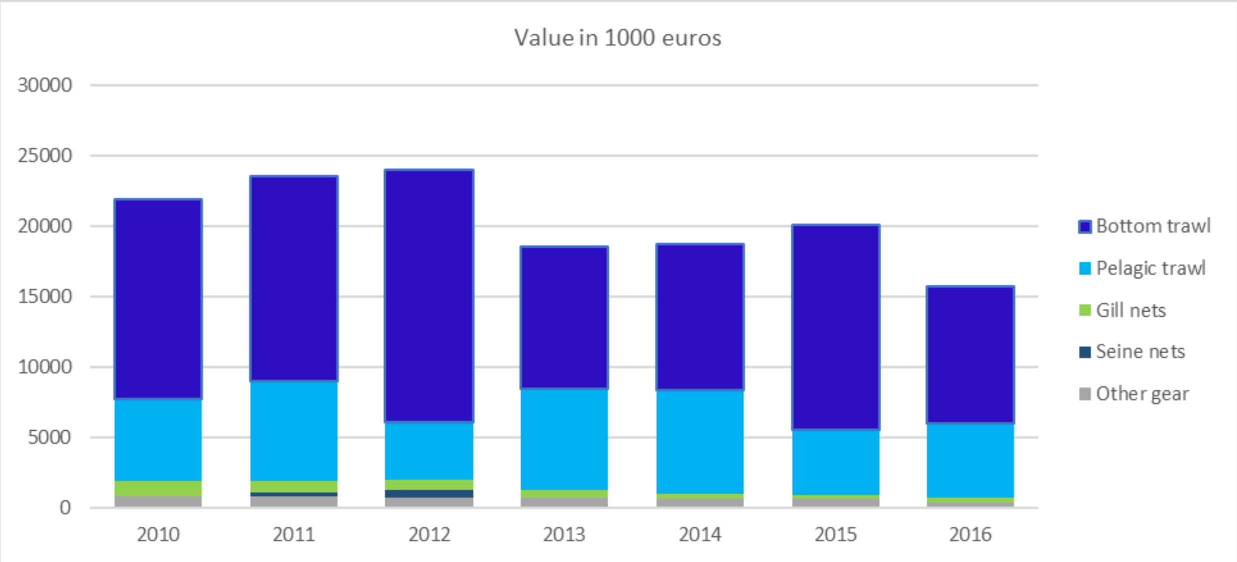

Figure 7-67 Mean annual value of Danish catches (x€1,000) in the ICES rectangles along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in 2010-2016 according to gear (ICES rectangles are shown in Figure 7-65). Source: Danish AgriFish Agency.

Pelagic trawls accounted for an average of 29% of the catch value (€4.1-7.4 mio.) (see Figure 7-67) and almost exclusively targeted large quantities of lower value industry fish (i.e., sprat and herring) (Table 7-45). In contrast, bottom trawls accounted for 64% of the catch value (€9.7-18 mio.). Bottom trawls typically targeted cod and had bycatch of a wide variety of valuable species such as flounder and plaice (Table 7-45).

Gill nets accounted for approximately 3% of the total catch value (€294,000-1 mio.) in the Danish fishery between 2010 and 2016 within the ICES rectangles along the entire proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 (Figure 7-67). Gill nets primarily targeted cod, plaice and flounder (Table 7-45).

Catches by seine nets fluctuated considerably between 2010 and 2016, but accounted for less than 1% of the value of the catches (€8,000-498,000). Seine nets primarily targeted cod, sprat and flatfish (Table 7-45).

Other gear such as hooks and lines, which targeted cod and salmon (Table 7-45) around the coast of Bornholm, and various fish traps such as pound nets, etc., together accounted for approximately 3% of the catch value (€360,000-769,000) (Figure 7-67).

Table 7-45 Mean annual value of Danish catches (x€1,000) of commercial species according to gear type in the ICES rectangles along and adjacent to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in 2010-2016. Source: Danish AgriFish Agency.

Mean annual value of Danish catches (x €1,000) (2010-2016)					
Species	Bottom trawl	Pelagic trawl	Gill net	Seine net	Other gear
Cod	11,917	42	480	78	215
Sprat	78	4,675	0	51	0
Herring	136	1,134	0	1	0
Flounder	482	1	29	0	0
Plaice	287	1	79	3	0
Dab	2	0	0	0	0
Turbot	22	0	9	0	0
Sole	2	0	1	0	0
Whiting	128	8	1	0	0
Salmon	1	0	0	0	422
Pollock	16	0	0	0	0
Other species	23	54	2	0	1
Total	13,094	5,916	599	133	639

7.16.7 Catches and target species in the Danish fishery

From 2010 to 2016, the mean annual catch and value of catches by Danish vessels in the ICES rectangles along the entire proposed NSP2 route (plus both the NSP2 route V1 and the NSP2 route V2) was approximately 35,000 t at a value of €20.4 mio. (Table 7-45). Sprat and herring comprised the majority of the catches along the northern section of the entire proposed NSP2 route, whereas cod, several flatfish species (flounder, brill, turbot and plaice) as well as sprat and herring comprised the catches along the southern section of the entire proposed NSP2 route. Overall, cod comprised 62.5% of the mean landing value (€12.7 mio.), while landings of sprat and herring comprised approximately 29.8% of the mean landing value (€6.1 mio.). The mean value of flounder, plaice and other species (e.g. salmon, turbot, brill, eel, garfish, etc.) amounted to 7.7% (€1.58 mio.) of the total value of the landings (Table 7-45). The spatial distributions of the catches by weight and value in the various ICES rectangles are shown in Figure 7-68 and Figure 7-69, respectively.

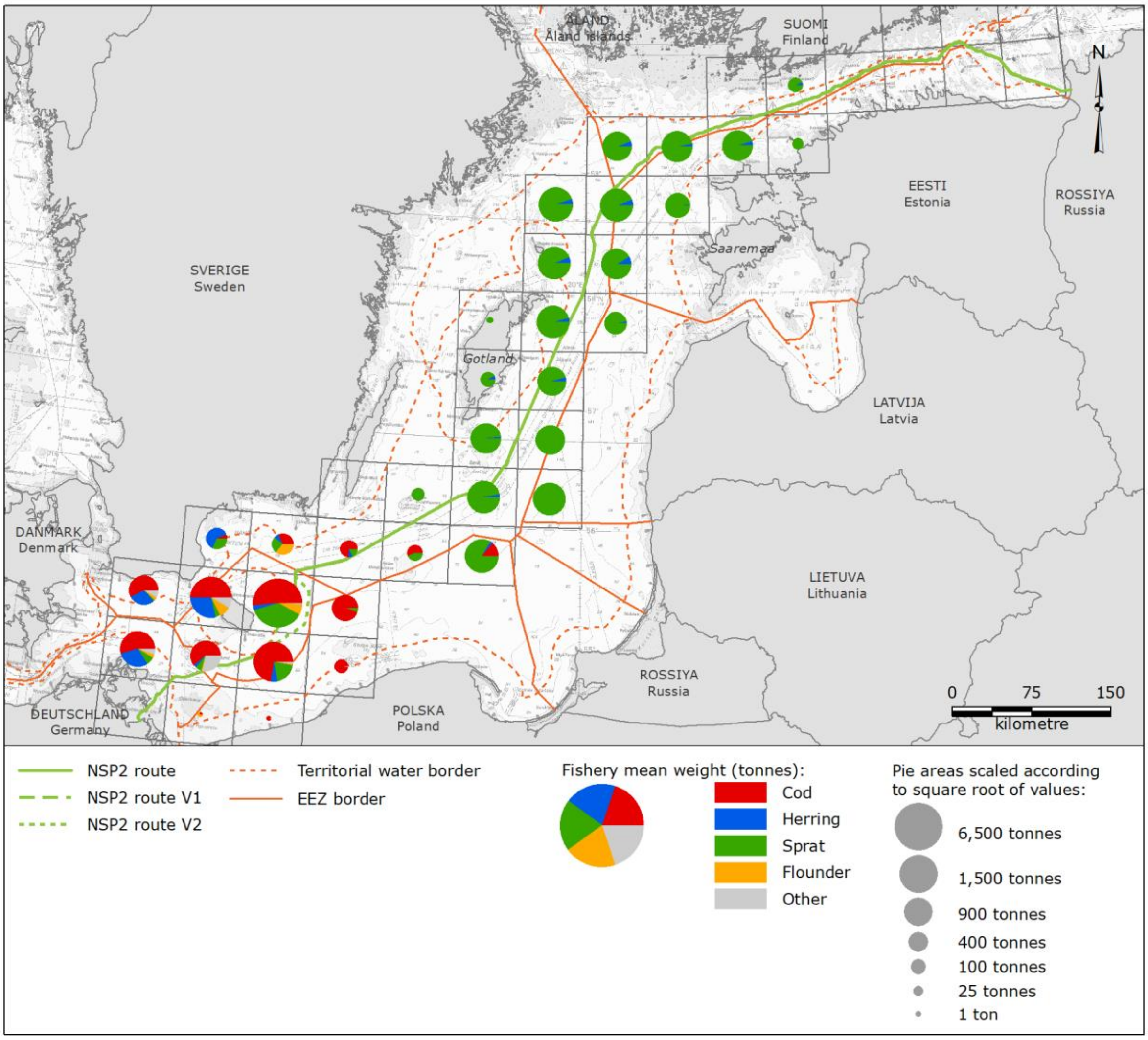

Figure 7-68 Mean annual catches by weight (t) of the most important commercial species caught by Danish vessels in the ICES rectangles along and adjacent to the NSP2 route, the NSP2 route V1 and the NSP2 route V2 in 2010-2016.

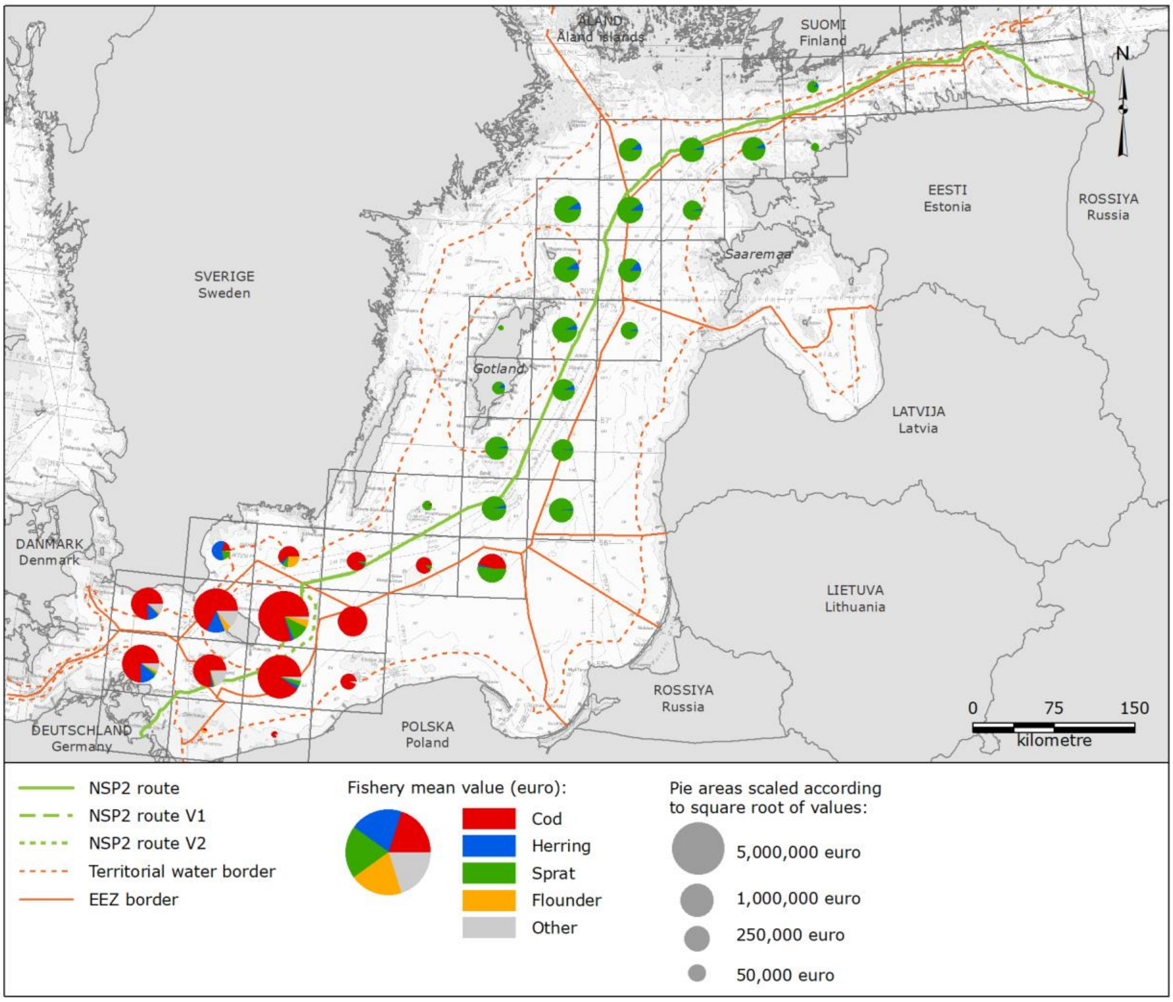

Figure 7-69 Mean annual catches by value (euro) of the most important commercial species caught by Danish vessels in the ICES rectangles along and adjacent to the NSP2 route, the NSP2 route V1 and the NSP2 route V2 in 2010-2016.

7.16.8 Distribution of Danish bottom and pelagic trawling

The overall spatial and seasonal distributions of bottom trawling activities in Danish waters by Danish fishermen are shown in Figure 7-70 and Figure 7-71, respectively. The density plots only include fishery vessels with a recorded speed of 0-5 knots. This is the speed interval at which bottom trawling is likely to be undertaken, based on speed frequency diagrams derived from VMS data points and knowledge of when vessels normally undertake fishery.

Overall, the bottom trawl fishery is particularly intense in two discrete areas on the western and northern sides of Bornholm, respectively, and in a larger area that extends from south of Bornholm all the way around to the north-east of Bornholm (Figure 7-70). The proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 cross the larger fishing area located south and east of Bornholm.

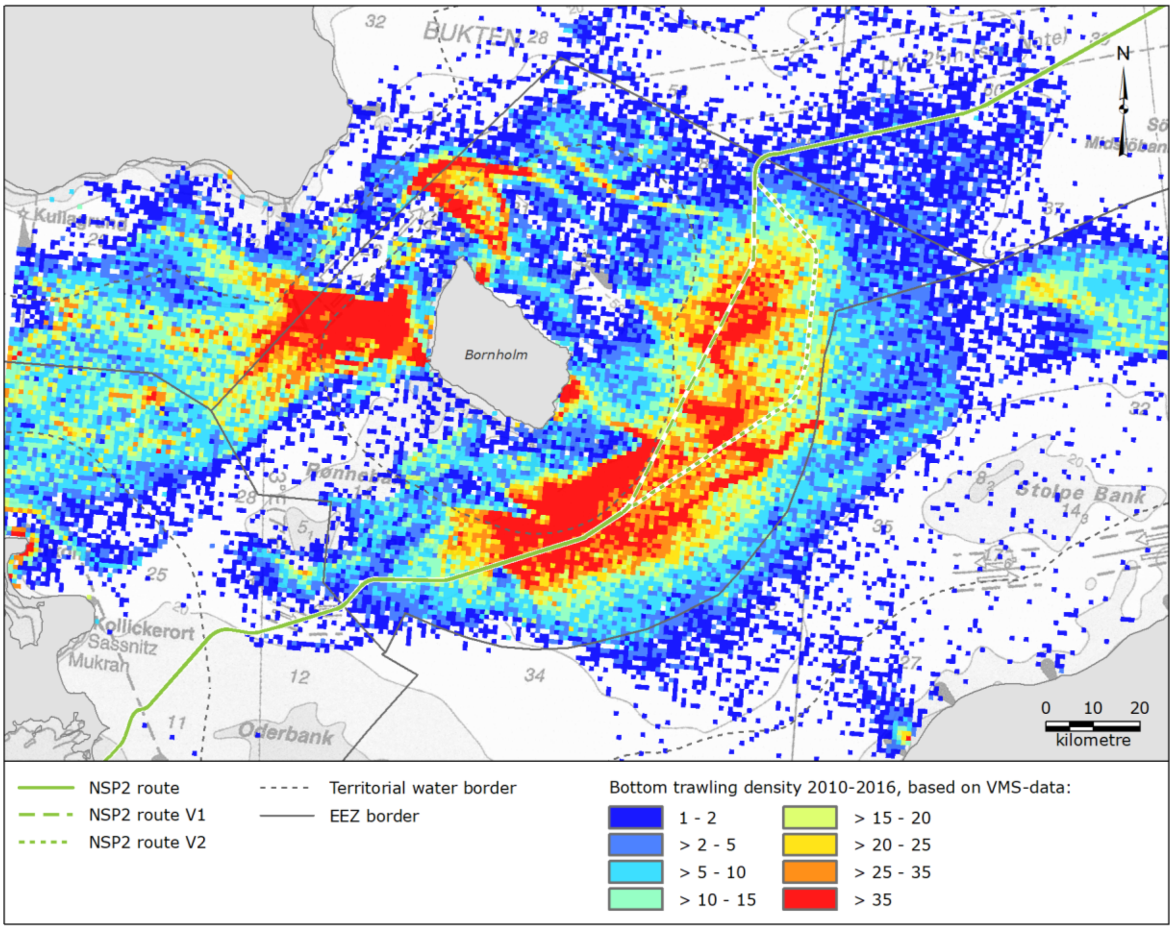

Figure 7-70 The overall distribution of fishery by bottom trawling in the waters around Bornholm, 2010-2016, derived from VMS data points per km^2. Source: Danish AgriFish Agency.

Maps showing the seasonal distribution of the Danish bottom trawl fisheries around Bornholm indicate that this fishery is undertaken throughout the year (see Figure 7-71). As the year progresses, however, fishing intensity generally decreases. This is also the case in the primary fishing area located within the corridor of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2, south and east of Bornholm.

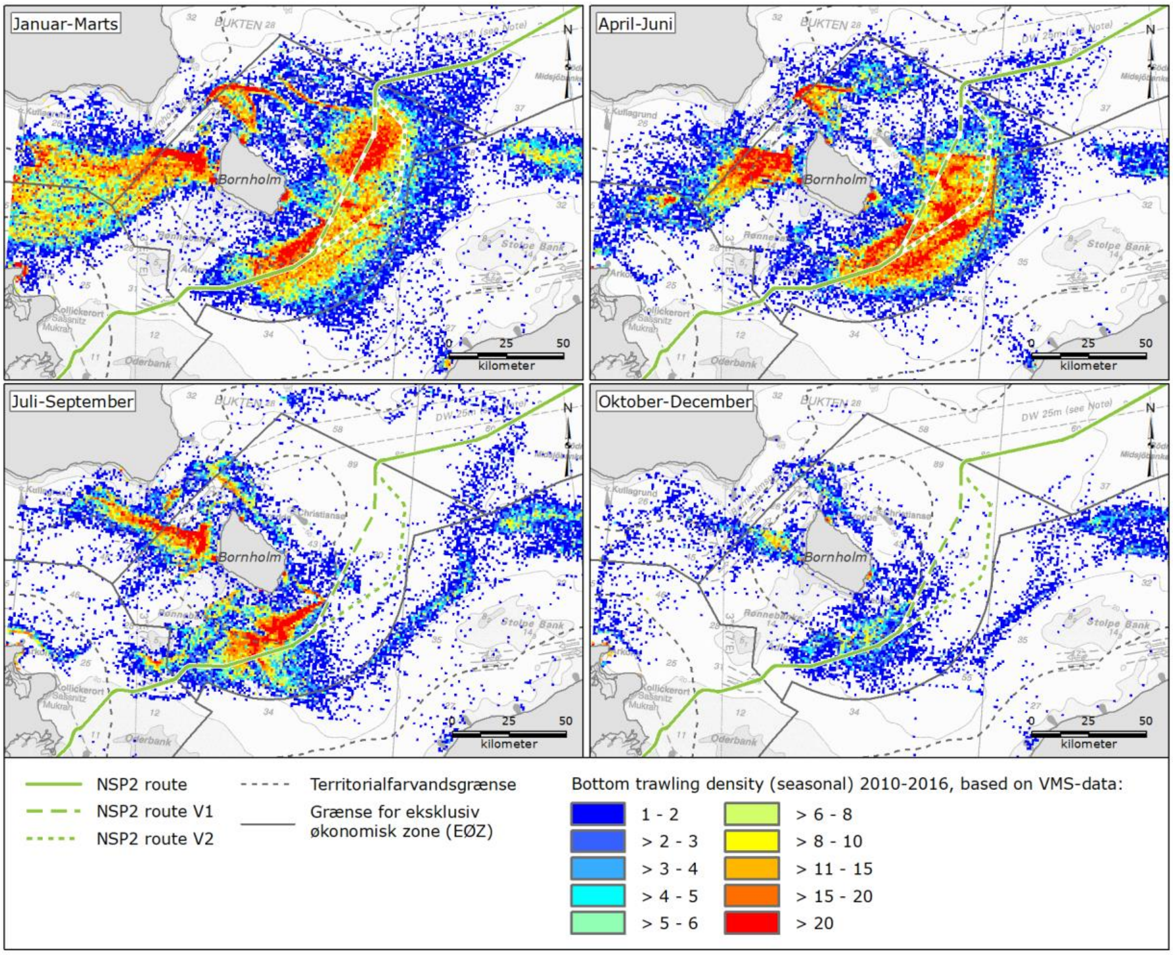

Figure 7-71 Seasonal distribution of fishery by bottom trawling in the waters around Bornholm, 2010-2016, derived from VMS data points per km². Top left: January-March; top right: April-June; bottom left: July-September; bottom right: October-December. Source: Danish AgriFish Agency.

The Danish pelagic trawl fishery generally extends from north to south along the entire eastern side of Bornholm and in an area south-west of Bornholm (Figure 7-72). None of the areas of particularly concentrated pelagic trawl fishery are within the corridor of the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2.

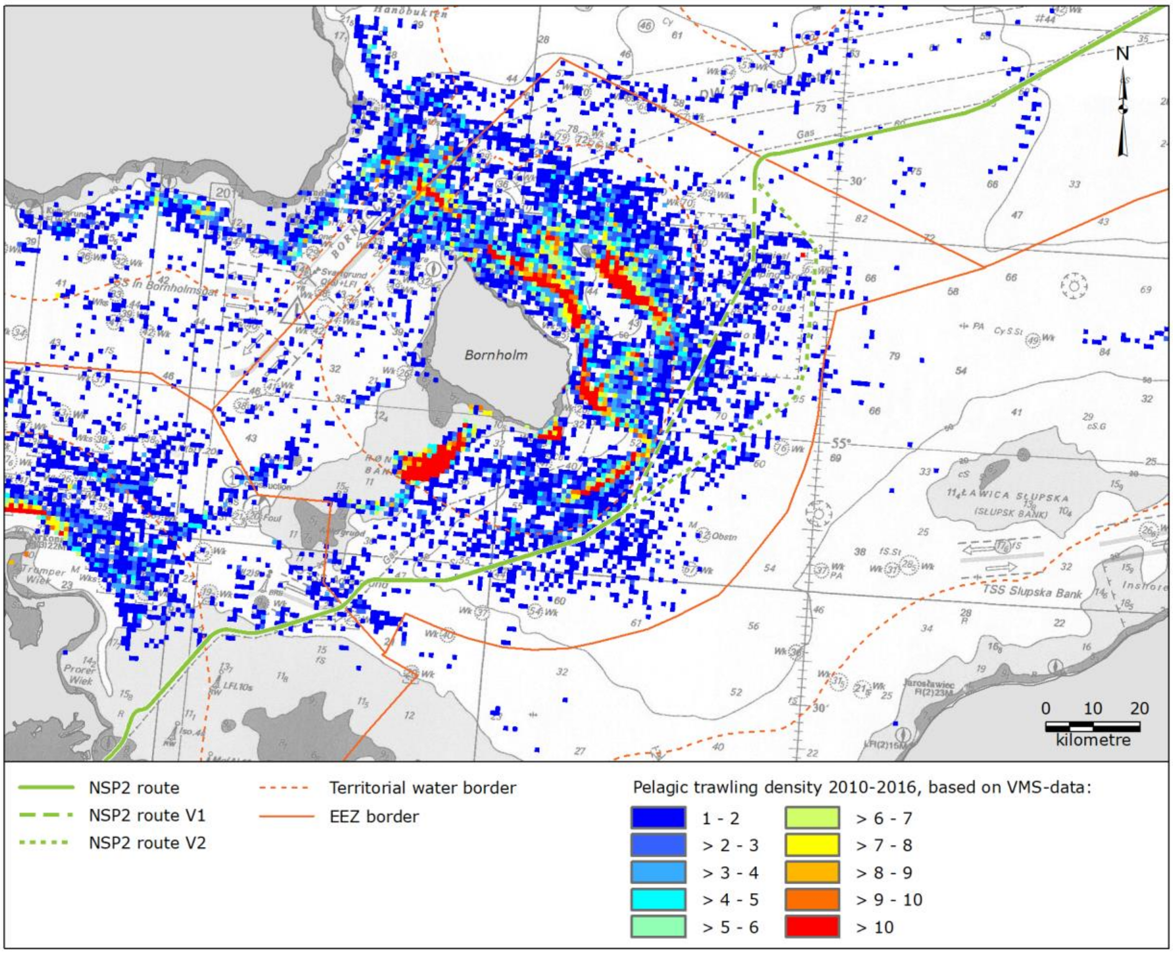

Figure 7-72 The overall distribution of fishery by pelagic trawling in the waters around Bornholm derived from VMS data points per km² from 2010-2016. Source: Danish AgriFish Agency.

Seasonally, the pelagic trawl fishery is predominantly undertaken to the east and south of Bornholm in the first quarter of the year (January-March), where after fishing effort increases north of Bornholm and in an area to the south-west of Bornholm in the second quarter (April-June) (see Figure 7-73). Thereafter, the pelagic fishery around Bornholm decreases as the year progresses and is rather diffuse and sporadic along the eastern coast of Bornholm in the fourth quarter (October-December) (see Figure 7-73).

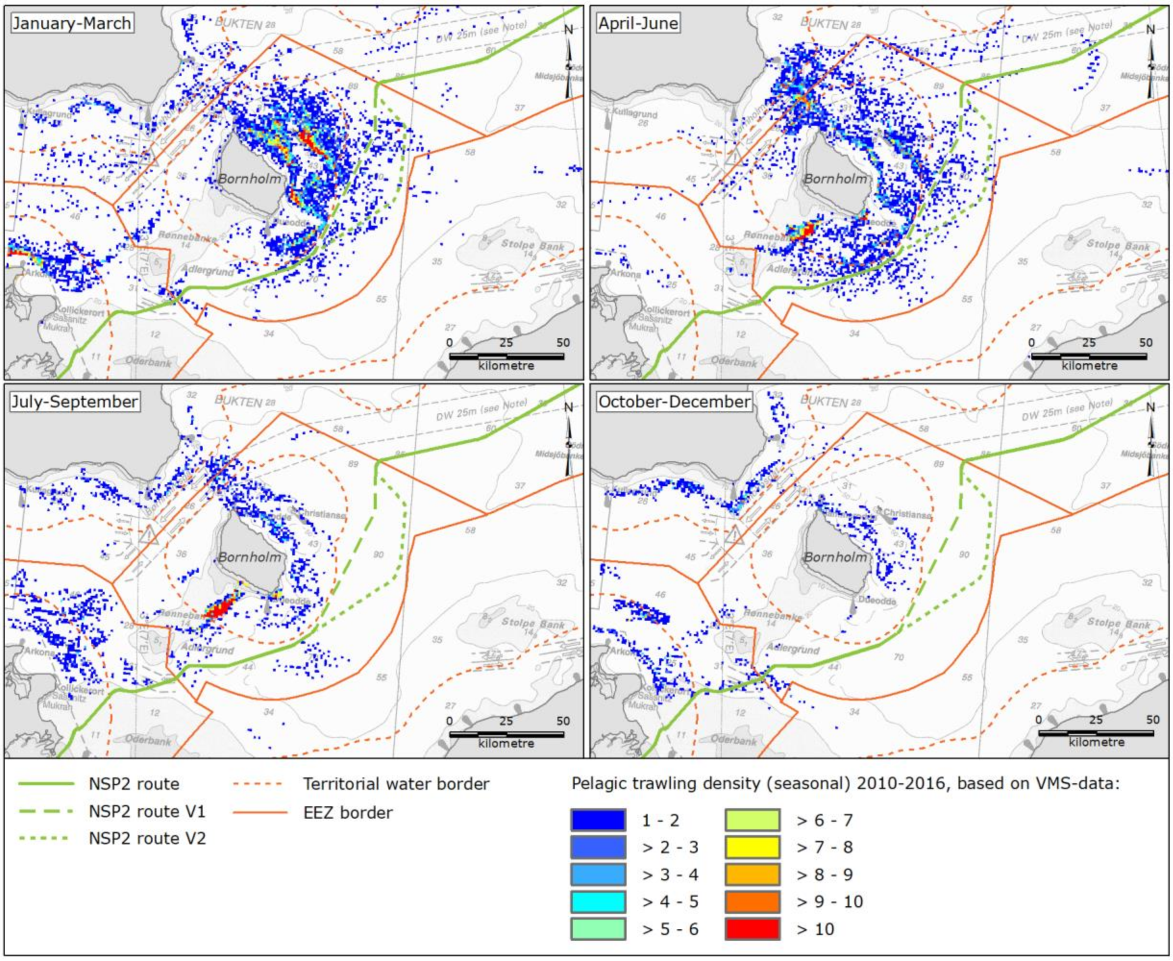

Figure 7-73 The seasonal distribution of fishery by pelagic trawling in the waters around Bornholm derived from VMS data points per km² from 2010-2016. Source: Danish AgriFish Agency.

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 t and €107 mio., respectively (Table 7-46). The Danish mean annual catch and value of the fishery was approximately 13.5% (37,578 t) of the total catch by weight and 20% (€21.3 mio.) 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 7-46).

Table 7-46 Mean annual catch (t) and value of the catch (x€1,000) by countries fishing along the entire planned NSP2 route in 2010-2014. Data sourced from logbooks that include vessels ≥8 m and from the ICES rectangles that follow or are adjacent to the NSP2 pipeline transect. Source: Derived from data obtained from the respective fishery authorities and fishery institutes for each country.

Country	Mean catch (t)	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 7-74.

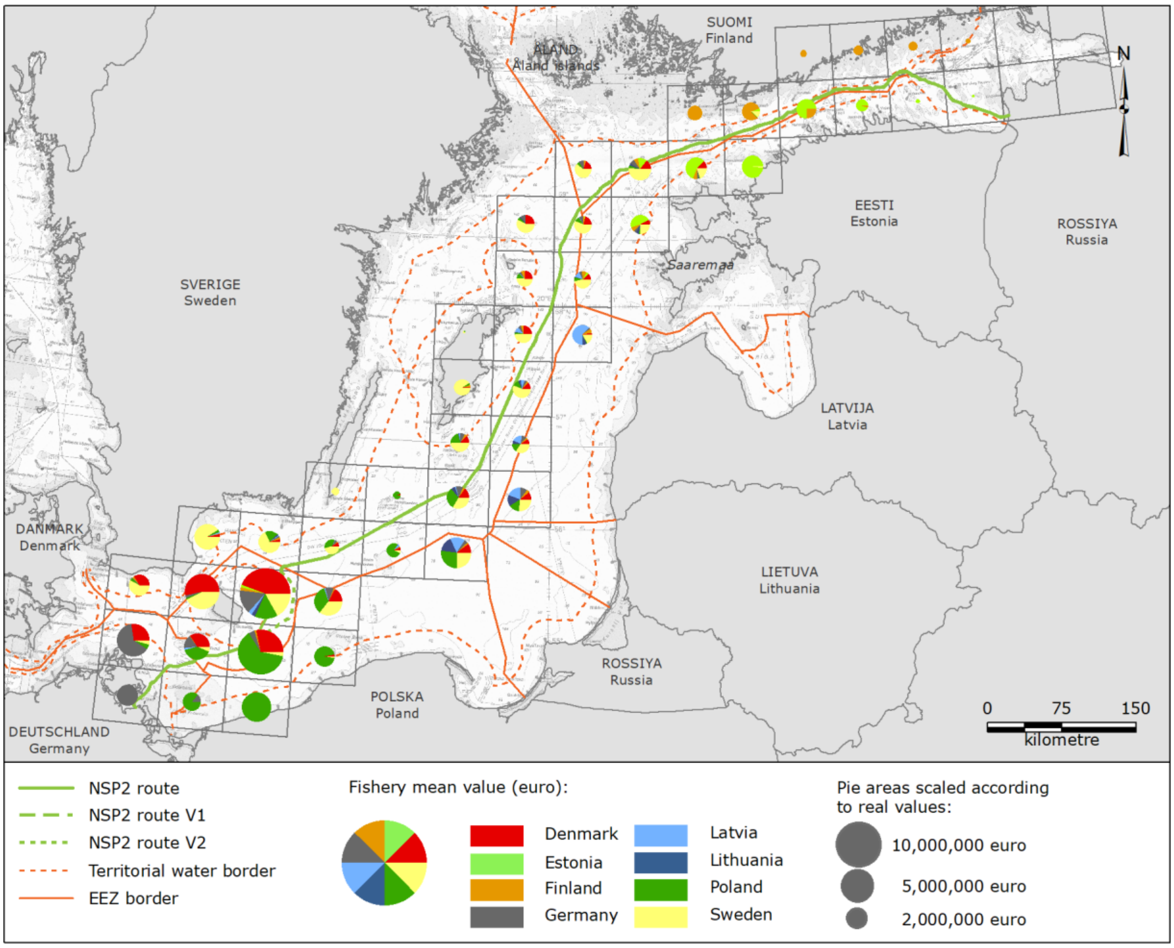

Figure 7-74 Ratio of the mean distribution of catches by value of fishery by eight countries in the ICES rectangles that follow or are adjacent the NSP2 pipeline transect. Source: Derived from data obtained from fishery authorities in each country, 2010-2014.

7.16.10 Aquaculture in Danish waters

The Danish strategy for sustainable development of the aquaculture sector in Denmark calls for the establishment of future aquaculture facilities in offshore areas /282/. However, there are currently no existing or planned aquaculture facilities in the project areas that could potentially be affected by seabed intervention works.

7.17 Cultural heritage

The maritime cultural heritage objects (CHOs) in the Baltic Sea primarily consist 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 Consolidation Act 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 presently 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 to successfully predict the 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 /283/ and, as such, demonstrated a clear preference for building settlements in specific areas that were favourable to fishing /284/.

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 /285/. 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 /286/. According to researchers at the Bornholm Museum, submerged settlements and ancient submerged forests may be encountered in waters shallower than approximately 40 m in the nearshore area around Bornholm. Figure 7-75 shows the areas that 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 primarily found along the south coast of Bornholm (see Figure 7-75).

It is highly unlikely that submerged Stone Age settlements would be found in the vicinity of the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2 in Danish waters, since these route alternatives cross areas that were inundated at all times of historical 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. The locations of registered shipwrecks in Danish waters are shown in the Figure 7-75.

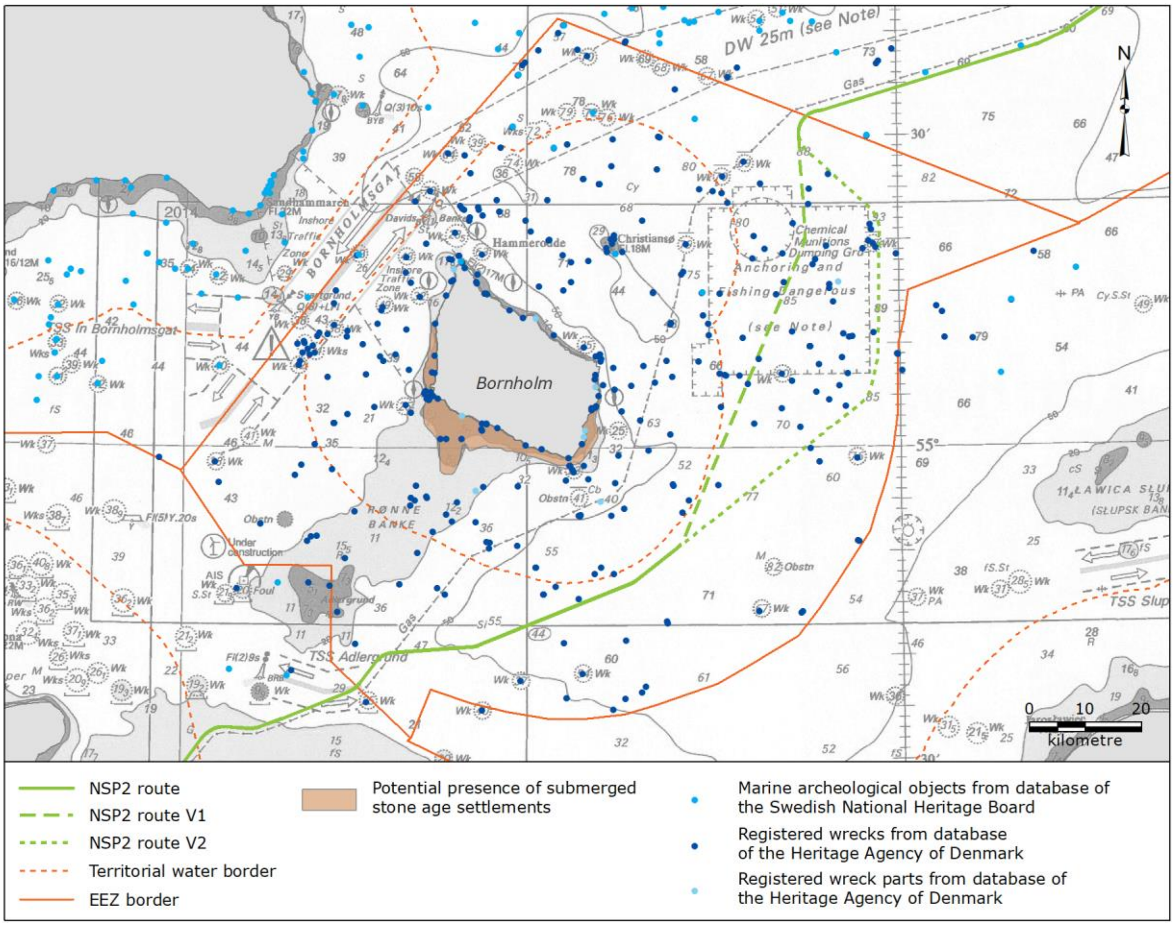

Figure 7-75 Locations of registered shipwrecks in the Baltic Sea around Bornholm.

As shown in Figure 7-75, the highest concentrations of registered wrecks are located close to Bornholm and off the island's northern and western coasts i.e. not within the corridor of the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2. Surveys to identify cultural heritage objects along these route alternatives have been completed.

7.17.3 Previous investigations as part of NSP and NSP2 surveys

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 shipwrecks (see Figure 7-75). This resulted in new knowledge on cultural heritage sites in Danish waters /287/.

During other previous surveys in relation to alternative routings for NSP and NSP2 south of Bornholm, several potential wrecks were identified /73//288/. The locations are shown in Figure 7-76.

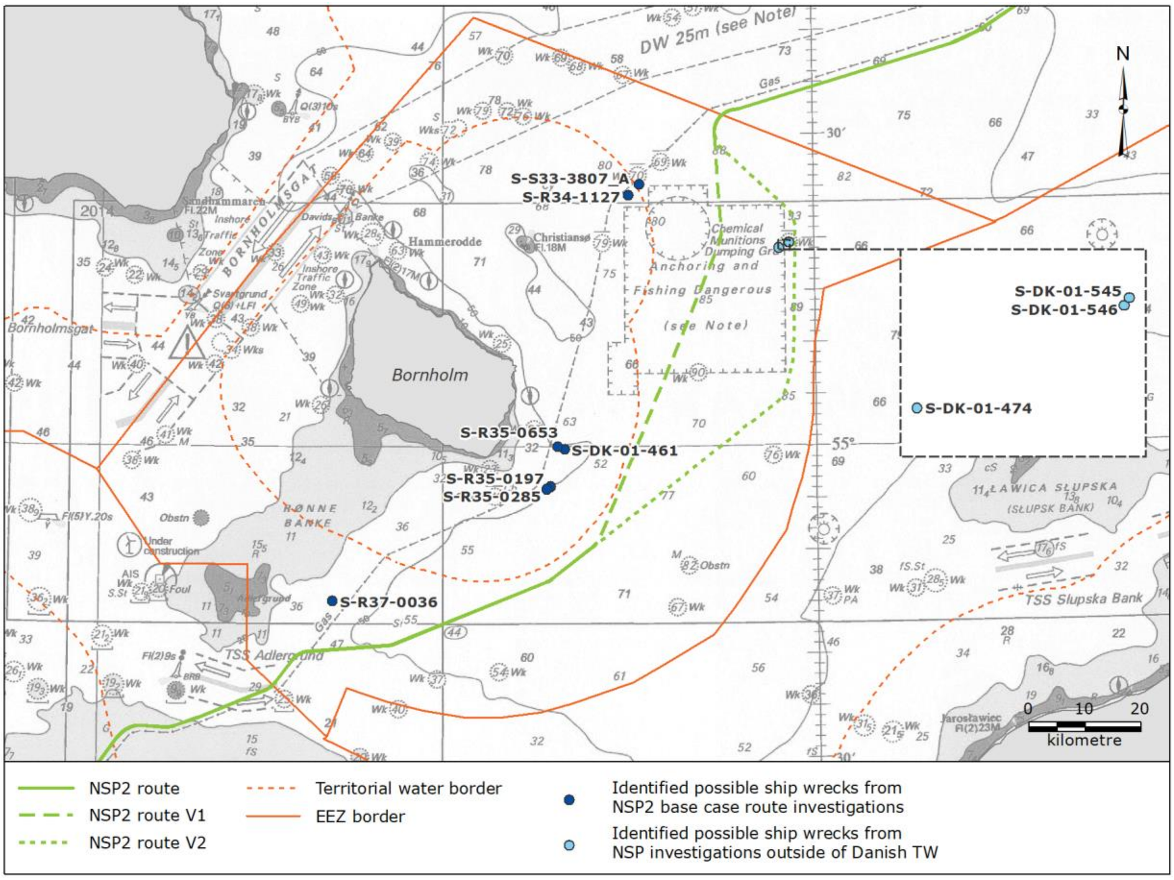

Figure 7-76 Identified possible wrecks during previous NSP2 route investigations south of Bornholm.

Investigations aimed at identification of potential CHOs along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 are ongoing. Surveys include examination of the seabed with multibeam echo sounder (MBES), side-scan sonar (SSS), sub-bottom profiler and magnetometer. Visual inspections with a remotely operated vehicle (ROV) will allow for confirmation of the finds. The need for further inspection and potential exclusion zones to be respected during pipe-lay will be agreed in consultation with the relevant Danish authorities (the Danish Agency for Culture and Palaces).

7.18 Conventional and chemical munitions

During WWI and WWII, the Baltic Sea was of great naval strategic importance, and 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 needed 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 with water depths exceeding 70 m south-east of Gotland, east of Bornholm (with water 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. It is possible that conventional munitions were co-dumped with chemical munitions /122/.

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 quantities of mines are 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 so that they can be identified.

Munitions screening surveys previously undertaken in Danish waters along the NSP route and base case NSP2 route did not result in any findings of conventional munitions that necessitated clearance, i.e. finds were avoided during the detailed route optimisation. Reporting of the munitions screening survey (UXO) covering the NSP2 pipe-lay corridors and the intervention works footprint is being finalised at the time of preparation of this EIA, and early results identify finds along both route variants. The routing has been adapted to safely accommodate all found munitions along the NSP2 routes, i.e. a minimum offset distance to the pipelines, with the exception of an identified line of ground mines (explosive charge in the order of 800 kg per mine), which traverses the complete corridor of the NSP2 route V2. At the time of this assessment, the required remedial actions have not been fully developed.

Such actions under consideration include one or a combination of the following:

- Rerouting; a potential reroute has been surveyed and is being assessed by engineering.
- Relocation of individual munitions to a permanent storage location on the seabed outside the influence of the pipeline corridor, which is yet to be agreed with the competent Danish authority.

7.18.2 Chemical munitions

Chemical munitions are munitions containing 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 them. 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 t of chemical munitions, containing approximately 15,000 t of CWA, were dumped in the Baltic Sea /122/.

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, and sealed 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 t 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 vessels 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 7-77 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 /289//290/. Fishermen occasionally find yellow or brown lumps of mustard gas in their fish catch. Between 2002 and 2012, 53 incidents were reported /122/.

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 /122//290/.

The Danish Navy 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.

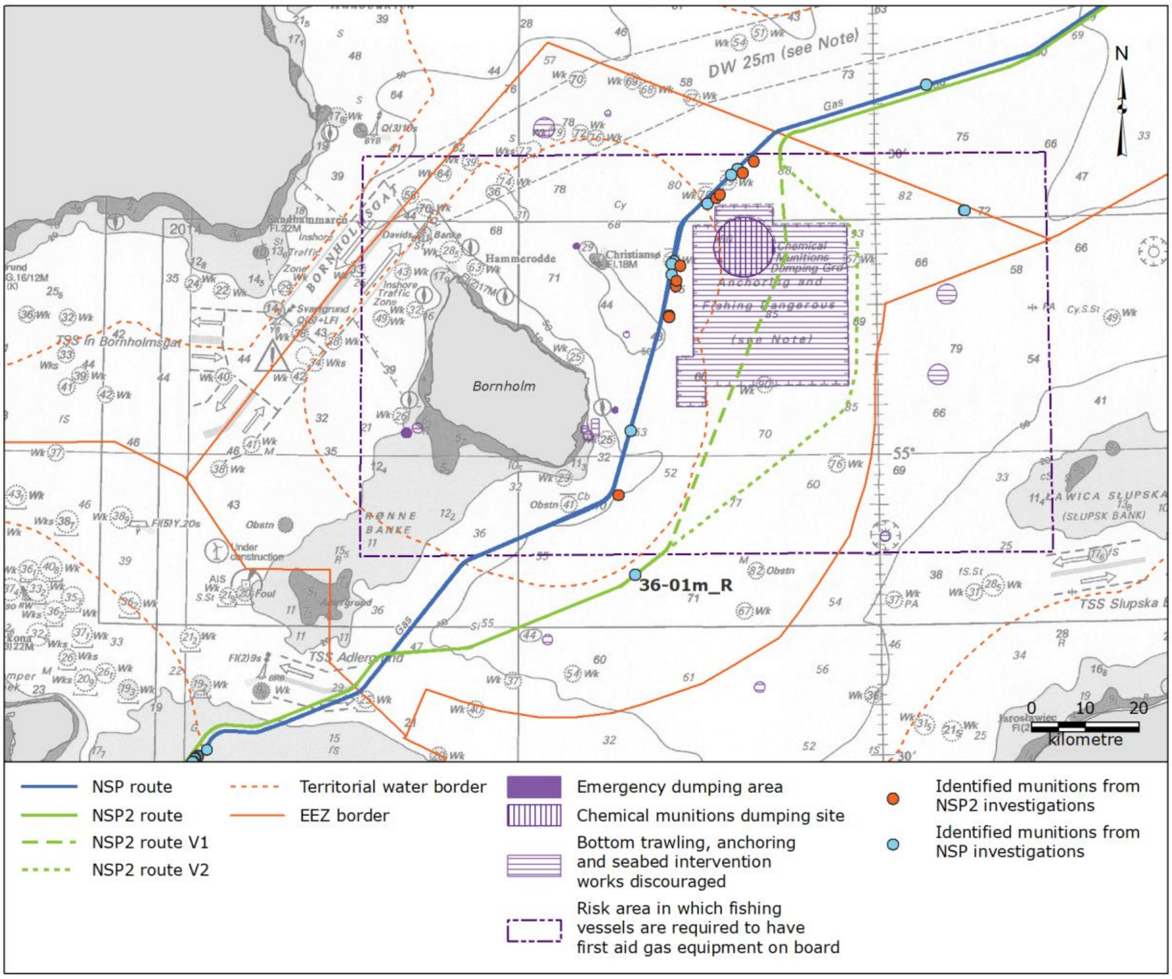

Figure 7-77 Chemical munitions dumping sites and risk areas in Danish waters, as well as identified munitions from previous NSP and NSP2 base case route investigations.

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 have rusted and have been 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 casings 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 Previous investigations as part of NSP and NSP2 surveys

Baseline investigations for munitions along the NSP route in Denmark were 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, which could not be avoided during the detailed route optimisation. 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 route in Denmark. All finds were reported to the Admiral Danish Fleet (ADF), and it was agreed between Nord Stream AG and the ADF that the chemical munitions were to be left on the seabed.

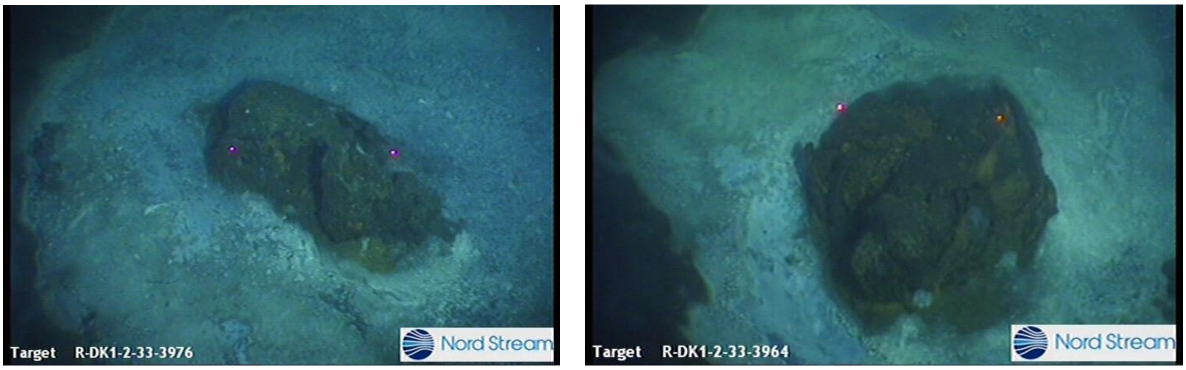

Figure 7-78 Underwater images of two of the seven chemical munitions objects identified in connection with NSP. Left: a chemical mustard gas bomb with heavily corroded casing; right: a corroded German KC250 mustard gas bomb.

Identified chemical munitions were monitored during and after construction of NSP. The monitoring of munitions in Danish waters has shown that the conditions of all seven munitions objects did not change /291/.

As part of the surveys of the NSP2 base case route corridor, a geophysical reconnaissance survey and a dedicated munitions screening survey were undertaken. No magnetic anomalies without an associated seabed feature were present along the NSP2 base case route.

Seabed features and objects were interpreted from SSS, MBES and magnetometer data as well as from visual inspections. Fifty-two objects were identified as possible munitions /292/. These objects were visually inspected by a ROV and 12 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 within the base case corridor in Denmark.

The locations of the identified chemical munitions in Danish waters for NSP and the NSP2 base case route are shown in Figure 7-77.

Reporting of the munitions screening survey (UXO) covering the proposed NSP2 pipe-lay corridors and the intervention works footprint is being finalised at the time of preparation of this EIA, and early results identify munitions finds on both route variants. The routing has been adapted to safely accommodate all found munitions along the NSP2 routes, i.e. a minimum offset distance to the pipelines, with the exception of an identified line of ground mines (explosive charge in the order of 800 kg per mine), which traverses the complete corridor of the NSP2 route V2. At the time of this assessment, the required remedial actions have not been fully developed.

Such actions under consideration include one or a combination of the following:

- Rerouting; a potential reroute has been surveyed and is being assessed by engineering.
- Relocation of individual munitions to a permanent storage location on the seabed outside the influence of the pipeline corridor, which is yet to be agreed with the competent Danish authority.

7.19 People and health

The closest human receptors are located on the islands of Bornholm and Ertholmene, which are respectively located approximately 23 km and 30 km (shortest distances) north-west of the NSP2 route V1 and approximately 24 km and 37 km (shortest distances) north-west of the NSP2 route V2. 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 /293/. 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 /294/ and data from the municipality of Bornholm /293/. The average age of the people of Bornholm is higher than in the rest of the Capital Region. Furthermore, the status in relation to health aspects, such as exercise habits, is poorer in this municipality, resulting in slightly poorer physical health than the average for 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 /294/.

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 on the health of the residents on the island are 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 and south of Bornholm, regardless of which variant is selected (i.e., the NSP2 route V1 or the NSP2 route V2), 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 most recently available (2013) Municipal Plan, Centre for Regional & Tourism Research, Destination Bornholm, VisitDenmark and a report on ferry traffic to and from Bornholm /295//296//297//298//299/, whilst interests on Ertholmene are described based on information from VisitDenmark and the webpage "Søfæstning Christiansø" /298//300/.

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 /295/ are presented in Figure 7-79.

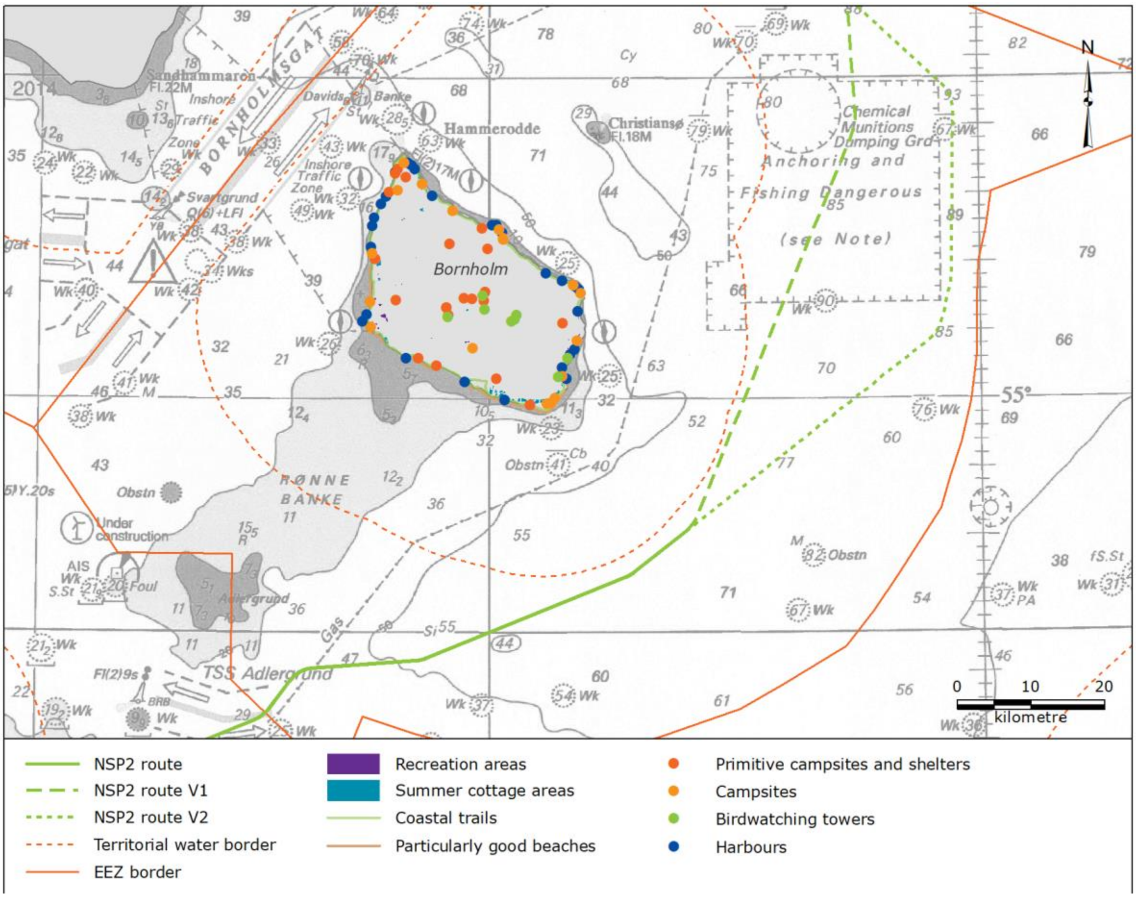

Figure 7-79 Recreational interests and areas of interest in relation to tourism on Bornholm /295/.

7.20.1 Tourism

The tourism industry is important for occupational and business-related development on Bornholm and the islands of Ertholmene (specifically, Christiansø and Frederiksø). To secure the development of this industry, the municipal council has prioritised the promotion and improvement of accommodation capacity, tourist attractions and activities as well as recreational and outdoor opportunities /295/.

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 /295//299/. The majority of the tourists visit the island during the summer months, with almost 75% of the overnight stays occurring in June, July or August. Most tourists visiting Bornholm are Danish or German, but Swedish, Norwegian and Polish tourists also frequently visit the island /296/. In 2012, the average Danish tourist stayed approximately seven days, while the average foreign tourist stayed approximately nine days /295//299/.

According to available data, most people visit Ertholmene on a one-day-trip /297/. There are several small businesses on the islands that are considered to be dependent on non-resident visits. Each year, approximately 40,000 visitors come to Ertholmene to experience the small island community, nature and birds /298/.

7.20.2 Transportation and accommodation

In 2007, 70% of the people who travelled to Bornholm were non-residents. Of these, 71% arrived by ferry, while 13% arrived by airplane /295/. There are ferry connections to Rønne, Bornholm from Ystad (Sweden), Køge (Denmark), Sassnitz (Germany) and Swinoujscie (Poland) /297/, but the ferry between Ystad and Rønne was by far the most used means of transportation to and from Bornholm in 2012 /299/.

In 2009, most tourists stayed in holiday homes (46%) or hotels and holiday centres (30%) when visiting Bornholm, but campsites were also a popular choice (18%) /296/. 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 seven of these sites were located on the east coast. Furthermore, it is also possible to stay overnight at more primitive campsites or shelters or on a boat in some of the harbours /295/.

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 in the harbour or at the campsite /300/.

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, Natur-Bornholm and Bornholm Butterfly Park. Only the latter is located on the east coast, in Nexø /297/.

The Ertholmene islands are also popular with tourists. The main attractions are considered to be the small community, nature and wildlife of the islands /297/.

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 /295/. "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 coasts of the islands of Ertholmene, particularly on Christiansø and Frederiksø /300/.

In connection with the coastal cities of Svaneke, Årsdale, Nexø and Snogebæk located on the eastern coast of Bornholm, the municipal plan identifies several areas where recreational activities are possible /295/.

The waters around Bornholm are 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, and in several marinas it is possible to launch a boat or embark on guided fishing trips to fishing areas further from the coast /298/.

Both trolling and jig fishing are popular activities in the waters around Bornholm. These activities are performed at least 1 nm (1.85 km) from the coast, but most often even further offshore /301/.

Several diving activities are possible in the waters around Bornholm and Ertholmene, with recreational diving and spearfishing accessible from the coast. Divers often stay close to the coastlines of Ertholmene and Bornholm, where sites such as Listed and Hullehavn near Svaneke are popular; however, residents and tourists also take diving excursions to visit underwater caves or the many well-preserved shipwrecks 5-10 km or further from the coast, depending on where the wrecks are located /298//302/ (see Figure 7-75).

7.21 Existing and planned installations

There are several existing and planned installations in Danish waters in close proximity to the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. Due to their economic importance, these installations are considered an important socio-economic receptor.

Most of the existing installations crossing Danish waters are telecom cables, but pipelines and planned offshore wind parks also take up relatively large areas. Various published maps, supplemented by communication with installation owners and survey results, have been used to compile and verify the locations of these existing and planned installations, see Figure 7-80.

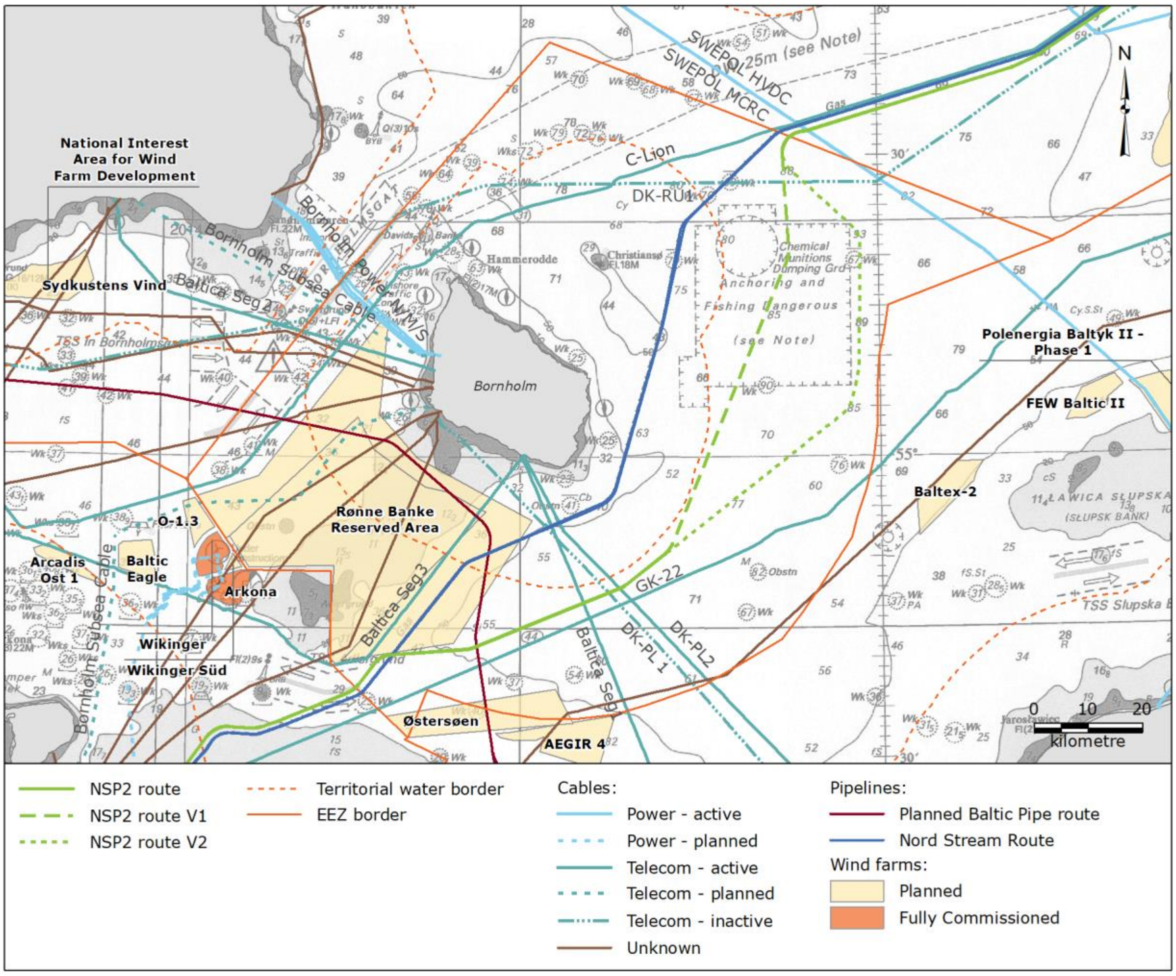

Figure 7-80 Existing and planned installations within Danish waters (a larger version of this figure can be seen in NSP2 Atlas Map IN-01-D).

Within Danish waters, the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 would cross several existing telecom and power cables and the NSP pipelines, as shown in Table 7-47. The Baltic Pipe is a planned natural gas pipeline that would run through the Baltic Sea between landfalls in Denmark and Poland. The proposed Baltic Pipe route passes within both the Danish EEZ and TW, and crosses the proposed NSP2 route south of Bornholm /303/.

Table 7-47 Existing installations to be crossed by the proposed NSP2 route, the NSP2 route V1 and/or the NSP2 route V2 in Danish waters.

Name	Crossed by	Type	Owner	Status
DK-RU1	Both alternatives	Telecom	TDC	Out of service
DK-PL 1	Both alternatives	Telecom	TDC	Out of service
DK-PL 2	Both alternatives	Telecom	TDC	Active
Baltica Seg 1	Both alternatives	Telecom	Polish Telecom	Active
NSP pipelines	Both alternatives	Natural gas pipeline	Nord Stream AG	Active

The proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 do not cross any areas where development of wind farms has been planned, as shown in Figure 7-80. However, several areas in the nearby vicinity are under consideration by the Danish, Polish, German and Swedish authorities for future wind farm development, as shown in Table 7-48.

Table 7-48 Current and planned offshore wind farms in Denmark, Poland, Germany and Sweden /304/.

Planned project name	Project location	Owner / developer	Development status	Distance to NSP2 route with V1 (km)	Distance to NSP2 route with V2 (km)
Rønne Banke Reserved Area	Denmark	DEA (promoting until a commercial developer takes project forward)	Development Zone	0.25	0.25
Østersøen	Denmark	DEA	Development Zone	7.7	7.7
AEGIR 4	Poland	ENERGA SA	Concept/Early Planning	16.4	16.4
Baltex-2	Poland	Grupa BALTEX	Concept/Early Planning	38.9	21.2
FEW Baltic II	Poland	Baltic Trade and Invest Sp. z o.o.	Concept/Early Planning	58.8	39.4
Polenergia Baltyk II – Phase 1	Poland	Polenergia SA and Equinor ASA	Consent Authorised	67	50
Arcadis Ost 1	Germany	Parkwind NV	Consent Authorised	49.9	49.9
Arkona	Germany	E.ON Energy Projects GmbH and Equinor ASA / E. ON AG	Under Construction	26.3	26.3
Baltic Eagle	Germany	Iberdrola S.A	Consent Authorised	42.3	42.3
O-1.3	Germany	Not reported	Development Zone	38.9	38.9
Wikinger	Germany	Iberdrola Renovables Deutschland GmbH	Fully Commissioned	32.9	32.9
Wikinger Süd	Germany	Iberdrola Renovables Energia, SA / Iberdrola Renovables Deutschland GmbH	Consent Authorised	30.3	30.3
National Interest Area for Wind Farm Development	Sweden	Energimyndigheten	Development Zone	87.7	87.7
Sydkustens Vind	Sweden	Kustvind	Concept/Early Planning	89.2	89.2

7.22 Raw material extraction sites

Baltic Sea sediments may contain valuable raw materials, especially for construction purposes. As such, several countries bordering the Baltic Sea have an interest in extracting marine sediments, and raw material extraction sites are therefore considered an important socio-economic receptor.

Greater water depths generally lead to increasing technical and mechanical constraints as well as operational costs. As a general rule, depths less than 20 m are typically considered most favourable for raw material extraction. All areas designated for raw material extraction around Bornholm, for example, are located at Rønne Banke at quite shallow water depths (see Figure 7-81).

There are 20 areas designated for extraction of raw materials (eight areas for current raw material extraction and 12 areas reserved for potential future raw material extraction) and one area designated for sediment dumping in Danish waters. These areas are mainly located south-west of Bornholm at Rønne Banke, see Figure 7-81. As shown in the figure, the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 do not cross any of the areas designated for extraction of raw materials, nor the area for sediment dumping.

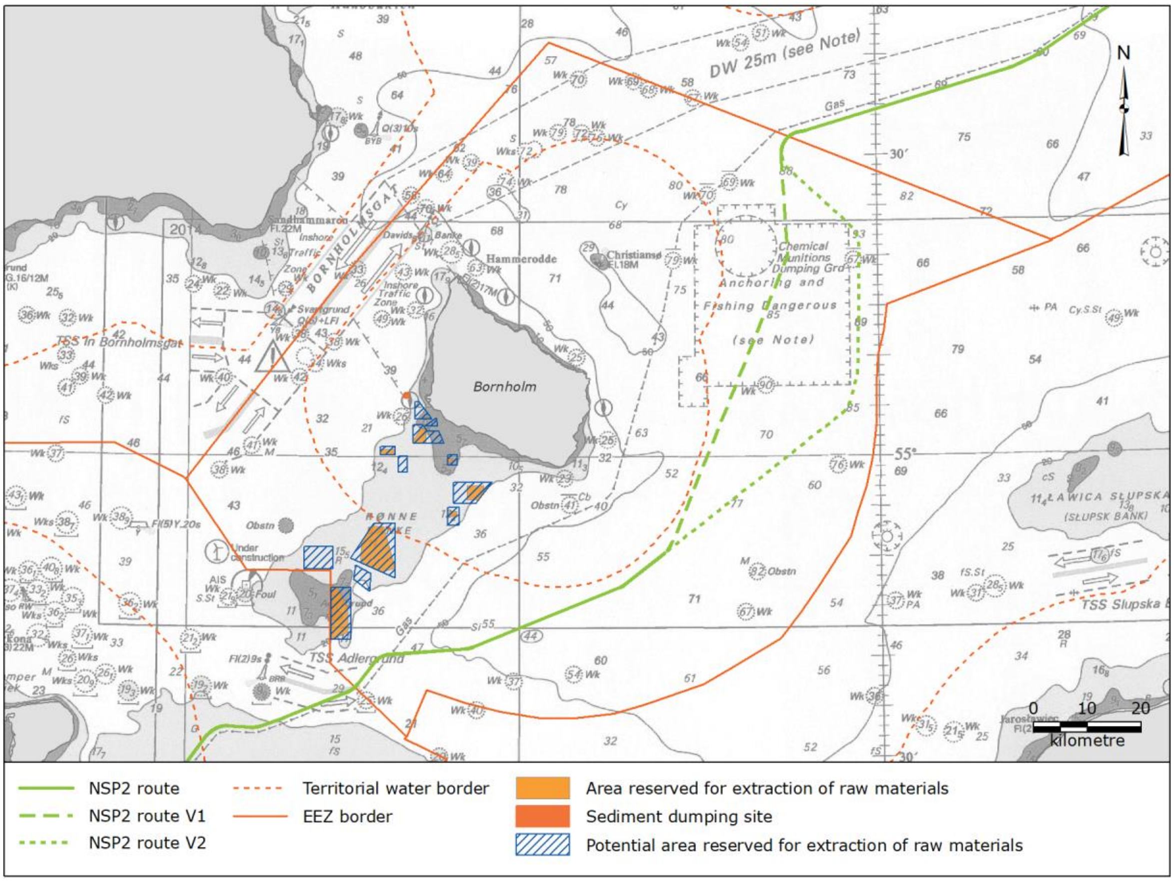

Figure 7-81 Designated areas for raw material extraction in Danish waters.

7.23 Military practice areas

The Baltic countries maintain various types of military practice areas in the Baltic Sea. Due to the national security role of these areas, they are considered an important socio-economic receptor.

Military practice areas may impose restrictions in regard to navigation and other access rights. Permanent restriction of access to areas used for military purposes may be applied by countries within their territorial waters. Temporary military practice or exercise areas may not be mapped.

To the east of Bornholm, there are several areas used for military purposes, see Figure 7-82.

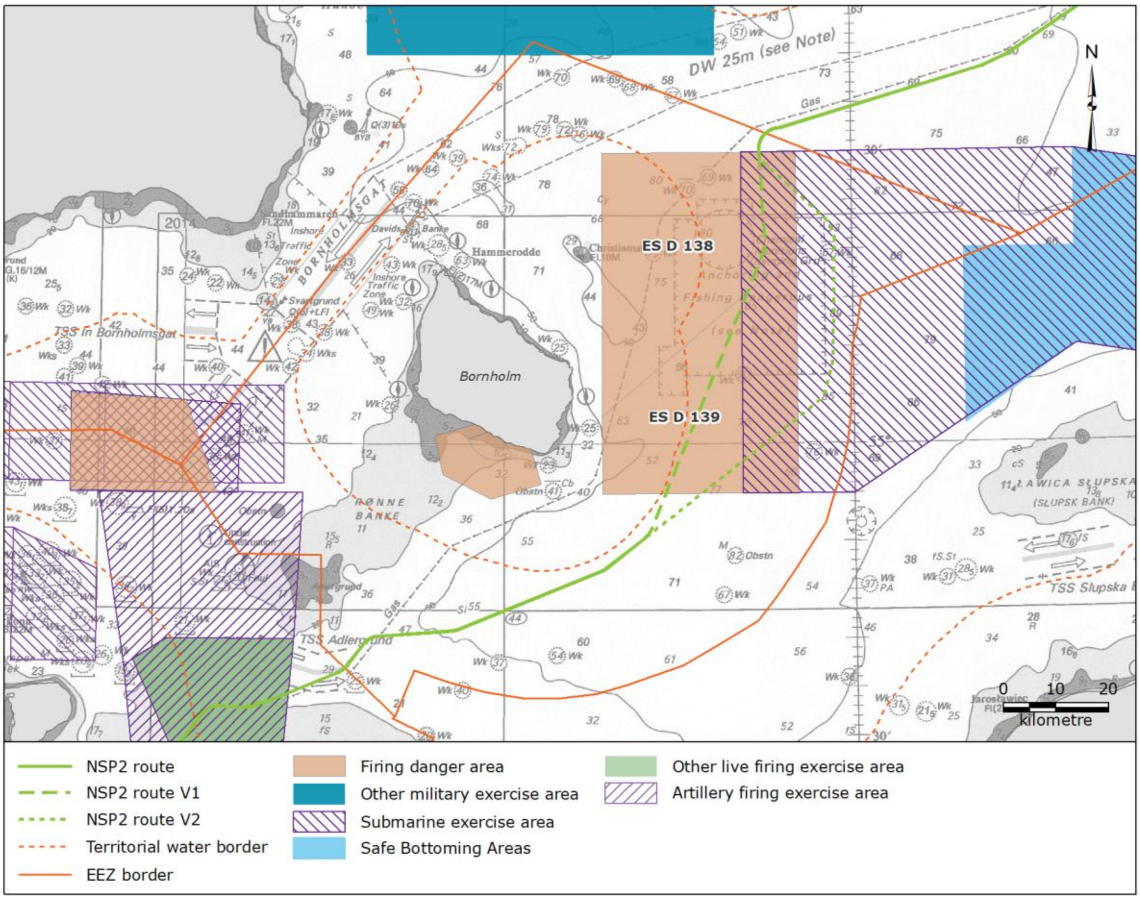

Figure 7-82 Military practice areas in Danish waters in the Baltic Sea.

ES D 138 and ES D 139, located east of Bornholm, are temporary shooting areas used for naval shooting exercises, and are managed by the Danish military together with Sweden. The NSP2 route V1 and the NSP2 route V2 cross both of these areas.

On behalf of the Danish Navy, the Joint Operations Centre is responsible for activities in the firing areas in Danish waters. Information about firing exercises (via notices to mariners) can be found via the DMA website or in the app "Sejlsikkert". Information is also broadcasted on longwave frequency 243 KHz at 17.45 – 18.05 local time.

A submarine exercise area used by the German military for submarine diving training exercises is located east of Bornholm, and will also be crossed by both the NSP2 route V1 and the NSP2 route V2. This area is used for submarine training exercises. A portion of this submarine exercise area is additionally designated as a Safe Bottoming Area (this portion is not crossed by the NSP2 route V1 or the NSP2 route V2). Safe Bottoming Areas are designated by military authorities as areas in which submarines may bottom without risking damage from rocks, wrecks, or munitions.

7.24 Environmental monitoring stations

7.24.1 General conditions

Long-term trends in physical, chemical and biological variables are being monitored at selected environmental monitoring stations located throughout the Baltic Sea. At each of these stations, different parameters are being monitored according to various national and international initiatives, thereby contributing to the scientific knowledge on the Baltic Sea. These stations comprise part of a procedure to harmonise monitoring throughout the Baltic Sea, which has been agreed on by the

Baltic countries to support implementation of the HELCOM objectives. On this basis, environmental monitoring stations are considered an important socio-economic receptor.

In the waters around Bornholm, there are Swedish, Finnish and HELCOM monitoring stations, as shown in Figure 7-83.

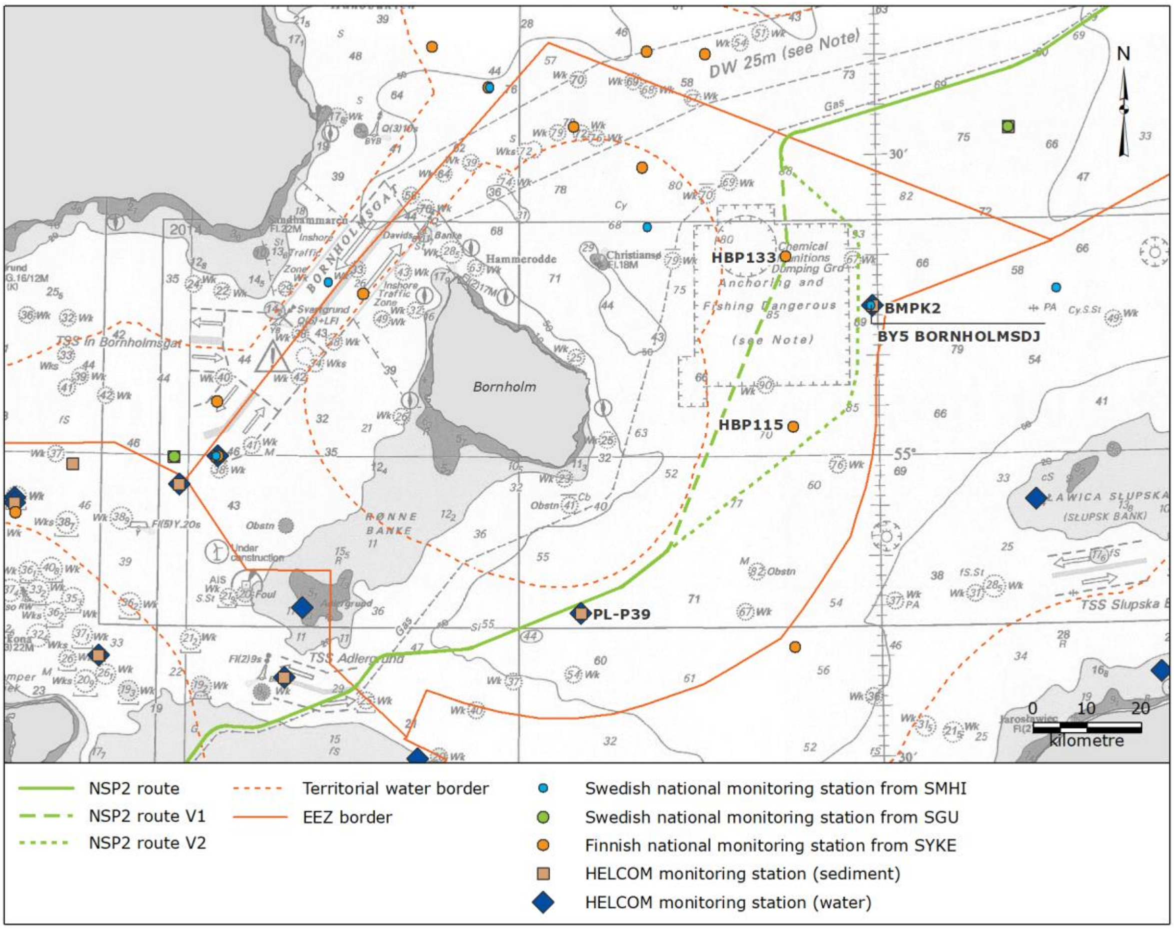

Figure 7-83 Offshore monitoring stations around Bornholm.

7.24.2 Combination of the proposed NSP2 route with V1

Table 7-49 provides information on the closest active monitoring stations (within 10 km) relative to the combination of the proposed NSP2 route with V1 in Danish waters.

Table 7-49 Active monitoring stations closest to the combination of the proposed NSP2 route with V1 in Danish waters /306//307/.

Monitoring station ID	Responsible authority (country)	Monitored parameter(s)	Distance from pipelines (minimum)
HBP133	SYKE (Finland)	Physical, chemical, benthos	0.1 km
BMPK2	HELCOM (Finland)	Water quality, sediment quality (two overlapping stations with same name)	17.9 km
BY5 BORNHOLMSDJ	SMHI (Sweden)	Physical, chemical, plankton	17.7 km
PL-P39	HELCOM (Finland)	Water quality, sediment quality (two overlapping stations with same name)	1.7 km
HBP115	SYKE (Finland)	Physical, chemical, benthos	12.8 km

7.24.3 Combination of the proposed NSP2 route with V2

Table 7-50 provides information on the closest active monitoring stations (within 10 km) relative to the combination of the proposed NSP2 route with V2 in Danish waters.

Table 7-50 Active monitoring stations closest to the combination of the proposed NSP2 route with V2 in Danish waters /306//307/.

Monitoring station ID	Responsible authority (country)	Monitored parameter(s)	Distance from pipelines (minimum)
HBP133	SYKE (Finland)	Physical, chemical, benthos	13.3 km
BMPK2	HELCOM (Finland)	Water quality, sediment quality (two overlapping stations with same name)	2.6 km
BY5 BORNHOLMSDJ	SMHI (Sweden)	Physical, chemical, plankton	2.4 km
PL-P39	HELCOM (Finland)	Water quality, sediment quality (two overlapping stations with same name)	1.7 km
HBP115	SYKE (Finland)	Physical, chemical, benthos	3.5 km

8 ASSESSMENT METHODOLOGY AND ASSUMPTIONS

In this section, the assessment methodology (see sections 8.1-8.3) as well as the modelling and assumptions (see section 8.4) applied in the EIA will be described.

As set out in section 4, the EU EIA Directive and the Danish EIA Act aim 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 that 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 the 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 in the environment that could potentially be impacted (see section 7);
- Assessment of potential impacts;
- Development of mitigation measures to address potentially significant environmental impacts;
- Assessment of potential transboundary impacts;
- 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 that 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 (see section 6), which defines and describes the various components of NSP2 relevant to Danish waters (during the construction, operational 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 sections 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 are therefore not included in Table 8-1, the topic has been identified as an issue requiring particular consideration, and is therefore included in sections 7 and 15.

Table 8-1 Resources or receptors susceptible to potential impacts associated with NSP2 in Danish waters.

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 assessing the 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 combination of the proposed NSP2 route with V1 is approximately 1,230 km in length, of which approximately 147 km are within Danish waters. The combination of the proposed NSP2 route with V2 is approximately 1,248 km in length, of which approximately 164 km are within Danish waters. The geographic area that may be affected by the project varies depending on the source of impact arising from each activity, i.e. how the component interacting with the environment (noise generation, sediment mobilisation etc.) propagates spatially. As such, the locus of a potential impact 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 pre-commissioning and commissioning will have no impacts on resources or receptors in Danish waters, see section 6.5. Therefore, the pre-commissioning and commissioning phases have not been assessed within this EIA; impacts from 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 115 days if the combination of the proposed NSP2 route with V1 is selected, or approximately 125 days if the combination of the NSP2 route with V2 is selected, with 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 selected 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 to utilise good international industry practice 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 impacts have been identified by considering how the various project activities within Danish waters (see section 6) may interact with resources and receptors. This has required detailed understanding of the various project activities and the baseline environmental and socio-economic conditions. Furthermore, experience and knowledge gained from the monitoring of NSP have served as important inputs 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 impacts for the construction and operational phases, respectively. Given the uncertainty regarding 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 potential 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	Physical disturbance on the seabed
	Release of sediments into the water column
	Release of contaminants into the water column
	Release of chemical warfare agents 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 greenhouse gases
	Introduction of non-indigenous species

* No advance works (e.g. munitions clearance, wreck or boulder removal) are planned in Danish waters.

** E.g. from the presence of vessels, noise and light.

Table 8-3 Project activities in Denmark and associated sources of potential 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
	Change of habitat
	Physical disturbance above water*
	Imposition of safety zones around survey vessels
	Emissions of air pollutants and greenhouse gases
	Generation of heat from gas flow through the pipelines
	Release of metals from anodes
	Introduction of non-indigenous species

* E.g. from the 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 potential impacts 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 of 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 judgement. 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 impacts and physical-chemical and biological resources or receptors. Protected areas include Ramsar sites and HELCOM MPAs.

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	Seabirds	Protected areas	Natura 2000	Biodiversity
Construction phase	Physical disturbance on the 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 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
	Physical disturbance above water (e.g. from presence of vessels, airborne noise and light)										X	X		X
	Emissions of air pollutants and greenhouse gases					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
	Change 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 greenhouse gases					X								X
	Generation of heat from gas flow through the pipelines				X									X
	Release of metals from anodes		X		X		X	X	X	X	X	X		X
	Introduction of non-indigenous species											X		X

Table 8-5 Interactions between sources of potential impacts and socio-economic resources or receptors.

Source of potential impact		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
Construction Phase	Physical disturbance on the seabed			X			X			
	Release of sediments into the water column					X				X
	Release of contaminants into the water column									X
	Physical disturbance above water (e.g. from presence of vessels)		X		X	X			X	
	Imposition of safety zones around vessels	X	X			X				
	Sedimentation on the seabed									X
Operational phase	Physical presence of pipelines and structures on the seabed		X	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.

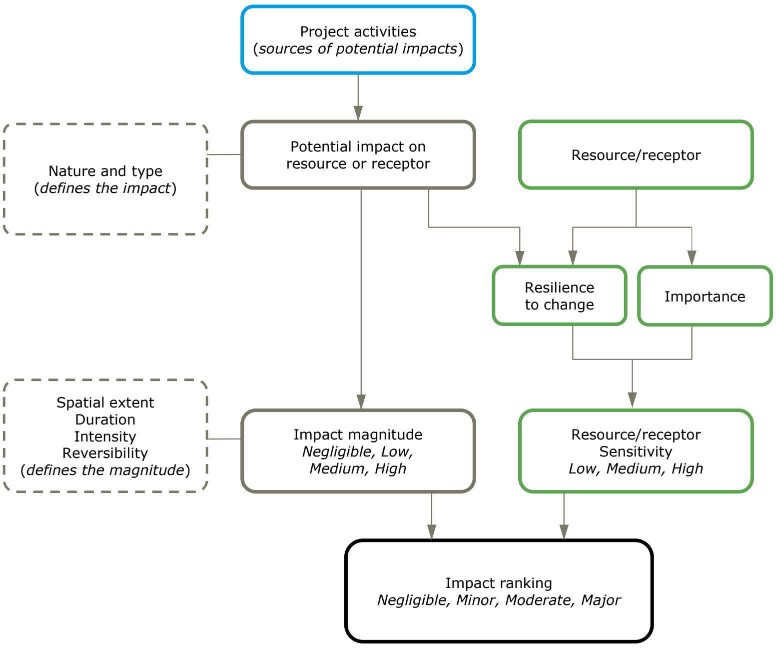

Figure 8-1 EIA methodology for potential impacts.

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 in Table 8-6.

Table 8-6 Nature and type of potential impacts.

Nature of impact Negative[1]: impact that is considered to represent an adverse change from the baseline or to introduce a new, undesirable factor. Positive[1]: impact that is considered to represent an improvement to the baseline or to introduce a new, desirable factor. **Type of impact** Direct: impact that results from a direct interaction between a project activity and the receiving environment (e.g. the loss of a habitat during pipeline installation). Indirect: impact that results 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 proposed NSP2 route due to the creation of an artificial habitat favourable to certain target species). Cumulative: impact that 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 that 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 or high.

Table 8-7 Impact magnitude.

Spatial extent of impact Local: impact affecting the pipeline route corridor and/or the immediate vicinity of the pipelines/construction site (<5 km). Regional: impact affecting an area between 5-20 km from the pipeline route corridor. National: impact affecting an area >20 km outside the pipeline route corridor, but restricted to country waters (EEZ/TW). Transboundary: impact 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: impact predicted to be of very short duration and/or intermittent/occasional in nature and ceasing 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: impact predicted to be of short duration and ceasing 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 the pipeline into the seabed and after re-instatement of the seabed). Long-term: impact 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: impact may be forecasted, but is frequently at the detection limit and does not lead to any permanent change in the structures or functions of the resource/receptor concerned. Medium: impact is forecasted to be above the detection limit and may lead to some detectable alterations to the resource/receptor concerned, but the 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 environment, as presented in Table 8-8 and Table 8-9, respectively.

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 does not lead to discernible changes.
Low	Impact on a socio-economic resource/receptor leading to very limited, temporary damage or changes.
Medium	Impact on a socio-economic resource/receptor that may bring about change in status but does not threaten the overall stability of the socio-economic resource/receptor.
High	Impact on a 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 for each resource and receptor in section 9.

8.3.3 Sensitivity of a resource or receptor

The sensitivity of a resource or receptor describes how it 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 resource or receptor's adaptability, diversity and whether it is present in the area impacted by the project activity, i.e. does a specific source of impact interact with it. Resilience to change is thus a characteristic of a resource or receptor but is not inherent to it, as it is also influenced by the nature of the impact to which it is subject.
- **Importance**, describing the resource or 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 sensitivity are elaborated upon in Table 8-10 and Table 8-11 for the physical-chemical and biological environment and the socio-economic environment, respectively, 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 have 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 restored 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 its resource, economic, cultural or social value.
Medium	An asset which is considered not to be important on a regional level but is of local importance to the asset base, livelihoods, etc.
High	An asset which is specifically protected by national or international policies or legislation and is of importance to the asset base, livelihoods etc.

The sensitivity of each resource and 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 the receptor 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. 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 "significant" or "not significant". 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 that 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 have been described qualitatively.

Where, following assessment, no impact is anticipated, this is stated and no further discussion is 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 (described further in section 15), whereby priority has been given to:

- avoiding or preventing impacts;
- if this is not possible, then reducing or abating them;
- only if the above is not possible, then offsetting them through repair (restoration or reinstatement) or, as a last resort, compensation.

This approach is driven by 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 sections 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 existing 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 is operational. These other projects may generate their own individually insignificant impacts, but when considered in combination with the impacts from NSP2, could amount to a significant cumulative impact. For example, the potential for combined sediment impacts from two or more (planned) projects that will occur within a certain timeframe and geographic area would be considered. Potential cumulative impacts have been described in section 12 following the same assessment methodology 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 Articles 6(3) and (4) of the Habitats Directive and Danish legislation (see section 4). Therefore, an assessment of potential impacts on Natura 2000 sites associated with NSP2 has been undertaken in this EIA.

The methodological guidance for Natura 2000 assessment outlined in /308/ 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 on a Natura 2000 site(s), either alone or in combination with other projects or plans, and considers where these impacts are likely to be significant.

Section 9.12 of this EIA includes a Natura 2000 screening that identifies the potential impacts of NSP2 on Natura 2000 sites within Danish waters in terms of their 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 Habitats Directive and Birds 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 are identified in section 12, while potential impacts on Natura 2000 sites outside of 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 /308/).

8.3.8 Protected species (Annex IV)

Article 12 of the Habitats Directive is 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 entire 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 on Annex IV species is included in line with the bullets above 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 be 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 on affected parties, including the public.

NSP2 crosses the jurisdiction of several countries and is being constructed in a marine environment, in which 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, these may in some instances extend into neighbouring countries, i.e. potentially give rise to 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 the communication of transboundary impacts on 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, airborne noise and underwater noise, this was achieved through targeted modelling studies as described below (see sections 8.4.1, 8.4.2, 8.4.3, 8.4.5 and 8.4.6). Emissions to air (see section 8.4.7) were calculated based on the project description and known emission factors for the various activities. The release of contaminants and nutrients (see section 8.4.3) as well as CWA (see section 8.4.4) was evaluated on the basis of the sediment release modelling and levels of contaminants and nutrients identified in previous environmental surveys (see section 7.1.1). The release of metals from anodes (see section 8.4.8) is evaluated based on existing knowledge regarding the toxicity of aluminium, zinc and cadmium 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 and dispersion in the water column is expected during seabed intervention works. Each pipeline is expected to need stabilisation against wave/current loads as well as measures to secure crossings of existing cables or pipelines. The following types of seabed intervention works are planned within Danish waters, see section 6:

- Post-lay trenching;
- Spot rock placement.

The planned intervention works are summarised in Table 8-13 and visualised in Figure 8-2. A short description is given below. It is noted that since seabed intervention works will only be undertaken along the main part of the proposed NSP2 route, close to the Danish/German EEZ border, the NSP2 route V1 and the NSP2 route V2 are considered the same with respect to sediment dispersion.

Table 8-13 Planned intervention works along the NSP2 route in Danish waters.

Sec-tion	Area	KP from – to	Interven-tion work	Remarks
1	South of Bornholm	128.6 – 132.6 (NSP2 route with V1) 146.3 – 150.3 (NSP2 route with V2)	Post-lay trenching	Soil volume: 24,600 m^3/line Alternative to below IW (equal)
			Spot rock placement	Rock volume: 21,440 m^3/line Alternative to above IW (equal).
2	NSP crossing	136.9 (NSP2 route with V1) 154.6 (NSP2 route with V2)	Spot rock placement	Rock volume: 15,000 m^3/line
		137.1 (NSP2 route with V1) 154.8 NSP2 route with V2)	Spot rock placement	Rock volume: 15,000 m^3/line

Stability along section 1 can be established either by post-lay trenching or rock placement. For precautionary reasons, the post-lay trenching scenario is modelled since it would cause the largest and most intensive spill. Therefore, the rock placement scenario is not modelled, since it is expected to cause less sediment dispersion than post-lay trenching. Rock placement along section 2, the crossing of the NSP pipeline system, is included in the modelling.

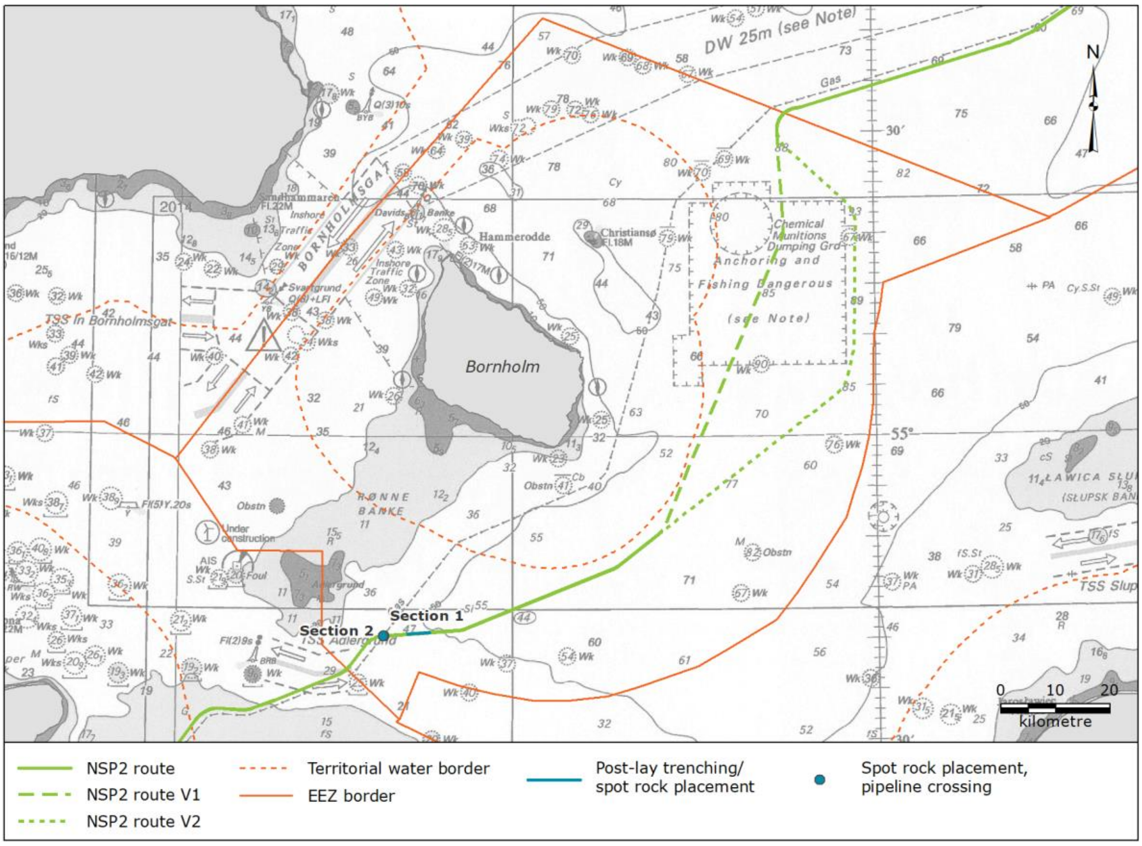

Figure 8-2 Planned intervention works along the NSP2 route in Danish waters.

According to the most recent project design, the following seabed intervention works in Danish waters are assumed as the basis for the evaluations in the EIA:

- **Post-lay trenching** is assumed in one section (refer to section 1 in Table 8-13) along a total of length of 4 km along each pipeline (see Figure 8-2) to a depth corresponding to the outer diameter of the pipeline (1.4 m assumed). Post-lay trenching is assumed to be performed with a speed of 300 m/hour and with a cross-section of 6.2 m^2, yielding a total soil volume of 24,660 m^3 per pipeline. The total duration of post-lay trenching is expected to be approximately two days per line.

- **Spot rock placement at the pipeline crossing**. It is assumed that 30,000 m^3 of pre-lay rock placement will be performed for each pipeline at the crossing of the existing Nord Stream pipelines, yielding a total of 60,000 m^3 of rock placement (refer to section 2 in Table 8-13).

Modelling of sediment dispersion caused by each type of seabed intervention works (i.e., post-lay trenching and spot rock placement) has been performed /309/ and a general description of the modelling methodology, the modelling scenarios and the results of the modelling are given in the sections below.

8.4.1.1 Modelling methodology

On the basis of the above, modelling has been undertaken for post-lay trenching and rock placement within Danish waters. The locations for potential intervention works in Danish waters are shown in Figure 8-2. The modelling has been presented in /310/ 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 basis is taken from dedicated modelling of the Baltic Sea, including adjacent waters /311/. The modelling is carried out in order to enhance the resolution of the model mesh within the route corridor. The modelling is carried out in 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. Preparation of the hydrodynamic basis is described in /311/.

As noted above, the model set-up used a flexible mesh that used different mesh sizes throughout the model domain. Within the route corridor, the horizontal model resolution is increased to 800-1,600 m in order to resolve the complicated bathymetry in this area. The resolution decreases with distance from the pipeline corridor. Further away from the pipeline corridor, the resolution increased gradually until it reached 3-5 km at some distance from the pipeline. For further documentation, see /311/.

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/material 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 particles were released at a source point for discharge (e.g. the location of trenching) and successively moved as the simulation progressed.

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 are 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 inputs 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/m^3), 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 /310/.

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 relatively high temperature and salinity stratification;
- Normal scenario (April 2010): Representation of average current conditions with average particle transport capacity and average temperature and salinity stratification;
- Winter scenario (November 2010): Representation of relatively strong current conditions with high particle transport capacity and 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 into the water column are based on an average of the lower 10 m of the water column.

The modelling of sediment dispersion has been based on the planned intervention works as presented in Figure 8-2. As the seabed intervention works are of a few days' duration, the modelling is terminated one week after the completion of the construction works in order to allow the released sediment to settle on the seabed.

8.4.1.3 Presentation of modelling results

The modelling results are presented in /310/ for each of the three modelling scenarios (refer to section 8.4.1.2) 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 in g/m^2. The corresponding thickness depends on the density, which in turn depends on the consolidation of the material. For loose/fine sediment, sedimentation of 100 g/m^2 corresponds to 0.6 mm thickness /310/. More consolidated sediment corresponds to a thinner layer;
- Maximum concentration of suspended sediment at 200 m, 500 m and 1,000 m from the pipeline.

Threshold values of 2, 10 and 15 mg/l have been chosen based on experience from previous projects such as the Great Belt link, the Øresund link and the Danish nearshore windfarm EIAs. These thresholds have been chosen on the basis of the following, and are accepted by the authorities in Denmark:

- Maximum concentration of suspended sediment at 200 m, 500 m and 1,000 m from the pipeline;

- 2 mg/l represents the concentration just above ambient level and at which the sediment is barely visible in the water column;
- 10 mg/l represents concentration at which vulnerable fish species will flee the area;
- 15 mg/l represents the concentration at which 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 regard 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 were obtained during the “Summer” scenario, under which conditions are calmer. Results from the “Winter” scenario are shown in the following figures. The full results for the “Summer” and “Normal” scenarios are presented in /310/.

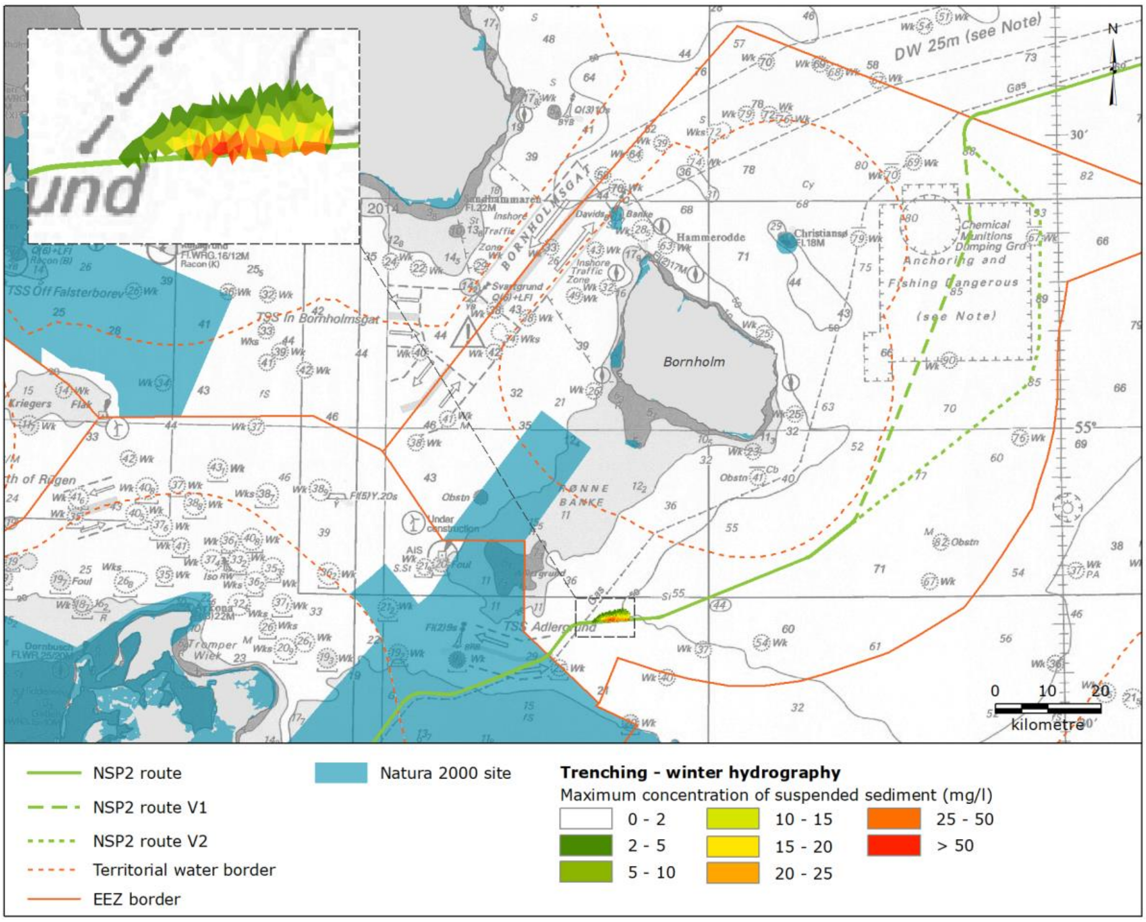

Figure 8-3 Maximum concentrations of suspended sediment as a result of trenching under typical winter conditions.

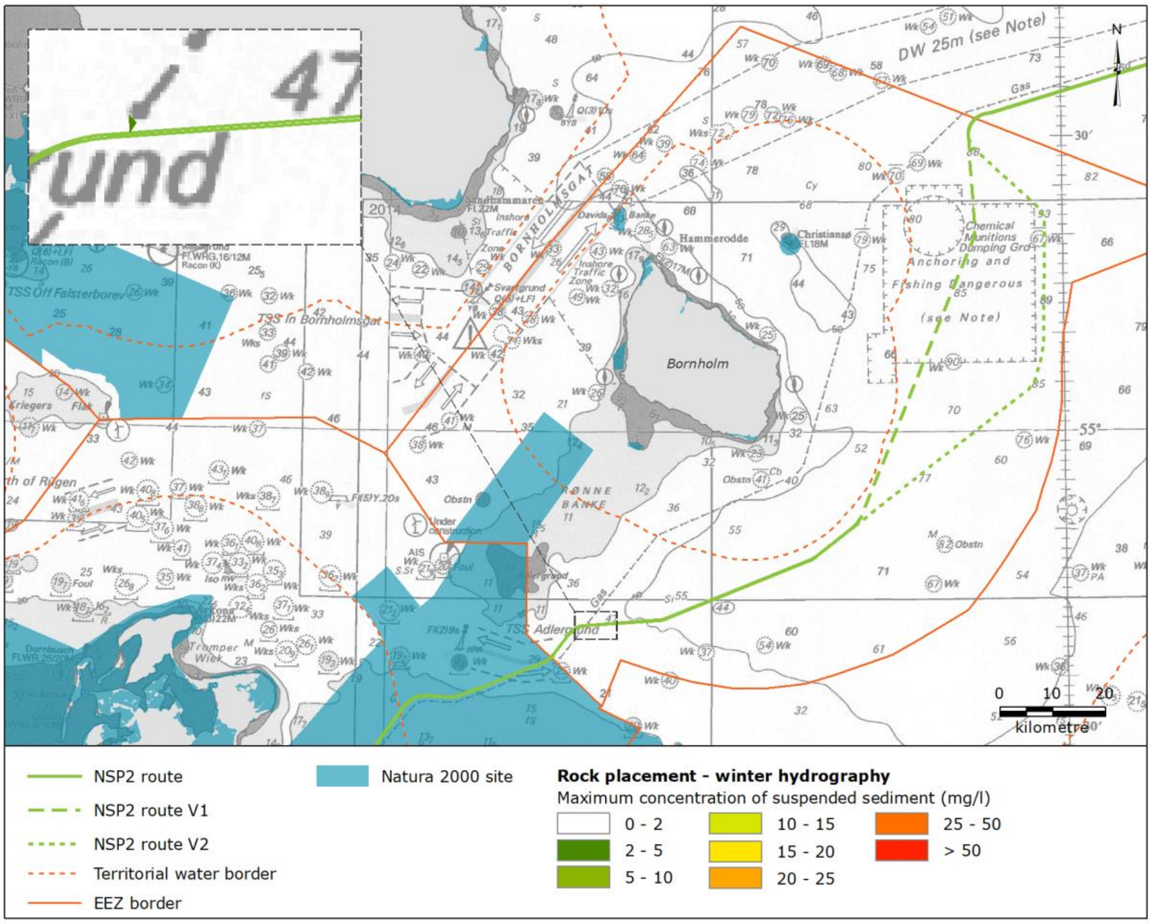

Figure 8-4 Maximum concentrations of suspended sediment as a result of rock placement under typical winter conditions.

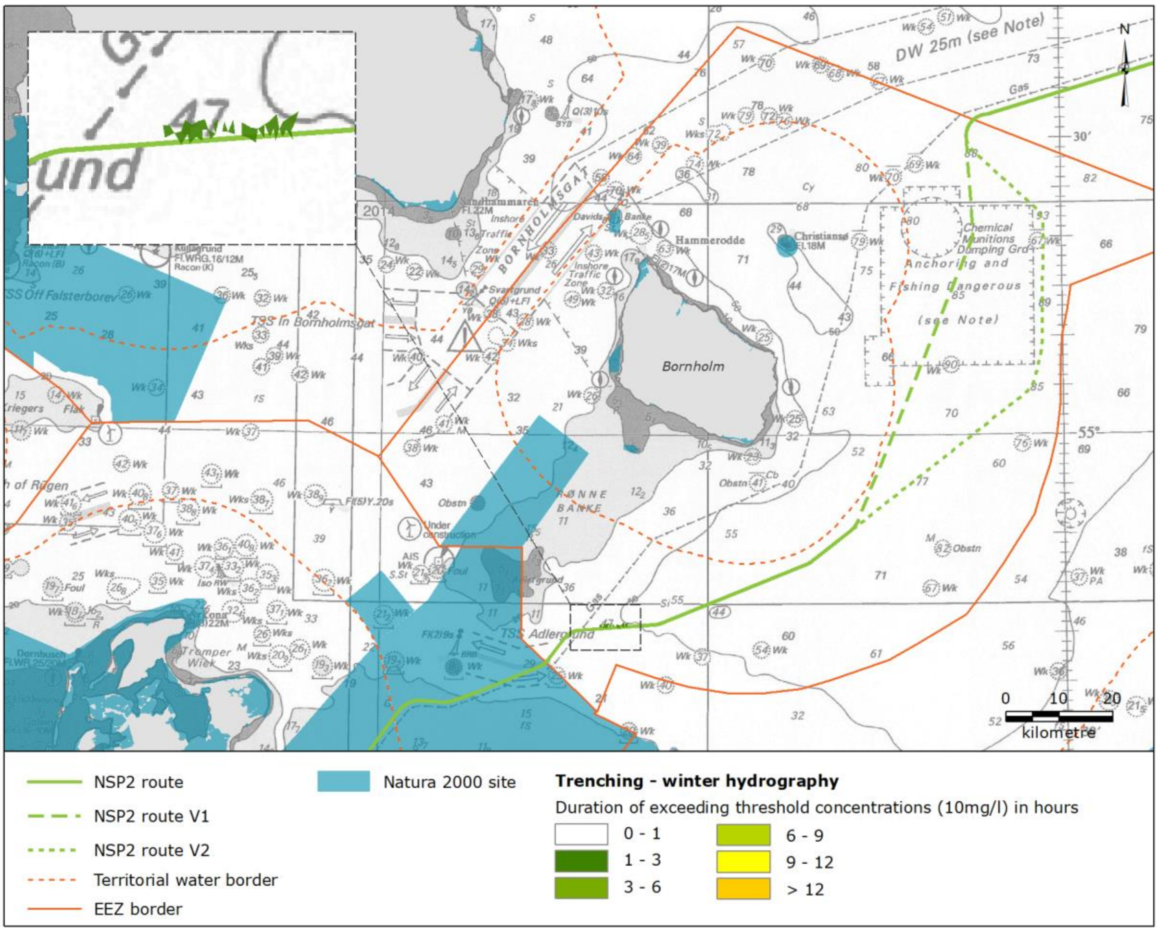

Figure 8-5 Duration of suspended sediment exceeding 10 mg/l as a result of trenching under typical winter conditions.

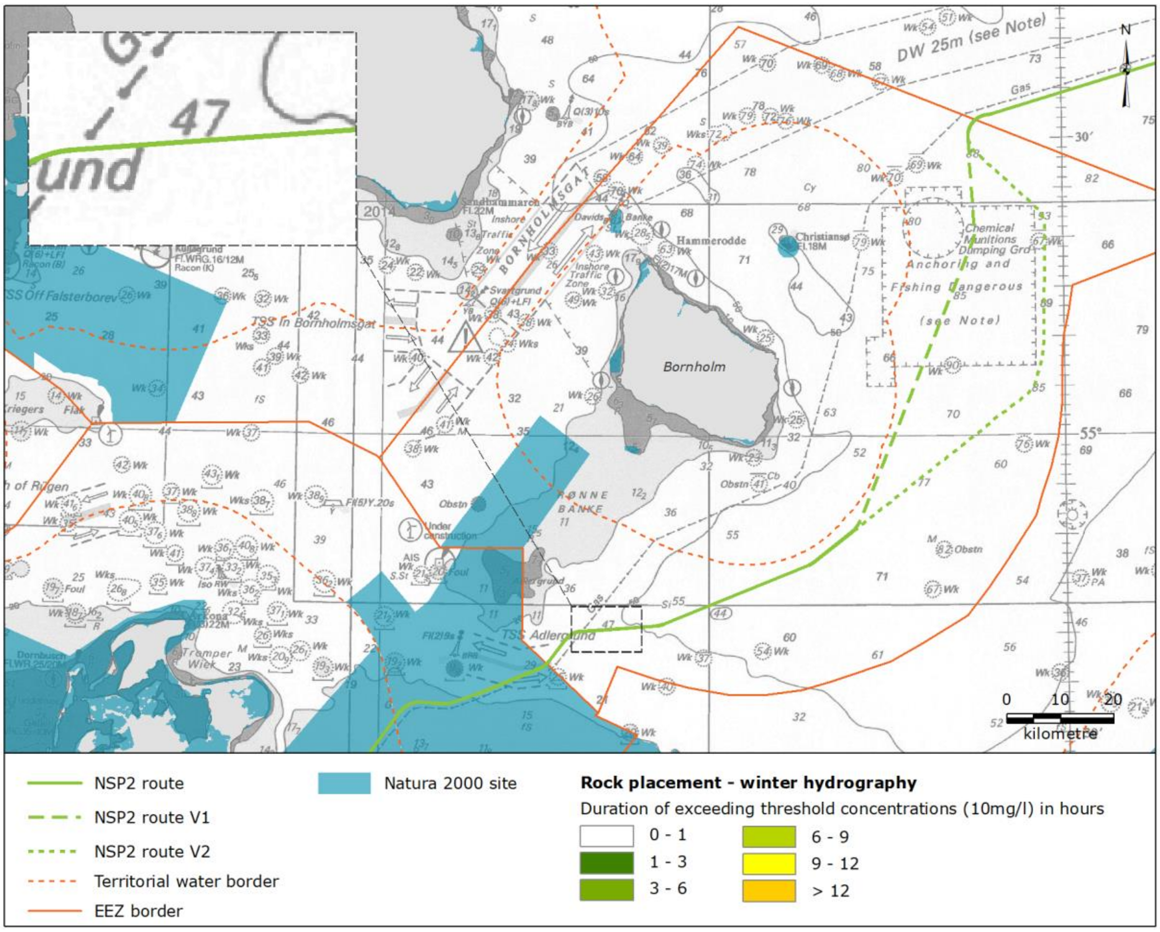

Figure 8-6 Duration of suspended sediment exceeding 10 mg/l as a result of rock placement under typical winter conditions.

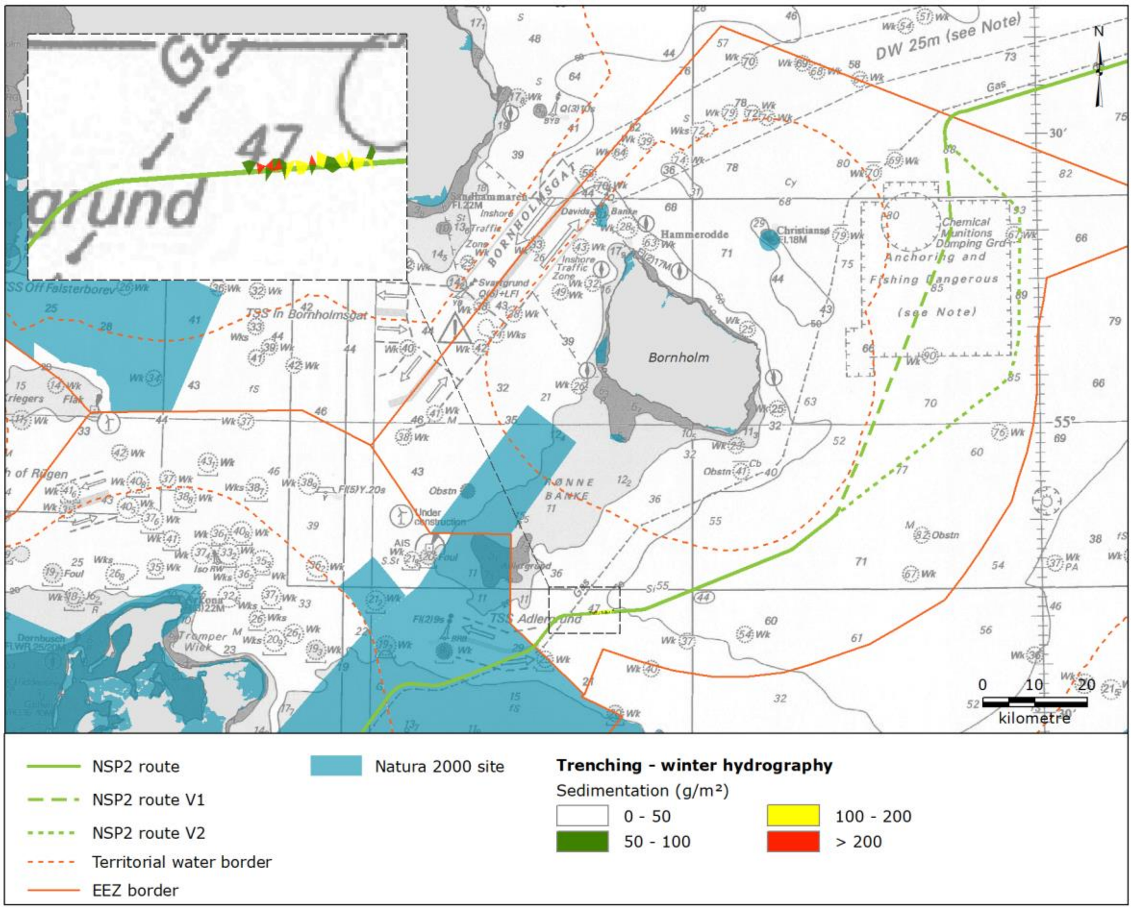

Figure 8-7 Maximum sedimentation levels as a result of trenching under typical winter conditions.

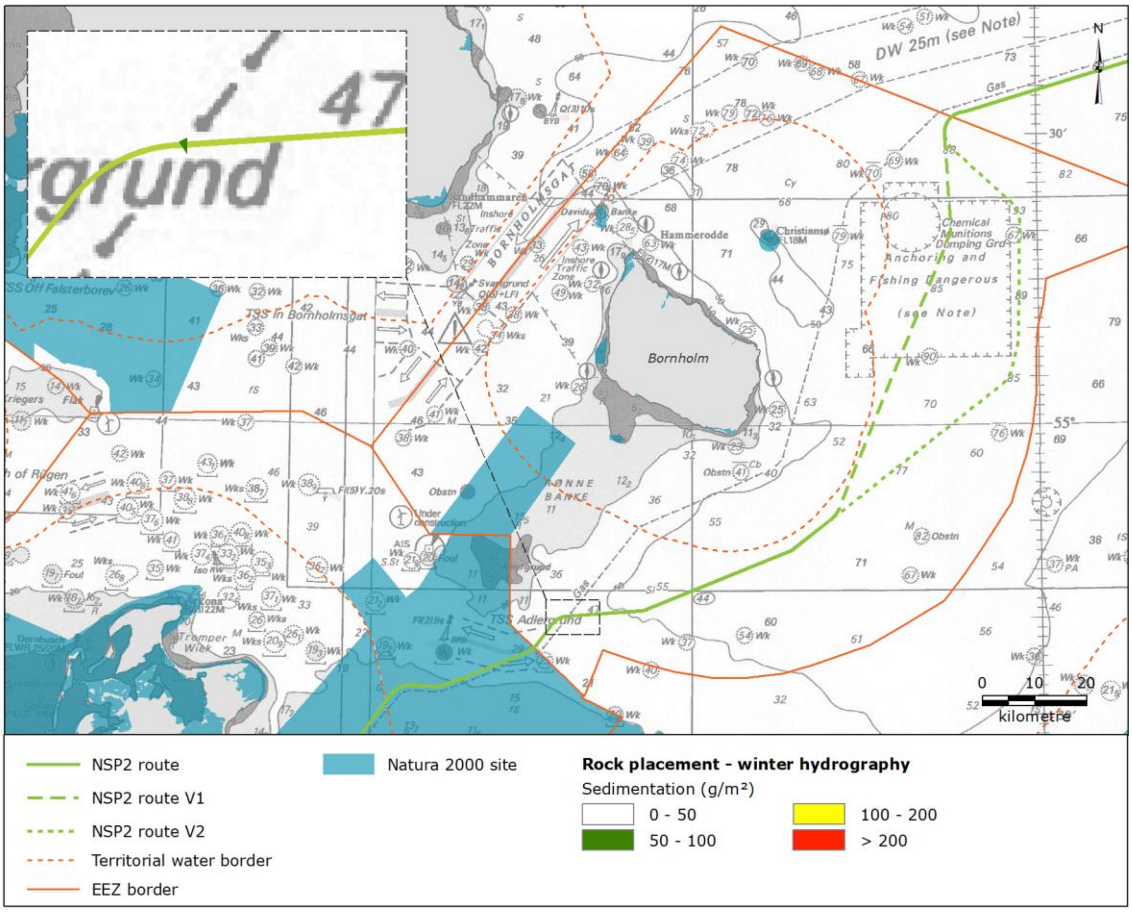

Figure 8-8 Maximum sedimentation levels as a result of rock placement under typical winter conditions.

8.4.1.4 Summary of modelling results

Modelling of the release of sediment has been undertaken for planned intervention works south of Bornholm (post-lay trenching) and at the crossing of NSP (rock placement).

Three scenarios have been modelled based on typical hydrodynamic conditions (winter, summer, normal), with the “Winter” condition being regarded as the most conservative. For all results please refer to /310/.

Modelling results indicate that release of suspended sediment will occur near the intervention works and that increased concentrations of sediment are generally local and short-term. The following is concluded based on the modelling:

- For the area south of Bornholm (post-lay trenching), modelling results indicate that increased concentrations of suspended sediment (>2 mg/l) can occur for up to 4.5 hours in an area of 12.9 km^2, with concentrations of up to 14.1 mg/l at a distance of 1 km from the intervention works;
- For the crossing of NSP (rock placement), modelling results indicate that increased concentrations of suspended sediment (>2 mg/l) can occur for up to 0.5 hours in an area of 0.04 km^2, with no measurable concentration at a distance of 1 km from the intervention works.

Modelling results also show that sedimentation is generally local and of low intensity. Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. Modelling results indicate that in the vicinity of post-lay trenching, an area of 1.05 km^2 may experience sedimentation above 100 g/m^2, and in the vicinity of rock placement, no area will experience sedimentation above 100 g/m^2.

The detailed modelling results are summarised in Table 8-14, Table 8-15 and Table 8-16.

Table 8-14 Modelling results for suspended sediment – duration and area.

Seabed intervention	Parameter	Concentration		
		>2 mg/l	>10 mg/l	>15 mg/l
South of Bornholm (post-lay trenching)	Maximum duration (hours)	4.50	2.00	2.00
	Area (km^2)	12.90	5.75	4.12
NSP crossing (rock placement)	Maximum duration (hours)	0.50	0.00	0.00
	Area (km^2)	0.04	0.00	0.00

Table 8-15 Modelling results for suspended sediment – maximum concentration.

Season	Maximum concentration at specific distances from pipelines (mg/l)		
	(200 m)	(500 m)	(1,000 m)
South of Bornholm (post-lay trenching)	78.50	37.1	14.1
NSP crossing (rock placement)	2.08	0.60	0.00

Table 8-16 Modelling results for sedimentation.

Season	Parameter	Sedimentation				
		>10 g/m^2	>50 g/m^2	>100 g/m^2	>150 g/m^2	>200 g/m^2
South of Bornholm (post-lay trenching)	Area (km^2)	7.54	1.85	1.05	0.32	0.24
NSP crossing (rock placement)	Area (km^2)	0.26	0.05	0.00	0.00	0.00

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 8-17.

Table 8-17 Summary of monitoring studies of sediment dispersion during NSP.

Country	Year	Purpose	Method	Period
Sweden	2010-2011	Monitoring the increase in turbidity (suspended sediment concentration) and sedimentation at the border of Hoburgs Banke and Norra Midsjöbanken	Fixed stations	November 2010 to August 2011
	2011	Monitoring of the sediment plume during trenching in the vicinity of Hoburgs Banke and Norra Midsjöbanken for NSP Line 1	Vessel-based monitoring	January 2011
	2012	Monitoring of the sediment plume during trenching in the vicinity of Hoburgs Banke and Norra Midsjöbanken for NSP Line 2	Vessel-based monitoring	March 2012
Denmark	2011	Evaluation and documentation of the sediment plume during trenching for NSP Line 1 in Danish waters	Vessel-based monitoring	February 2011
	2012	Evaluation and documentation of 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 measurements of water column	Fixed sensor	June-July 2010
	2011	Monitoring of water quality during rock placement	Fixed sensors	March-May 2011
Russia	2011	Sediment dispersion monitoring 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 suspended sediment concentrations and sedimentation rates before, during and after post-lay trenching of NSP Line 1 in 2011. Furthermore, the sediment plume generated by post-lay trenching was monitored from vessels during the trenching of NSP Line 1 in 2011 and NSP Line 2 in 2012 /312//313/.

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) /314//315/.

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 20 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 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 in 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 /316/. Subsequent monitoring in Finland (2011) showed suspended sediment concentration 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 suspended sediment concentration caused by rock placement were significantly lower than those calculated by numerical modelling (i.e. the numerical modelling presented a conservative scenario).

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.

Since the conditions are similar along the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2, the two route alternatives are considered the same with respect to sediment dispersion in connection with pipeline installation.

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 as it is lowered through the near-seabed water and comes into contact with the seabed;
- The pressure from the pipeline when it makes contact with the seabed.

The pipeline will be laid from a pipe-lay vessel with a low horizontal speed of approximately 3 km/day for a DP vessel and approximately 1-2 km/day for an anchored vessel. Modelling has shown that only a very small amount of sediment is suspended as the pipeline is laid on the seabed, even for worst-case scenarios /317/. 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 may sink partially into the seabed, some small suspension of sediment near the bottom can be expected /317/. 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 suspended sediment concentrations 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 /318/. 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 /316/. Similarly, there were no suspended sediment concentration recordings above background levels at fixed turbidity sensors, located 50 m from the pipeline route (approx. 1.5–2 m above the seabed), when using a DP vessel /316/.

Both modelling results and the results of NSP monitoring have shown that the levels of suspended sediments caused by the pipe-lay are lower than those resulting from intervention works (post-lay trenching and rock placement).

Pipe-lay will be carried out by either anchored or DP pipe-lay vessels in Danish waters. 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 pipe-lay vessel (see below for further description).

An anchor-based pipe-lay vessel moves with a speed of approximately 1-2 km/day. When the pipe-lay vessel is moving forward, the anchor wire will sweep across the seabed in a section of a circle, as shown in Figure 8-9. 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).

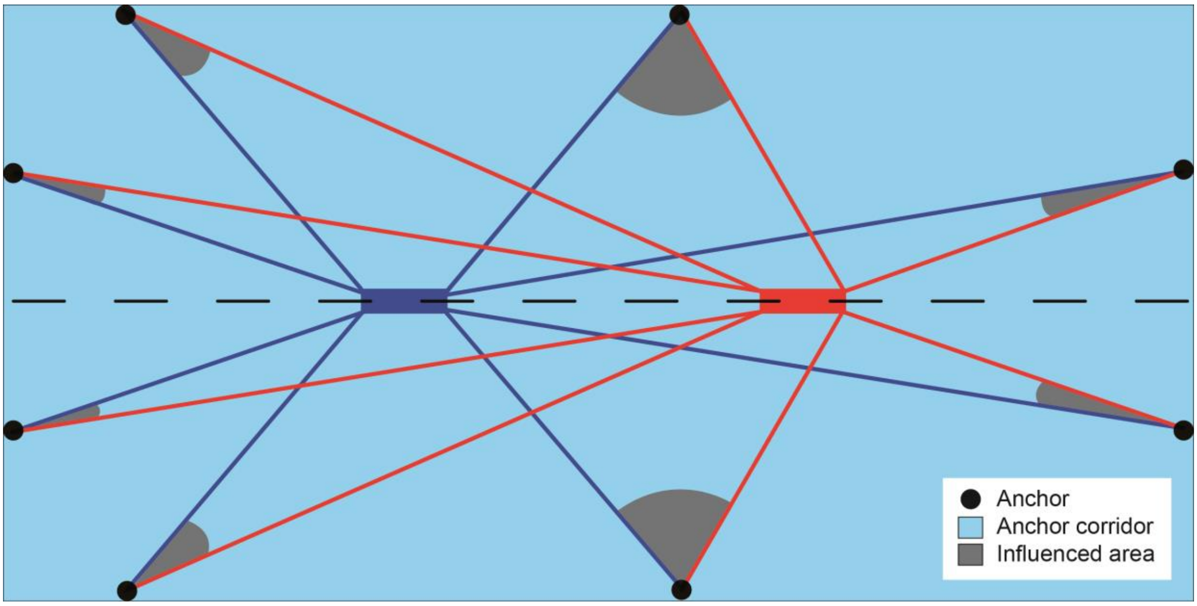

Figure 8-9 Schematic illustration of the areas influenced by the anchor wire (2% of the total anchor corridor of 2 km). It should be noted that this is an explanatory illustration and that the number of anchors can be up to 12. Red and blue colours represent relocation of the pipe-lay vessel from one position to another one.

As noted above, monitoring in 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 /319/.

In sensitive areas, an anchor pattern will be developed to minimise impacts from anchor handling.

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 /320/. 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 concentrations (dry weight) <500 kg/m^3 /320/. 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 concentrations (dry weight) <200 kg/m^3 /320/.

The water depth along the proposed NSP2 route in Danish waters is predominantly >40 m (up to approximately 92 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. 6 km stretch leading up to the German-Danish EEZ-border), the water depth varies between 30 and 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. 6 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. 145 km).

As noted above, monitoring in 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) /316/.

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 8.4.2.1) and/or from vessel-related operations (anchored pipe-lay vessel or DP vessel, see sections 0 and 8.4.2.3, respectively). The highest magnitude of sediment dispersion is expected to be related to intervention works (post-lay trenching and rock placement), and the assessments performed in section 9 focus on these activities.

8.4.3 Release of contaminants and nutrients into the water column

Suspension and dispersion of sediment during the construction phase will result in the release of contaminants and nutrients (N and P) into the water column. In this section, the quantities of contaminants and nutrients that may be remobilised together with seabed sediments and potentially released during NSP2 construction are evaluated. This is performed based on the modelling results presented in section 8.4.1 and the current knowledge regarding the content of contaminants in the sediments along the proposed NSP2 route (see section 7.3.3). It is noted that the increased concentrations discussed below are caused by the release of contaminants and nutrients that are already present in the environment (in the seabed), and not by a net addition into the system.

Since the conditions are similar along the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2, the two route alternatives are considered the same with respect to the release of contaminants and nutrients into the water column.

As a worst-case scenario in regard to sediment spill, it is assumed that the pipeline will be supported by post-lay trenching rather than rock placement throughout Section 1 (see Figure 6-17). In that case, rock placement will only occur in section 2, and will amount to a total of 60,000 m^3 (102,000 t) of rock. The rocks will be placed with a rate of 40,000 t/day, and the rock placement will thus take approximately 2.6 days. The spill rate during rock placement in Danish waters has been modelled to be 0.22 kg/s of sediment /309/, which yields a total spill of approximately 48 t of sediment. A typical DW of the sediment in this area is 45%, and this number therefore corresponds to the release of approximately 22 t of sediment by dry weight.

In the worst-case scenario, post-lay trenching will be performed throughout section 1, i.e. along 4 km of the route for each pipeline with a rate of 300 m/hour, thus lasting in total 27 hours. The typical rate of sediment spill is 7 kg/s during trenching. Using these figures and a dry weight of 45%, which is typical for this area, in total 302 t of dry sediment will be suspended during post-lay trenching in the area.

Multiplying these amounts of spilled sediment with the highest measured sediment concentrations of N and P along the route (see Table 7-17), it can be calculated that rock placement and post-lay trenching will cause the release of 2.1 t N and 0.5 t P into the water phase.

The amounts of contaminants that will be suspended into the water column during seabed interventions 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 in the sediment along the route (see Table 7-3 to Table 7-15). The results of such a calculation are given in Table 8-18.

Table 8-18 Amounts of contaminants expected to be remobilised during rock placement and post-lay trenching.

Contaminant	Highest concentration measured in sediment from the area, mg/kg	Total amount of contaminant suspended during seabed intervention, kg
N	6,500	2,107
P	1,600	519
As	21	6.8
Pb	66	21
Cd	1.2	0.39
Cr	58	19
Cu	52	17
Co	22	7.1
Hg	0.066	0.021
Ni	45	15
V	105	34
Zn	200	65
Total PAH	3.0	1.0
Total PCB	0.0052	0.0017
Total organochlorine	0.014	0.0045
TBT, DBT, MBT	0.015	0.0047

The concentrations of the different contaminants corresponding to suspended sediment concentration values of 2 mg/l and 15 mg/l are listed in Table 8-19. Also listed in the table are DEPA/EU criteria for environmental quality standards (EQS) for seawater. The calculation of contaminants in the water column is based on the highest measured concentrations along the proposed NSP2 route and the highly conservative assumption that all contaminants contained in the seabed sediment will be released.

Table 8-19 Amounts of contaminants in the water column when the suspended sediment concentration is 2 mg/l and 15 mg/l. Values that exceed the DEPA/EU EQS thresholds are indicated in bold.

Contaminant	Concentration in water (max value at 2 mg/l suspended sediment concentration), µg/l	Concentration in water (max value at 15 mg/l suspended sediment concentration), µg/l	DEPA/EU EQS, Maximum concentration, µg/l
As	0.042	0.32	1.1
Pb	0.132	1.0	14
Cd	0.0024	0.018	0.45
Cr	0.116	0.87	17
Cu	0.104	0.78	4.9
Co	0.044	0.33	34
Hg	0.00013	0.0010	0.07
Ni	0.090	0.68	34
V	0.21	1.6	57.8
Zn	0.40	3.0	8.4
Acenaphthene	0	0.000000	3.8
Acenaphthylene	0.000042	0.00032	3.6
Benz[a]anthracene	0.00026	0.0020	0.018
Benzo[a]pyrene	0.00034	0.0026	0.027
Benzo[b]fluoranthene	0.0008	0.0060	0.017
Benzo[k]fluoranthene	0.00036	0.0027	0.017
Benzo[ghi]perylene*	**0.00092**	**0.0069**	0.00082
Chrysene	0.00020	0.00149	0.014
Dibenz[a,h]anthracene	0.00026	0.0020	0.018
Indeno[1,2,3-cd]py-rene**	**0.0013**	**0.00975**	0.00017
Fluoranthene	0.00102	0.00765	0.12
Fluorene	0.00006000	0.0004500	21.2
Naphthalene	0.000186	0.001395	130
Phenanthrene	0.00042	0.0032	4.1
Pyrene	0.00062	0.00465	0.023
TBT	0.000029	0.000218	0.0015
* Also abbreviated in this report as BghiPer. ** Also abbreviated in this report as Ipyr.			

With the exception of BghiPer and Ipyr, the contaminant concentrations corresponding to 2 mg/l and 15 mg/l suspended sediment concentration are far below the EQS thresholds. As described in section 8.4.1, modelling indicates that in connection with post-lay trenching, an area of 12.9 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 4.5 hours, and an area of approximately 4.12 km^2 may be affected by a suspended sediment concentration of >15 mg/l for a period of up to two hours. In connection with rock placement, an area of 0.04 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 0.5 hours, and no area will be affected by a suspended sediment concentration of >10 mg/l.

8.4.4 Release of chemical warfare agents into the water column

As described in section 7.3.3.8, quantitative chemical analysis of target CWA and their degradation products in sediment samples from the Bornholm Basin and the surrounding area has been undertaken, both in the context of NSP, NSP2 and the CHEMSEA project /91//92//125/.

An in-depth evaluation of the potential toxicological effects of CWA has been performed based on the measurements taken during a survey along the proposed NSP2 route and the NSP2 route V2 in 2018 /322/. Only three different CWA compounds were detected during this survey; 1,4-dithiane, 1,2,5-trithiepane, and dipropyl phenylarsonodithioite (see also section 7.3.3.8). The pore water CWA concentrations that correspond to the measured concentrations in the bulk sediment (calculated from total concentrations of CWA and equilibrium partitioning between solid and dissolved state) are listed in Table 8-20 and compared to their respective predicted no-effect concentration (PNEC) in relation to fish populations /322/.

Table 8-20 Predicted environmental concentrations (PEC) in pore water/bottom water and PNEC of each CWA and CWA degradation product.

CWA	Calculated mean inherent pore water concentration (PEC) µg/l	PNEC µg/l
1,4-dithiane	0.57	1.65
1,2,5-trithiepane	0.037	1.65
Dipropyl phenylarsonodithioite	0.022	290

As can be seen in Table 8-20, the inherent pore water concentrations of CWA in the sediment along the proposed NSP2 route and NSP2 route V2 are far below their respective PNEC for fish. Thus, even assuming a bottom water concentration of CWA similar to that of the sediment pore water, the current level of CWA in the water does not pose any risk to fish populations.

Furthermore, it was calculated that even in areas of seabed intervention, where sediment dispersion is most severe, the CWA concentration in the water will only increase marginally and will remain far below the PNEC for fish /322/.

A similar evaluation was carried out for the NSP2 route V1 based on data from the area collected during the 2015 survey (see description in section 7.3.3.8) /289/. The NSP2 route V1 passes closer to the dumping area and the frequency and diversity of CWA detections was greater than for the NSP2 route V2. The calculated mean concentrations of CWA compounds are summarized in Table 8-21.

Table 8-21 Predicted environmental concentrations (PEC) in pore water/bottom water and PNEC of each CWA and CWA degradation product based on 2015 data from the CWA risk area.

CWA	Calculated mean inherent pore water concentration (PEC) µg/l	PNEC µg/l
Sulphur mustard	0.040	690
1,4-dithiane	1.8	1.65
1,4,5-oxadithiepane	0.52	1.65
1,2,5-trithiepane	0.13	1.65
Adamsite	0.75	290
5,10-dihydroxyphenarsazin-10-ol 10-oxide	0.0020	290
Diphenylarsinic acid	0.0091	290
Diphenylpropylthioarsine	0.0062	290
Triphenylarsine	0.0004	290
Triphenylarsine oxide	0.0008	290
Phenylarsonic acid	0.67	290
Dipropyl phenylarsonodithioite	0.16	290

With the exception of 1,4-dithiane, the porewater concentrations of the CWA compounds was below the PNEC. Thus, even assuming a bottom water concentration of CWA similar to that of the sediment pore water, the level of most CWA in the water does not pose any risk to fish populations. The calculated porewater concentration of the sulphur mustard degradation product 1,4-dithiane is slightly above the PNEC. However, as was the case for the NSP2 route V2, the potential increase in bottom water concentration of the various CWA compounds caused by seabed interventions will be marginal /289/. Thus, since no seabed interventions are planned in the area of the NSP2 route V1, it is assessed that there will be no detectable increase in the concentrations of 1,4-dithiane or other CWA compounds in the bottom water. Furthermore, it should be noted that the concentration of 1,4-dithiane was lower during the more recent survey performed along the NSP2 route V1 in 2019 (see Table 7-23). A detailed analysis of the 2019 results is ongoing at the time of issuing this report.

The conclusion of the above is that neither the combination of the proposed NSP2 route with V1 nor the combination of the proposed NSP2 route with V2 are expected to cause any detectable increase in CWA concentration in the water column or negative impacts on fish populations.

8.4.5 Underwater noise

During the construction of NSP2, activities may generate underwater noise. Rock placement activities are considered to be the noisiest of construction activities within Danish waters and were therefore the focus of modelling (summarised below). Generation of underwater noise from pipe-lay and post-lay trenching will be less than or similar to rock placement and has therefore not been modelled.

Since rock placement is planned to occur in the same location regardless of which route variant (i.e., NSP2 route V1 or NSP2 route V2) is selected in combination with the proposed NSP2 route, the two route alternatives are considered the same with respect to the generation of underwater noise.

8.4.5.1 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 8-10 exemplifies the spectral distribution of the sound pressure level (SPL) 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).

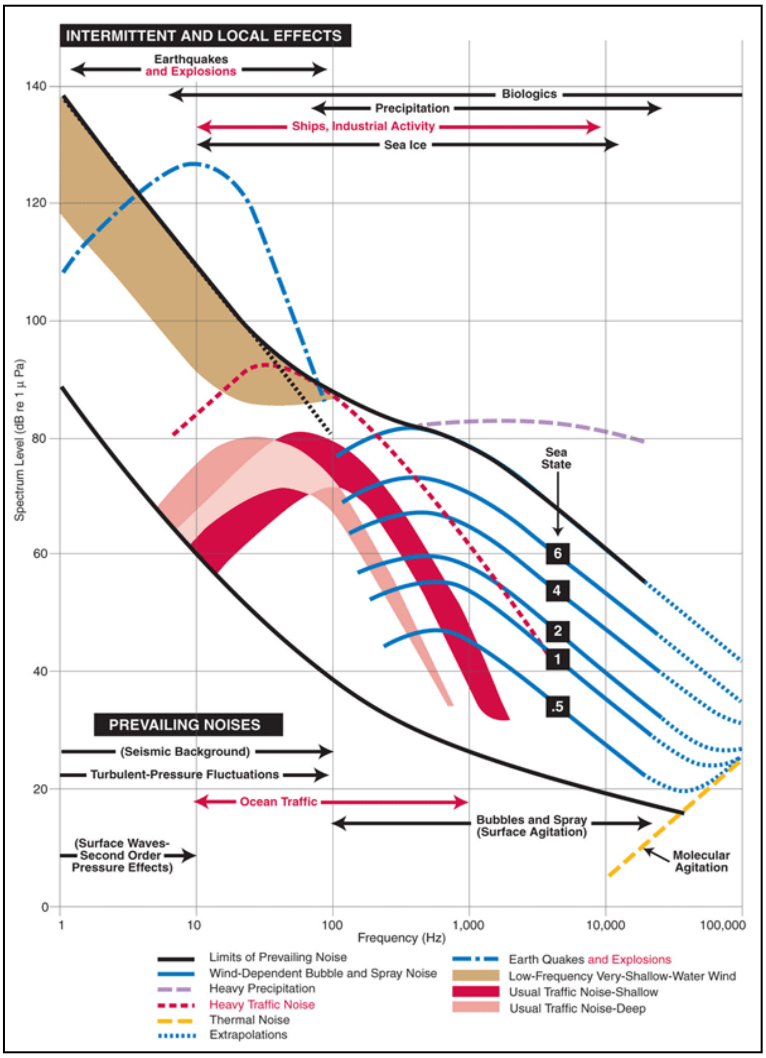

Figure 8-10 General expression of sound pressure spectral distribution in the sea /323/.

The main sources of anthropogenic underwater noise are commercial shipping, fishing, military activities, construction activities, seismic exploration, recreational boating and operational wind farms. Underwater noise may carry long distances from known sources and, depending on its intensity and frequency, may have the potential to disturb marine fauna /324/.

8.4.5.2 HELCOM background data

The HELCOM definition of GES with respect to underwater sound requires that "the level and distribution of both continuous and impulsive sounds should not cause negative impacts on marine life" /111/.

Continuous sound from a source (e.g. bridges, offshore wind turbines, shipping) can be constant, fluctuating, or slowly varying over a long time interval. Continuous sound levels in the Baltic Sea were measured in a comprehensive study using automated hydrophone loggers in 2014 by the project Baltic Sea Information on the Acoustic Soundscape (BIAS). The data were used to develop modelled soundscapes, which show the spatial and temporal distribution of continuous sound in different frequency bands across the Baltic Sea (1/3 octave bands of 63, 125 and 2,000 Hz). The lower frequency bands are typical of ship-induced sound, and the higher frequency bands are measured due to their ecological relevance.

Data from the BIAS project are shown in Figure 8-11 /325/. The figure shows the 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.

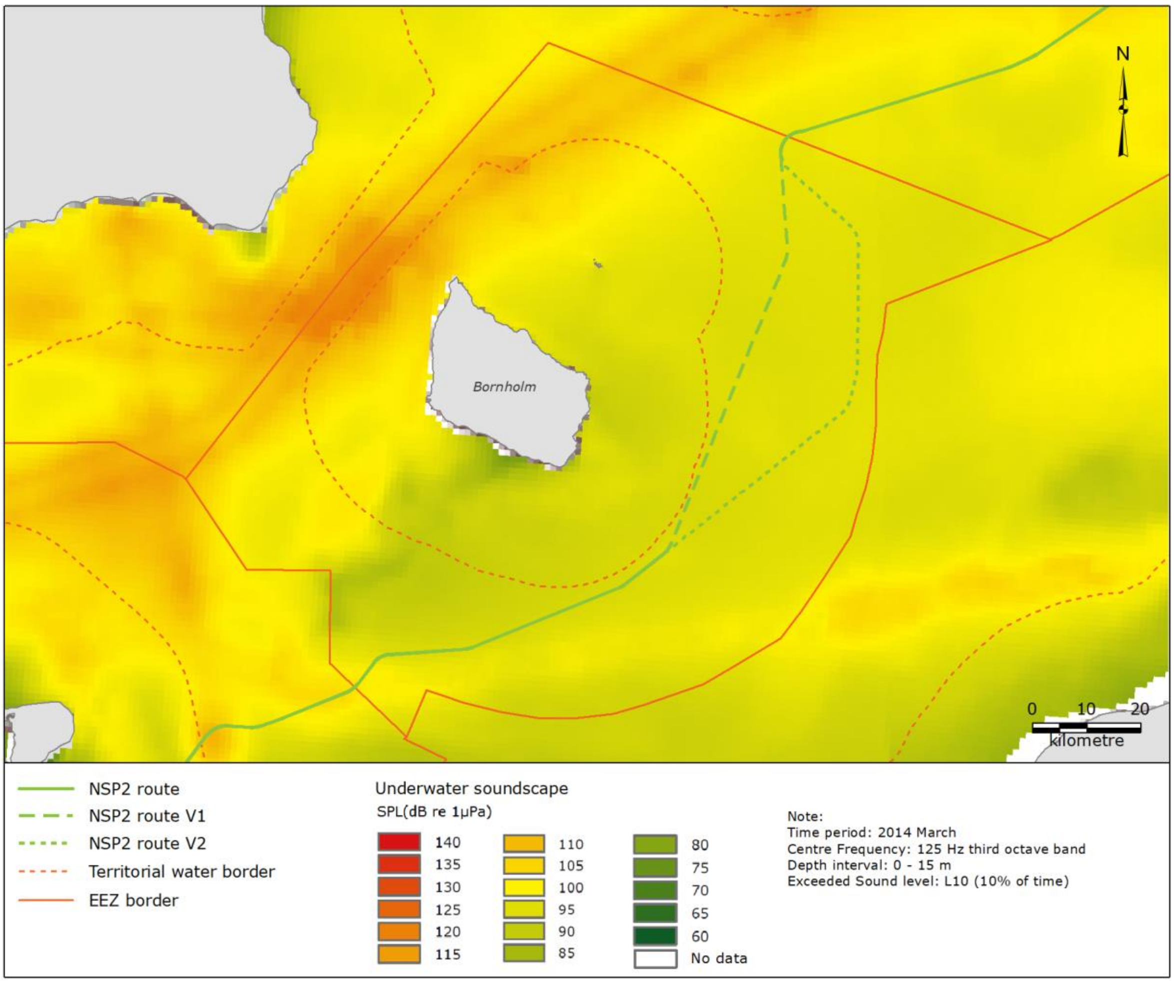

Figure 8-11 Underwater noise levels from BIAS. The figure shows the SPL for March 2014. The figure shows L10, which is the sound levels exceeded 10% of the time. *These results have been extracted with help of the BIAS soundscape planning tool, which was prepared within the EU LIFE project Baltic Sea Information on the Acoustic Soundscape (BIAS LIFE11 ENV/SE 841);* www.bias-project.eu.

Impulsive sound is characterised by short duration and a fast pulse rise time (e.g. piling, underwater explosions or airgun signals used in seismic surveying). The occurrence of activities associated with loud impulsive sounds, such as sonar events, airguns and underwater explosions and pile driving, can (since 2015) be logged in a regional registry established by HELCOM and OSPAR and hosted by ICES. Countries have agreed to register these activities, and Denmark has delivered data on pile driving for 2015 (12 events) /111/.

8.4.5.3 Modelling methodology

Modelling of noise from rock placement (considered the worst case planned underwater noise) was undertaken at one location (RP1), namely, the crossing of the proposed NSP2 pipelines with the NSP pipelines (see Figure 8-12).

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 in the area. Based on source location and underwater source sound level, 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 programme, 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 centre 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 3,000 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) re 1 m[10]. 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 /326/.

[10] 1 m from the sound source.

8.4.5.4 Modelling results

The full modelling results for Denmark (both winter and summer conditions) are presented in /326/.

The underwater sound propagation modelling results included the root mean square (RMS), sound exposure level (SEL) and SELcumulative (2 hour) levels relative to distances and as noise maps. The levels depicted in the noise maps are the maximum predicted level for the location at any depth down to the bottom and include the following acoustic parameters for each of the identified significant sound sources.

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 below 110 dB re 1 µPa at a distance of >25-30 km from the source, corresponding to the ambient noise level in the Baltic Sea, and the noise from NSP2 activities will be similar to that of passing ships in the nearby shipping routes (see section 8.4.5.1).

The modelling results for rock placement during winter (worst case) are shown for SEL in Figure 8-12. 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 SEL(Cum) levels are presented and related to threshold levels used to evaluate impact on the 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 sections 9.8 and 9.9, and summarised in Table 8-22. The modelling results show that underwater noise from rock placement will not exceed threshold levels causing PTS, whilst exceedance of threshold levels causing TTS will only be detectable in the vicinity of the proposed NSP2 pipeline route (80 m or less for marine mammals and 100 m or less for fish).

The assessment of potential impact of noise from construction and operation of NSP2 is based on unweighted (broadband) thresholds for inducing temporary and permanent threshold shifts (TTS and PTS, respectively) in seals and harbour porpoises. Recent recommendations from the US /388/ advocate for the use of frequency-weighted sound levels and thresholds in assessments (referred to as NOAA guidelines). The NOAA guideline thresholds are lower than shown in Table 9-20. The thresholds used in this EIA and in the NOAA guidelines are based on the same experimental data, however, so the difference lies in the frequency weighting. The frequency weighting is equivalent to the A-weighting routinely performed in human audiology and noise assessments, and is essentially a normalisation of thresholds to the frequency range of best sensitivity for the animal. This means that because most of the experimental data on TTS in seals and porpoises is from low-frequency signals, the thresholds are lowered considerably in the normalisation process. It has been decided to perform assessments using unweighted levels and thresholds, as no Danish or European guidelines exist. If a frequency weighting had been applied to the NSP2 assessment, this would have resulted in significantly lower weighted exposure levels used in the modelling and thus the thresholds applied in the modelling are conservative.

Table 8-22 Underwater noise assessment levels for marine mammals and fish, and distances to these.

Rock placement		Assessment levels	Threshold distances (summer/winter)
		SEL(Cum*)	SEL(Cum*)
Marine group	**Effect**	**dB re 1µPa²s**	**m**
Seals	PTS	200 dB	0
	TTS	188 dB	80
Porpoises	PTS	203 dB	0
	TTS	188 dB	80
Fish	Mortality (mortal injury)	207 dB	0
	Injury	203 dB	0
	TTS	186 dB	100
Eggs and larvae	Injury	210 dB	0
* Cumulative SEL (2 hour rock placement)			

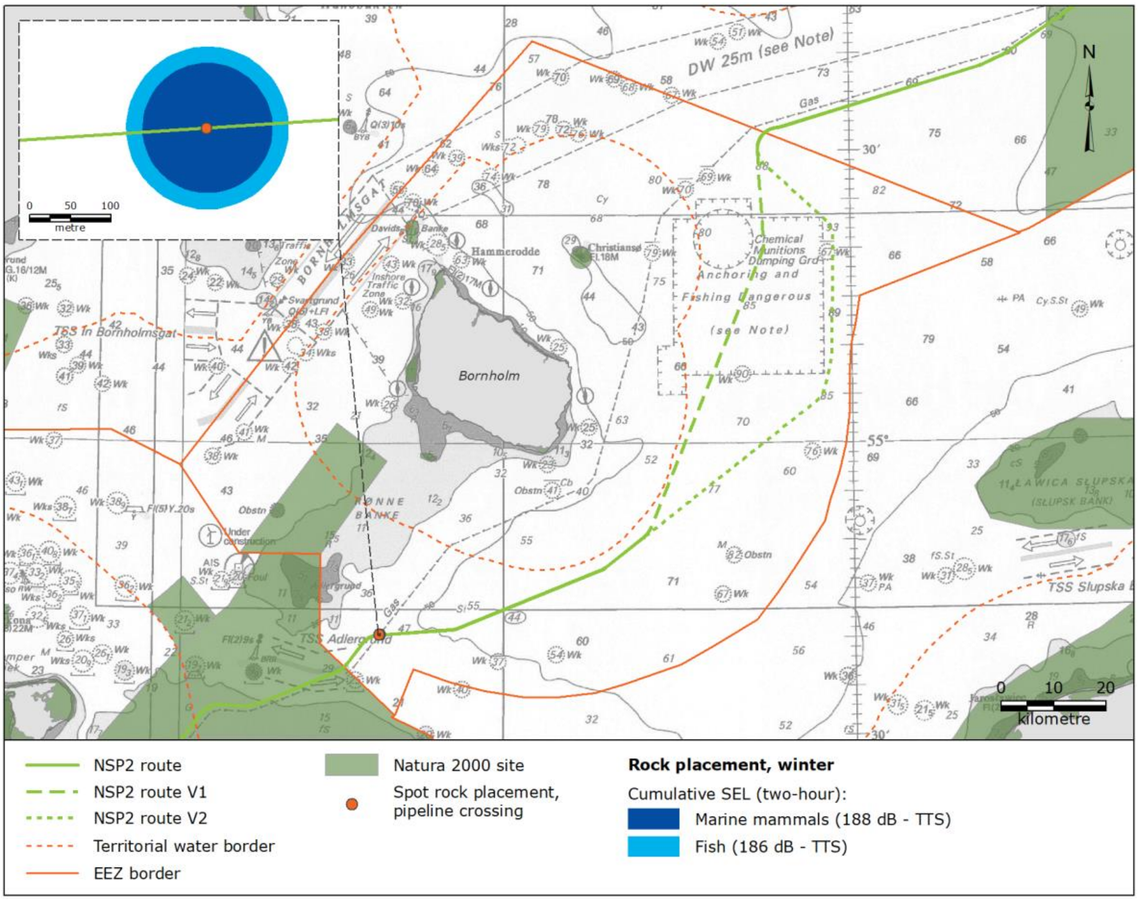

Figure 8-12 Rock placement, underwater continuous noise level contour plot showing cumulative SEL, dB re 1 µPa², 1 sec (winter). The SEL levels are related to the threshold levels used in the assessment for fish and marine mammals.

8.4.6 Airborne noise

During construction and operation, there is the potential for airborne noise to be generated by vessels (i.e., from main and auxiliary engines and from ventilation fans).

Since the same vessels will be used during construction and operation of the NSP2 pipeline regardless of which route variant (i.e. NSP2 route V1 or NSP2 route V2) is selected in combination with the proposed NSP2 route, the two route alternatives are considered the same with respect to the generation of airborne noise.

8.4.6.1 Modelling methodology

Modelling of airborne noise was undertaken based on the characteristics that result in the highest noise level; i.e. with downwind and a moderate negative temperature gradient (lower temperature near the ground). This situation was estimated using the General Prediction Model /327/. This method anticipates a geometrical noise transmission (6 dB reduction in noise levels for each doubling of the distance).

The General Prediction Model /327/ 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]

8.4.6.2 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. Airborne noise from the pipe-lay vessel (considered worst case) during construction activities was modelled for the existing NSP pipelines.

The calculated noise levels are shown in Figure 8-13 at the location along the NSP2 route closest to land (this is the same location along both the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2). At a distance of 4,100 m from the vessel, the noise level was assessed to be 33 dB (see Atlas Map NM-02-D).

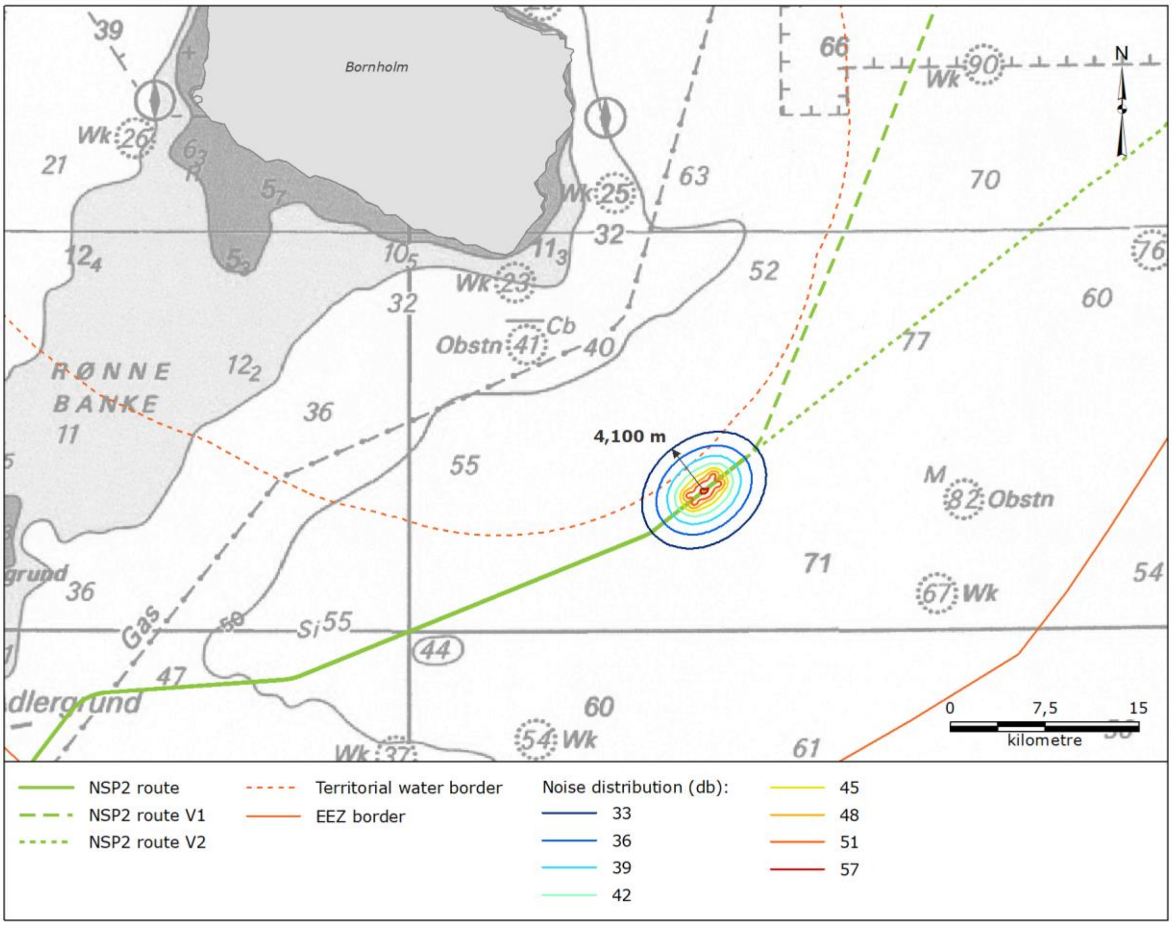

Figure 8-13 Propagation of airborne noise from the pipe-lay vessel.

8.4.7 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.

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 areas set more stringent standards for SO_X, NO_X and particulate matter.

In order to assess the impact of the project on air emissions, emission calculations have been undertaken for the construction and operation of NSP2 within Danish waters, as summarised below. The emission calculations have been performed for the combination of the proposed NSP2 route with V2. Since there are only marginal differences between this route and the proposed NSP2 route with V1 (relating to a slight difference in the length of the pipeline), the two route alternatives are considered similar with regard to emissions.

8.4.7.1 Methodology

The following activities (described in general words) are included in the emission calculations for the Danish section of NSP2:

1. Construction phase
   - Transport of coated pipes from interim stockyards to the NSP2 route;
   - Pipe-lay (including both pipe-lay and survey vessel);
   - Transport of rocks from interim stockyards to the NSP2 route;

- Rock placement;
- Post-lay trenching;
- Crossing of existing installations (mattress placement);
- Fuel supply by bunker vessel;
- Crew change, other materials.

2. Operation phase
    - Inspection
    - Maintenance of rock berms

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 the 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 t CO_2/t fuel /328/.

The NO_X emissions from vessels working in the Baltic Sea are for this purpose set at 5.7 g NO_X/kWh (medium speed 4-stroke diesel ship engines 2000-2010) /328/. For evaluation purposes, NO_X has been treated as NO_2.

The SO_2 emissions from vessels working in the Baltic Sea, which has SECA status, are for evaluation purposes set at 0.001 t SO_2/t fuel, according to limit values on sulphur content in marine fuels /329/.

The particle emissions from vessels working in the Baltic Sea are for evaluation purposes set at 0.0018 t TSP/t fuel (emission factors for diesel ship engines in international seas after 2010) /328/.

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:

$$Emission\ (t) = Energy\ consumption\ (kWh)\ x\ time\ slice\ (\%)\ x\ emission\ factor\ (\frac{t}{kWh}) \qquad \text{Eqn. 2}$$

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 and up to 220 g/kWh for a 4-stroke engine /330/. For evaluation purposes, a fuel consumption rate of 195 g/kWh has been assumed for all engines /331/.

In the 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 the pipe-lay vessel.

A large share of the emissions to air within Danish waters will be due to the operation of the DP vessel used for pipe-lay. Generally, emissions from a DP vessel to be used for pipe-lay in Danish waters are higher compared to a suitable anchored vessel. Therefore, calculations of emissions for a DP vessel are considered for further assessment. In the emission calculations, the DP vessel is assumed to operate with 70% engine power, which can be considered a worst case.

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 here will be in the order of magnitude of the emissions that will effectively arise.

8.4.7.2 Total emission loads

Table 8-23 summarises the estimated emission loads associated with each activity planned within Danish waters during construction and operation of NSP2.

Table 8-23 Estimated emissions loads from Danish offshore activities during construction and operation of NSP2, scenario with the use of a DP vessel for pipe-lay (worst case engine power use).

Activity	Estimated emissions loads (t)			
	CO_2	NO_X	SO_2	Particulate matter
Crossing of existing cables	1,922	18	1.2	1.1
Pipe supply, including thrusters	25,081	237	16	15
Pipe-lay	57,531	542	37	33
Survey vessel during pipe-lay	11,490	108	7.4	6.7
Rock placement	844	8.0	0.5	0.5
Trenching	387	3.6	0.2	0.2
Fuel supply, crew exchange, etc.	167	1.1	0.2	0.1
Operation (50 years)	33,667	317	22	20
Total Denmark (rounded)	131,090	1,236	85	76

8.4.8 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 consist mainly of aluminium, with about 5% zinc and 0.002% cadmium as well as small amounts of indium, iron, silicon and copper (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.

Since the seawater conditions are similar along the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2, the two route alternatives are considered the same with respect to the release of metals from anodes into the water column.

8.4.8.1 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 /332/.

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 /333/. At pH values less than 6, dissolved and toxic Al^{3+} 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 aluminium from anodic corrosion protection is given in /334/. It 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 aluminium in the water above the sediment was not above the background level observed at a reference station outside the harbour. This illustrates efficient precipitation of aluminium released into the water from the anodes.

The low toxicity of aluminium in aquatic environments is illustrated by the fact that bulk addition of aluminium sulphate 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 /335/. 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 aluminium ions at normal marine pH and the high background of naturally occurring aluminium in the sediment, it is concluded that the release of aluminium 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 will cross 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 along the rest of the NSP2 route. However, as discussed above, the release of aluminium will not be harmful to biota in the area.

8.4.8.2 Release of zinc

Zinc ions are potentially toxic to aquatic life, as reflected by the ERL value listed in Table 7-3 (150 mg/kg in marine sediment) and the EQS value listed in Table 7-24 (8.4 µg/l in marine water).

The potential release of zinc from anodes was modelled and evaluated during the EIA phase for NSP /336/, 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 metres around the pipelines. It was also concluded that bioaccumulation, i.e. concentration of zinc 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.

In deep areas of the proposed NSP2 route where free sulphide is present in the water phase, zinc may form ZnS that will precipitate locally on the sediment surface. However, because there are no bottom fauna or fish in these anoxic areas, the resulting locally increased zinc concentrations in the sediment will have no impact on higher life.

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 along the rest of the NSP2 route. Based on the conclusions above, however, it is assessed that the higher number of anodes in the area of the NSP/NSP2 crossing will not change the assessment, and the release of zinc will have no impact on water quality.

8.4.8.3 Release of cadmium

Cadmium ions are potentially toxic to aquatic life, as reflected by the low ERL value listed in Table 7-3 (1.2 mg/kg in marine sediment) and the EQS value listed in Table 7-24 (0.45 µg/l in marine water). Cadmium constitutes about 0.002% of the anode material, whereas zinc constitutes about 5%. The amount of released Cd is thus expected to be roughly 2,500 less than the amount of released zinc, whereas the ERL for cadmium is about 127 times less than for zinc (see Table 7-3). The impacts from cadmium can thus be expected to be less than for zinc. Therefore, as was the case for zinc, it is not expected that the release of cadmium to the water will have any implications for the water quality or bioaccumulation, except for in a zone of a few metres 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 change the assessment that the release of cadmium will have no impact on the water quality.

8.4.8.4 Conclusion

The release of aluminium, zinc and cadmium from anodes during the lifetime of the NSP2 pipelines will not result in general increases of the concentration of these metals in seawater, apart from a few metres in the vicinity of the pipelines. It is also noted that the resulting chemical compounds (ZnS, $Al(OH)_3$) generated under anoxic conditions are basically inert and not bio-active, and therefore do not pose a risk to sediment quality or benthic fauna.

Where the NSP2 pipelines cross the NSP pipelines, there is a potential for multiple anodes to be located in close proximity to one another. However, due to dilution, elevated concentrations of metals will be localised to the area immediately around the crossing, and it is assessed that the combined impact from the pipelines will be negligible.

Due to the nature of the impact and its very localised extent, no cumulative impacts from the release of contaminants from pipeline anodes are anticipated during operation. As the anodes will be depleted over time, any localised impacts on sediment or water quality in the immediate vicinity are also expected to incrementally decrease over time.

9 ASSESSMENT OF POTENTIAL IMPACTS

9.1 Bathymetry

The sources of potential impacts on bathymetry during construction and operation of NSP2 are listed in Table 9-1 and assessed below.

Table 9-1 Sources of potential impacts on bathymetry during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on the seabed	X	
Sedimentation on the seabed	X	
Physical presence of pipelines and structures on the seabed		X

9.1.1 Construction phase

In the following sections, the identified sources of potential impacts on bathymetry during the construction phase are assessed. Since the impacts during the construction phase relate to seabed intervention works that will not take place in the area close to the Swedish EEZ (i.e. where the proposed NSP2 route diverges into the NSP2 route V1 and the NSP2 route V2), the two route alternatives are considered equal in this section.

9.1.1.1 Physical disturbance on the seabed

Construction activities, mainly post-lay trenching and rock placement, will result in physical disturbance on 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 and which is not resilient to the changes caused by physical disturbance. Therefore, the sensitivity is assessed to be high.

The location and extent of seabed intervention works (post-lay trenching and rock placement) to be carried out along the proposed NSP2 route in Danish waters are described in section 6. Post-lay trenching will displace 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 sediment deposits 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.

Regardless of the route alternative selected, post-lay trenching is expected to be carried out along a 4-km section of the route south of Bornholm, and is estimated to take approximately two days (one day for each line).

Rock placement will be used for protection and support of the pipelines at the intersection between the NSP and NSP2 pipelines south of Bornholm (approximately 42 m water depth), and potentially for support in other sections of the proposed NSP2 route south of the Bornholm Basin (at approximately 50 m water depth). In total, 60,000 m^3 of rock material will be placed at the crossing with NSP, and approximately 42,880 m^3 will be placed in sections where stabilisation is needed.

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, NSP2 route V1 and NSP2 route V2 (see section 7.3.3.1), no erosion is expected at water depths shallower than 40 m. Along the proposed NSP2 route, NSP2 route V1 and NSP2 route V2, the water depth is less than 40 m only along the last kilometres of the proposed NSP2 route before it enters the German EEZ. In this area, the sediment is naturally sandy, and the impact from thrusters on the seabed bathymetry is expected to be minimal.

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 to be affected by construction works is very small compared to the surrounding region, which is characterised by a similar environment. In the case that an anchored pipe-lay vessel is employed, anchors and anchor chains will disturb the sediment locally, but there will be very little impact on bathymetry.

In summary, the impact on bathymetry associated with physical disturbance on the seabed during construction is assessed to be local, long-term and of medium intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the high sensitivity and negligible impact magnitude, 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 layers on the seabed, which may affect the seabed profile. With a yearly sedimentation rate of a few millimetres, 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.

As described in section 8.4.1, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 – 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a find sand sediment layer of less than 1 mm. According to the modelling, a total area of 0.24 km^2 will experience >200 g/m^2 of deposited sediment due to post-lay trenching and no area will experience >200 g/m^2 of deposited sediment due to rock placement. 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, the impact on bathymetry associated with sedimentation during construction is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on bathymetry from sedimentation on the seabed is assessed to be negligible.

9.1.2 Operational phase

In the following section, the identified source of potential impact on bathymetry during the operational phase is assessed. Since the environmental conditions at the seabed and bathymetric profiles are similar for the two route alternatives, they are considered equal in this section.

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 (i.e. rock placement, mattresses) will result in a localised reduction of water depth. However, given that the diameter of the pipeline will be approximately 1.4 m, the overall reduction in water depth should not exceed a few metres. It will be greatest in areas of rock placement at the NSP crossing. The water depth at the planned crossing with NSP south of Bornholm (which is presently approximately 45 m) will be reduced by approximately 4-5 m (see section 6.4.2.2).

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 effects of scour on seabed accretion and erosion processes were modelled to assess the impact of NSP /448/. 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) would be up to 10-12 times the pipeline diameter, corresponding to 12-14 m. Potential impacts of scour caused by the presence of pipelines in shallower areas (i.e. with relatively stronger currents than would be expected long the proposed route) have also been modelled /449/. This showed that scour will not cause sediment transport in these areas unless water currents exceed 0.4 m/s. Both these studies concluded, that scouring along the pipeline would not cause the release of significant amounts of sediment that could cause environmental impacts /448/.

The maximum speed of the inflowing bottom current is achieved during large bottom water inflows, and is around 0.3 m/s /127/. A scour effect can thus be expected only during extreme events of major bottom water inflows. 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 associated with the physical presence of pipelines and structures on the seabed during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on bathymetry from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.1.3 Summary of impacts

The assessments of the potential impacts on bathymetry during the construction and operational phases of NSP2 are summarised in Table 9-2.

Table 9-2 Assessment of the overall impacts on bathymetry during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance on the 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 the conclusions in the sections above (see Table 9-2), the 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 sediment quality during construction and operation of NSP2 are listed in Table 9-3 and assessed below.

Table 9-3 Sources of potential impacts on sediment quality during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on the seabed	X	
Sedimentation on the seabed	X	
Physical presence of pipelines and structures on the seabed		X
Release of metals from anodes		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 sections, the identified sources of potential impacts on sediment quality during the construction phase are assessed. Since the impacts during the construction phase relate to seabed intervention works that will not take place in the area close to the Swedish EEZ (i.e. where the proposed NSP2 route diverges into the NSP2 route V1 and the NSP2 route V2), the two route alternatives are considered equal in this section.

9.2.1.1 Physical disturbance on the seabed

Construction activities, mainly post-lay trenching and rock placement, will result in physical disturbance on the seabed, which may affect seabed sediment quality. A conservative assumption is that physical disturbance on the seabed may cause long-term changes, which do not revert naturally over time; the sensitivity to physical disturbance is therefore assessed to be high.

The locations of seabed intervention works to be carried out along the proposed NSP2 route in Danish waters are described in section 6, and include post-lay trenching and rock placement.

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, it is not expected 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 expected to be present in all the affected layers. The surface layer of the sediment is thus expected to revert to pre-intervention conditions.

Rock placement will result in a new hard substrate being placed on the seabed, but will not change the quality of the existing sediment.

Further sediment disturbance can be caused by anchoring or the use of DP vessels in shallow areas. These impacts are highly localised and on a much smaller scale than those caused by seabed interventions discussed above.

Contaminants will be resuspended with sediment and re-distributed on the seafloor as it settles in the areas around the seabed interventions. However, this will not lead to any overall changes in sediment quality. 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.

CWA is present in the sediment along parts of the proposed NSP2 route, NSP2 route V1 and NSP2 route V2, mainly in the deep sections within the Bornholm Basin, where no post-lay trenching and rock placement will take place. CWA bound to sediment particles as well as larger intact lumps may also be remobilised and redistributed together with sediments during intervention works. Larger lumps of CWA (e.g. viscous mustard gas) can be broken into smaller pieces, thus increasing their 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 /445//446/. This concluded that the relocation of chemical munitions is primarily caused by 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 chemical munitions and CWA /122/. 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 /446/. Therefore, it must be expected that 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.

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 to the marine environment were insignificant /447/. 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 contaminant levels of the surrounding seabed environment.

In summary, the impact on sediment quality associated with physical disturbance on the seabed during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on sediment quality from physical disturbance on the seabed 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 to sedimentation is therefore assessed to be high.

As shown in section 8.4.1, modelling indicates that as a result of trenching, a total area of 0.24 km^2 may experience sedimentation that exceeds 200 g/m^2, corresponding to a sediment layer of approximately 1 mm. Rock placement will not result in sedimentation exceeding 200 g/m^2. The sedimentation that is predicted is therefore below the range of natural background sedimentation rates (1.5 - 4.5 mm/year, see section 7.3.2).

Sediment dispersion and sedimentation can also be caused by the physical impact of laying the pipeline on the seabed, anchor handling or the use of DP vessels in shallow water during pipe-lay. Based on the results presented in section 8.4.2, the amount of sedimentation caused by pipe-lay (including anchor handling and DP vessels) is expected to be less than that caused by seabed intervention works.

The sedimentation will be temporary, within natural variation and highly localised. Therefore, the 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 activity.

In summary, the impact on sediment quality associated with sedimentation on the seabed during construction is local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on sediment quality from sedimentation on the seabed is assessed to be negligible.

9.2.2 Operational phase

In the following sections, the identified sources of potential impacts on sediment quality during the operational phase are assessed. Since the environmental conditions at the seabed and bathymetric profiles are similar for the two route alternatives, they are considered equal in this section.

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 the pipelines and piles of rocks from rock placement. These changes can affect the resuspension rate in the immediate vicinity of the pipelines (scour) as well as the local sedimentation rate. Taking into account that seabed sediment is an important receptor, the sensitivity is assessed to be high.

As discussed in section 9.1.2.1, the spatial scale and intensity of scour and the associated sedimentation are highly localised and insignificant in comparison to the vast area of bottom habitat surrounding the proposed NSP2 route, NSP2 route V1 and NSP2 route V2.

In summary, the impact on sediment quality associated with the physical presence of pipelines and structures on the seabed during operation is considered local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on sediment quality from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.2.2.2 Release of metals from anodes

Metals (aluminium, zinc, cadmium) will be released from the corrosion protection anodes during the lifetime of the pipeline and most will ultimately settle on the sediment, where they will be efficiently retained. Taking into account that seabed sediment is an important receptor, the sensitivity is assessed to be high.

The spatial extent of the wider area around the pipeline where the metals will ultimately accumulate and add to the natural background content of aluminium, zinc and cadmium depends on local patterns of currents and erosion/sedimentation, similar to the general sedimentation process discussed in section 7.3.2. As discussed in section 8.4.8, the amounts of metals released from the pipeline anodes will be very small compared to other sources of metals sedimenting in the same areas, and it is not expected that the levels of aluminium, zinc or cadmium in the seabed sediment will be affected above background variations.

In summary, the impact on sediment quality associated with the release of metals from anodes during operation is considered local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on sediment quality from the release of metals from anodes is assessed to be negligible.

9.2.3 Summary of impacts

The assessments of the potential impacts on sediment quality during the construction and operational phases of NSP2 are summarised in Table 9-4.

Table 9-4 Assessment of the overall impacts on sediment quality during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance on the 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
Release of metals from anodes	High	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-4), the 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 9-5 and assessed below.

Table 9-5 Sources of potential 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, the identified source of potential impact on hydrography during the construction phase is assessed. Since the impacts during the construction phase relate to seabed intervention works that will not take place in the area close to the Swedish EEZ (i.e. where the proposed NSP2 route diverges into the NSP2 route V1 and the NSP2 route V2), the two route alternatives are considered equal in this section.

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 may 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 works and pipe-lay activities during NSP2 construction are discussed in sections 8.4.1, 8.4.2 and 9.1.1.2. Sedimentation will generally be less than 1 mm, which is within the natural range of yearly sedimentation in the Bornholm Basin /346/. The changes are therefore not of a magnitude that will cause any hydrographical changes in the marine environment.

In summary, the impact on hydrography associated with sedimentation on the seabed during construction is assessed to be temporary, local and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on hydrography from sedimentation on the seabed is assessed to be negligible.

9.3.2 Operational phase

In the following section, the identified source of potential impact on hydrography during the operational phase is assessed. Since the environmental conditions at the seabed and bottom water and the bathymetric profiles are similar for the two route alternatives, they are considered equal in this section.

9.3.2.1 Physical presence of pipelines and structures on the seabed

The physical presence of 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 /448//450/. 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 phosphorus dynamics;
- The pipelines will have no effect on or will 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 /451/. 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 thorough review of the hydrographic impacts on the Baltic Proper for the NSP2 base case route conducted in 2016 also concluded that there would be no impacts on hydrographical bulk flow or sediment accretion/erosion /451//484/. The proposed NSP2 route lies further away from the main areas of seawater inflow to the Baltic Sea than the NSP route and NSP2 base case route, and effects can thus be expected to be even smaller. In addition, the results of the 2016 evaluation of the

NSP2 base case route have been re-examined with respect to the proposed NSP2 route and are assessed to remain valid.

In summary, the impact on hydrography associated with the physical presence of pipelines and structures on the seabed during operation is considered local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on hydrography from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.3.3 Summary of impacts

The assessments of the potential impacts on hydrography during the construction and operational phases of NSP2 are summarised in Table 9-6. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-6 Assessment of the overall impacts on hydrography during construction and operation of NSP2.

Source of potential impact	Receptor Sensitivity	Impact magnitude	Overall impact	Potential transboundary 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 the conclusions in the sections above (see Table 9-6), the 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 water quality during construction and operation of NSP2 are listed in Table 9-7 and assessed below.

Table 9-7 Sources of potential impacts on water quality 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 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 sections, the identified sources of potential impacts on water quality during the construction phase are assessed. Since the impacts during the construction phase relate to seabed intervention works that will not take place in the area close to the Swedish EEZ (i.e. where the proposed NSP2 route diverges into the NSP2 route V1 and the NSP2 route V2), the two route alternatives are considered equal in this section.

9.4.1.1 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. Although water quality will be affected by increased suspended sediment loads, 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 into 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 in connection with post-lay trenching, an area of 12.9 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 4.5 hours, with concentrations of up to 14.1 mg/l at a distance of 1 km from the intervention works. An area of approximately 4.12 km^2 may be affected by a suspended sediment concentration of >15 mg/l for a period of up to two hours. 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 seabed intervention works. Thus, the system will rapidly revert to its pre-impact state once the activity ceases.

In the deep sections of the proposed route the halocline will limit the mixing of dense bottom water with less saline surface water. This will limit the spread of sediment at the spot rock placement at the crossing with NSP south of Bornholm.

In summary, the impact on water quality associated with the release of sediments into the water column during construction is assessed to be temporary, local, and of medium intensity. Therefore, the impact magnitude is considered low.

Based on the low sensitivity and low impact magnitude, the overall impact on water quality from the release of sediments into the water column is assessed to be minor.

9.4.1.2 Release of contaminants into the water column

Construction activities will result in the release of contaminants into the water column. Water quality will be affected by increased contaminant levels in areas with suspended sediment, but most contaminants will resettle on the seabed, adsorbed to the sediment particles, and thus be removed from the water in a short time period. Therefore, the water quality will revert back to pre-impact status in regard to most contaminants found in the sediment. Contaminants may also be released from vessels during construction. These contaminants are more likely to be dissolved and thus remain in the water for a longer time period. Overall, it is conservatively assessed that the sensitivity of water quality towards impacts of released contaminants is medium.

Release from sediments

Based on the modelling of sediment spreading during NSP2 construction as well as field survey results, section 8.4.3 provides a conservative estimate of the total amount of heavy metals and organic contaminants that may be remobilised and released into the water during seabed intervention works. The concentrations of heavy metals and organic contaminants dispersed in the water at a suspended sediment concentration of 2 and 15 mg/l were also estimated. These calculations show that heavy metal concentrations in the water column are not expected to exceed thresholds for EQS established by DEPA/EU. The impact from metals in the water column is therefore considered to be temporary, localised and of low intensity. With the exceptions of BghiPer and Ipyr, the same can be concluded with respect to organic contaminants. At an SSC of 15 mg/l, the water content of BghiPer and Ipyr may be up to 8- and 57-fold higher than the DEPA/EU EQS threshold value, respectively, assuming that all contaminants associated with the sediments are released (see Table 8-19) and that the concentrations in the sediment are similar to the highest values measured during surveys in 2015 and 2018. However, the exceedances of EQS thresholds will only last for a few hours since most of the organic contaminants (including BghiPer and Ipyr) will remain adsorbed to the sediment particles and therefore settle on the seabed together with the sediment.

It is noted that the halocline in the water column will restrict the transport of metals, organic contaminants and CWA suspended during post-lay trenching to shallower water depths.

The impact from contaminants in the water column is therefore considered to be temporary, localised and of low intensity.

As discussed in section 8.4.3, the total re-suspension of N and P along the NSP2 route due to seabed intervention works is conservatively estimated to amount to 2.1 t of N and 0.5 t of P. In comparison, the yearly waterborne N/P loads to the Baltic Proper were in the range of 310,000-560,000 t of N and 13,000-27,000 t of P in the years 1995 to 2010 /107/. Thus, the levels of N and P released from the sediment as a result of seabed intervention during NSP2 would not cause a measurable change in nutrient availability or level 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, local and of low intensity.

Hydrogen sulphide is a common end product of the microbial degradation of organic material, and is naturally 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 hydrogen sulphide is released into oxygenated bottom water (areas where the bottom 10 m 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 /154/, 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 a negligible impact on water quality.

Discharge from vessels
During construction of NSP2, a number of vessels will be operating along the proposed route. On this basis, there is the potential for discharges from vessels to impact water quality. 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; 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 away 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 water 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 untreated sewage will take place from stationary 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.
- Ballast water. Vessels will be compliant with the provisions of the Ballast Water Management Convention (September 2017) (see also section 9.11.2.3).

In light of the above, no impacts on water quality as a result of discharges from vessels are anticipated.

In summary, the impact on water quality associated with the release of contaminants (metals, organic contaminants, N and P, hydrogen sulphide and/or discharges from vessels) into the water column during construction is assessed to be local, temporary and of low to medium intensity. Therefore, the impact magnitude is considered low.

Based on the medium sensitivity and low impact magnitude, 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 into the water column

As noted in section 8.4.1.1, seabed intervention works, pipe-lay, anchoring operations and the 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 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 particulate 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 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 was discussed in section 8.4.4 and was shown not to constitute a threat to fish in the area. Furthermore, any increase in CWA concentration in the water will be temporary because the CWA will resettle on the seabed shortly after suspension.

In summary, the impact on water quality associated with the release of CWA into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, 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, the identified sources of potential impacts on water quality during the operational phase are assessed. Since the environmental conditions at the seabed and bottom water and the bathymetric profiles are similar for the two route alternatives, they are considered equal in this section.

9.4.2.1 Generation of heat from gas flow through the pipelines

Water that comes in contact with unburied pipeline sections may experience a small increase in temperature as it passes over the surface. This temperature effect is temporary, and the water will quickly revert to its original temperature, with no lasting effects on water quality. Therefore, 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, 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 cause 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 reaches equilibrium with the surrounding water body within 0.5 to 1 m after crossing the pipeline, and the impact is therefore highly local. 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, the impact on water quality associated with the generation of heat from gas flow through the pipelines during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on water quality from the generation of heat from gas flow through 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 section of NSP2 to protect the pipelines from corrosion, which will result in the release of aluminium, zinc and cadmium. Water passing the anodes will be affected by increased levels of these metals, and will afterwards revert back to its pre-impact status as it is diluted with unaffected water from the surrounding area. 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 near vicinity of the anodes (within a 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 regard to such effects.

Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity to one another. However, elevated concentrations of metals will be localised 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 water quality associated with the release of metals from anodes during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on water quality from the release of metals from anodes is assessed to be negligible.

9.4.3 Summary of impacts

The assessments of the potential impacts on water quality during the construction and operational phases of NSP2 are summarised in Table 9-8.

Table 9-8 Assessment of the overall impacts on water quality 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	Low	Minor	No
Release of contaminants into the water column	Medium	Low	Minor	No
Release of chemical warfare agents into the water column	Low	Negligible	Negligible	No
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 9-8), 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 9-9 and assessed below.

Table 9-9 Sources of potential impacts on climate and air quality during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Emissions of air pollutants and greenhouse gases - impacts on climate	X	X
Emissions of air pollutants and greenhouse gases - impacts on local air quality	X	X

Within this section, the phrase "air emissions" is used to collectively refer to CO_2 (an important GHG, which is considered the main driver of climate change), as well as NO_X, SO_2 and PM (gases that affect local air quality).

As discussed in section 8.4.7, emissions are considered to be of a similar magnitude for both route alternatives, and they are therefore considered equal in this section.

9.5.1 Construction and operational phases

Construction and operation of NSP2 will generate air emissions that have the potential to impact climate (through emissions of GHGs) 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 precipitate within a relatively short time span. Emitted CO_2, however, will remain in the atmosphere and contribute to global warming. Taking into account that climate and air quality is an important receptor, it is assessed that the sensitivity of the receptor to NO_X, SO_2 and PM emissions is low, while the sensitivity to 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 8.4.7. The total load is predicted to comprise approximately 131,090 t of CO_2, 1,236 t of NO_X, 85 t of SO_2 and 76 t of PM. No other GHG (e.g. methane) is expected to be emitted during NSP2 construction or operation.

The majority of emissions 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 2016, the total annual Danish emissions of CO_2, NO_X, SO_X and PM caused by shipping in all Danish waters were approximately 2,596,000 t, 58,687 t, 1,636 t and 1,497 t, respectively /328/.

Indirect effects from the construction of NSP2 include the increased availability and consumption of natural gas in the EU. As discussed in section 3, the natural gas exported by NSP2 is largely expected to substitute the current consumption of coal and will therefore have a positive impact on the total CO_2 emission of the EU.

In summary, the impacts on climate during construction and operation are assessed to be regional, temporary to long-term (dependant on the project phase) and of low intensity. With respect to air quality, the impacts during the construction and operational phases are local, temporary to long-term (dependant on the project phase) and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low to medium sensitivity and negligible impact magnitude, the overall impact on climate and air quality from emissions from NSP2 vessels is assessed to be negligible.

9.5.2 Summary of impacts

The assessments of the potential impacts on climate and air quality during the construction and operational phases of NSP2 are 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 on climate and air quality 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 9-10), 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 plankton during construction and operation of NSP2 are listed in Table 9-11 and assessed below.

Table 9-11 Sources of potential impacts on plankton 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 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 sections, the identified sources of potential impacts on plankton during the construction phase are assessed. Since the impacts during the construction phase relate to seabed intervention works that will not take place in the area close to the Swedish EEZ (i.e. where the proposed NSP2 route diverges into the NSP2 route V1 and the NSP2 route V2), the two route alternatives are considered equal in this section.

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 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 environmental 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.

Increased concentration of suspended sediment may occur in the vicinity of the proposed intervention works (post-lay trenching, rock placement). Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the duration of sediment concentration above 2 mg/l is expected to last up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing (see section 8.4.1).

Furthermore, it is noted that where intervention works are planned on sections of the route that are beneath the halocline, natural stratification will reduce the upwards transport of suspended sediment (see section 9.4). Therefore, any increases in the concentration of suspended sediment will be contained within the lower section of the water column, where phytoplankton is 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 on 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 /337/. 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 previously been shown to cause significant damage to a zooplankton community in the form of decreased growth and reproduction /337/. As discussed above, such levels of suspended sediments will be confined to the close proximity of the pipeline in the areas where post-lay trenching will take place.

In summary, the impact on plankton associated with the release of sediments into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on plankton from the release of sediments into 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 and nutrients (N and P), 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 (moving with water currents) and has a short turnover time, which enables it to rapidly recover to its pre-impact status once an environmental impact ceases. Thus, plankton is assessed to be resilient to contaminants in the water column and the sensitivity is assessed to be low.

Calculations and modelling have been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column are generally not expected to result in concentrations which exceed thresholds for EQS, with the exception of the two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. The majority of contaminants will re-deposit on the seabed (associated with sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route. In addition, the majority of the released contaminants would be limited to the lower 10 m of the water column, and most (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/.

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 contaminant and nutrient release (see section 9.4.1.2), the amounts will be considerably below 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 /338/. 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 that 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, the impact on plankton associated with the release of contaminants into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on plankton from the release of contaminants into the water column is assessed to be negligible.

9.6.1.3 Release of chemical warfare agents 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 (moving with 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.

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. As discussed in section 9.4.1.3, the impact on water quality from CWA has been assessed to be negligible, and below applicable PNEC thresholds (see section 8.4.4).

Furthermore, it is noted that where intervention works are planned on sections of the route that are beneath the halocline, natural stratification will reduce the upwards transport of CWA (see section 9.4). Therefore, any increases in the concentration of CWA will be contained within the lower section of the water column, where plankton are generally not abundant.

In summary, the impact on plankton associated with the release of CWA into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, 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 section, the identified source of potential impact on plankton during the operational phase is assessed. Since the environmental conditions at the seabed and bottom water and the bathymetric profiles are similar for the two route alternatives, they are considered equal in this section.

9.6.2.1 Release of metals from anodes

As described in sections 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 (aluminium, zinc, cadmium) into the water column. Release of aluminium from the anodes will not cause ecotoxicological impacts; however, cadmium and zinc 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 the release of metals into the water column and the sensitivity is assessed to be low.

As discussed in sections 8.4.8 and 9.4.2.2, the release of aluminium, zinc and cadmium 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 near vicinity of the anodes (within a 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 level of water-borne inflow of metals to the area, and no discernible impacts on plankton populations are expected.

Where NSP2 crosses NSP, there is the potential for multiple anodes to be located in close proximity to one another, which may have a combined impact on the concentrations of metals in the water column. However, these elevated concentrations of metals will be confined to a highly localised area (within a few metres) around the crossing. Although some individuals may be impacted, the concentrations are not expected to be elevated to such a level that would cause a discernible impact on plankton populations.

In summary, the impact on plankton associated with the release of metals from anodes during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, 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 on plankton during the construction and operational phases of NSP2 are 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 on plankton 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 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 9-12) 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 flora and fauna during construction and operation of NSP2 are listed in Table 9-13 and assessed below.

Table 9-13 Sources of potential impacts on benthic flora and fauna during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on the 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 into the water column	X	
Change 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.

9.7.1 Construction phase

In the following sections, the identified sources of potential impacts on benthic flora and fauna during the construction phase are assessed.

9.7.1.1 Physical disturbance on the seabed

Construction activities, mainly post-lay trenching and rock placement, will result in physical disturbance on the seabed. This has the potential to impact the survival of benthic flora and fauna. Benthic flora and fauna will generally not be able to avoid physical disturbance with any form of evasive behaviour, and the resilience towards physical disturbance is therefore considered to be low. However, the populations are expected to recover over time after an environmental disturbance. Taking into account that benthic flora and fauna constitute an important receptor, the sensitivity is considered to be medium.

Impacts on benthic flora due to physical disturbance on the seabed are not expected, as the proposed NSP2 route will be placed at depths below the photic zone (i.e., greater than 20 m water depth), see section 7.8.

Most of the proposed NSP2 route will be placed at depths where the bottom water has a low oxygen content, which prevents the establishment of higher life forms on the seabed (i.e. the deep parts of the Bornholm Basin, see section 7.8).

However, physical disturbance associated with pipe-lay, post-lay trenching and/or rock placement in areas where oxygen levels and light conditions allow higher life forms to exist (i.e. primarily west of Bornholm, see section 7.8), may result in impacts such as mortality or temporary exposure of buried or bottom-dwelling organisms (infauna).

For fauna, 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 species that may be impacted are not considered to be threatened and are abundant throughout the Baltic Sea. No further impacts on the benthic community associated with physical disturbance on the seabed will occur outside the immediate footprint of construction activities.

Experience from the North Atlantic Ocean, North Sea and Baltic Sea shows that benthic faunal communities on a sandy seabed generally re-establish during a period of two to three years /340//341/. A study in inner Danish waters showed that benthic fauna were gradually normalised within a period of one year with regard to diversity and community structure, although biomass was still reduced to ~30% of the original level after sand extraction /342/. The first species to colonise disturbed habitat are typically small, fast-growing species of polychaetes (e.g. *Capitallidae* and *Spionidae*) and crustaceans, whilst recovery of other species such as bivalves may take up to two years /343/. A limiting factor for re-establishment of benthic fauna is the availability of larval stages. Studies of the pelagic environment in Kattegat show that biomass of pelagic larvae is unlikely to limit recruitment (that is, the number of larvae is high enough to ensure re-establishment of the benthic fauna) /342/. Another factor to consider is whether benthic fauna can colonise the disturbed habitat from nearby areas. As the expected disturbance is limited to local areas, colonisation from nearby areas is assessed to be likely.

In summary, the impact on benthic flora and fauna associated with the physical disturbance on the seabed during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on benthic flora and fauna from physical disturbance on the seabed is assessed to be negligible.

9.7.1.2 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. The local benthic flora and fauna can be buried by sediments and, in a worst-case scenario, be killed. Species-specific resilience will depend on the ability to dig through the additional sediment layer, though benthic organisms in the project area are likely to have a high tolerance to temporary increases in sedimentation, as shown by their ability to withstand the natural sedimentation rates in the Baltic Sea. Although benthic flora and fauna are considered an important receptor, the sensitivity to sedimentation on the seabed is assessed to be low.

As described in section 8.4.1, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 - 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. A total area of 0.24 km^2 is expected to experience >200 g/m^2 of deposited sediment due to post-lay trenching and rock placement. Areas that are expected to experience >200 g/m^2 of deposited sediment are associated with intervention works at the NSP crossing (rock placement and post-lay trenching) and the material will be deposited locally. Overall, the sedimentation will thus be local and of low intensity.

The marine benthic flora and fauna live 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 temporary increases in turbidity.

For fauna, studies of benthic invertebrate tolerance to sedimentation have shown that rates of about 1 mm/day, equivalent to a deposition of 1-2 kg sandy sediment per square metre per day (wet weight), may have a detrimental effect /339/. Specific thresholds for sedimentation of different species are presented in Table 9-14. Infauna species are generally tolerant to burial and can survive a cover of 2-26 cm of sand /340//344/. In general, epifauna are more vulnerable to sedimentation, and studies suggest that burial with 3-5 cm sand causes a decrease in total epibenthic biomass /340//344/.

Table 9-14 Sedimentation thresholds for different taxa /340//344//345/.

Taxa	Threshold
Infauna (polychaetes, bivalves, molluscs, crustaceans)	2-26 cm
Infauna (*Limecola baltica*)	10 cm
Infauna (crustacean, *Corphium volutator*)	1-3 cm
Epifauna (sea anemones, bivalves, sponges, sea urchins)	3-5 cm

Within the area of the Danish section of the proposed NSP2 route, flora have only been observed at Rønne Banke, at a distance of at least 10 km from the pipeline. The sensitivity of macroalgae to sedimentation is low, as the observed species are adapted to a turbid environment with periodic sedimentation events /340/.

As described above, the potential modelled sedimentation is highly localised, temporary, and less than 1 mm, and any impact will thus be of low intensity to benthic flora and fauna. The ecosystem, including benthic flora and fauna, will quickly revert to its natural state after the termination of the project activities.

In summary, the impact on benthic flora and fauna associated with sedimentation on the seabed during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on benthic flora and fauna from sedimentation on the 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 sediments 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 flora and fauna will generally not be able to avoid areas of increased suspended sediment with any form of evasive behaviour. However, benthic organisms in Danish waters are likely to have developed a high tolerance to temporary increases in suspended sediment, as shown by their ability to withstand natural peaks in turbidity during storm events. The sensitivity to physical disturbance is therefore considered to be low.

Increased concentration of suspended sediment may occur in the vicinity of the proposed intervention works (post-lay trenching, rock placement). Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the duration of sediment concentration above 2 mg/l is expected to last up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing (see section 8.4.1).

Most of proposed NSP2 route will be placed in an area with little benthic fauna. Benthic fauna is only found along the western part of the route, see section 7.8, and is dominated by bivalves, polychaetes and gastropods. Previous studies have shown that negative effects on benthic communities are unlikely at a suspended sediment concentration below 100 mg/l /347//348/. Most studies on the effects of suspended sediments have focused on bivalves and show that adult specimens can tolerate very high suspended sediment concentrations /349//350/ and that moderate levels may in some areas have a positive impact on growth (due to greater availability of nutrients) /351//352/. Studies of the blue mussel (*Mytilus edulis*) show that the species is able to adapt to different concentrations of suspended sediment by regulating filter speed (which is done by keeping the shells more or less open) /353/. Filtering capacity for small individuals (~3 cm) in an area with an annual fluctuation in concentrations of suspended sediment between 5-35 mg/l decreased at concentrations of 250 mg/l. The larger individuals were more tolerant /354/. In addition, bivalves are able to compensate for a negative effect from elevated suspended sediment concentrations through particle selection /355/.

However, not all benthic organisms are able to compensate for the negative effects of elevated suspended sediment concentrations. Immobile epibenthic organisms (e.g. ascidians, moss animals, filtering worms and sponges) lacking protective shells or the capability to regulate behaviour with variations in suspended sediment concentrations are generally considered more intolerant to elevated levels of suspended sediments. Studies have shown a short-term, negative effect on nutrient intake and a decrease in activity level in such organisms situated 1-1.5 km from a sand extraction area. The study concluded that potential significant negative effects were limited to the close vicinity of the extraction works /355/. Such epibenthic organisms are mainly present in the Rønne Banke area.

Based on the local and temporary nature of the potential sediment release (on the basis of the modelling results) and the sensitivity of the species, the impact of sediment spill on benthic fauna is considered to be of low intensity.

Within the Danish section of the proposed NSP2 route, benthic flora have not been observed. This is because the proposed NSP2 route will be placed at water depths below the photic zone (i.e. depths greater than 20 m, see section 7.8). The closest area of observed benthic flora is at Rønne Banke, located at a distance of more than 10 km from the pipeline. As described previously, the potential modelled sediment spill would be highly localised and temporary (up to 4.5 hours). As such, no impacts on benthic flora are expected due to release of sediments into the water column.

In summary, the impact on benthic flora and fauna associated with the release of sediments into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on benthic flora and fauna from the release of sediments into 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 lead to 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. Contaminants have a high potential for bioaccumulation, and may be acutely toxic at elevated concentrations. Benthic flora and fauna will generally not be able to avoid exposure with any form of evasive behaviour, and the resilience towards contaminants is therefore considered to be low. However, the populations are expected to be resilient, and to recover over time after an environmental disturbance. Taking into consideration that benthic flora and fauna constitute an important receptor, the sensitivity is considered to be medium.

Calculations and modelling has been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column is generally not expected to result in concentrations that exceed thresholds for EQS, with the exception of two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. 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 addition, most of the released contaminants would be limited to the lower 10 m of the water column, and most of the released contaminants (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/.

Hence, it is considered unlikely that activities during the construction phase will directly expose benthic organisms to contaminants of critical levels that would cause increased mortality or reduced growth rates. Based on the above, as well as the conclusions in 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 /136/. 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 the release of contaminants into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on benthic flora and fauna from the release of contaminants into the water column is assessed to be negligible.

9.7.1.5 Release of chemical warfare agents 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 lead to 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 a toxic effect on the biological environment, including benthic fauna. Benthic fauna will generally not be able to avoid exposure to CWA with any form of evasive behaviour, and the resilience is therefore considered to be low. However, the population is expected to be resilient, and recover over time after an environmental disturbance. Taking into consideration that benthic flora and fauna is considered an important receptor, the sensitivity is considered 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. As discussed in section 9.4.1.3, the impact on water quality from CWA has been assessed to be negligible, and below applicable PNEC thresholds (see section 8.4.4).

In summary, the impact on benthic flora and fauna associated with the release of CWA into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on benthic flora and fauna from the release of CWA into the water column is assessed to be negligible.

9.7.2 Operational phase

In the following sections, the identified sources of potential impacts on benthic flora and fauna during the operational phase are assessed.

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 a solid structure emerging from a seafloor consisting of sand and mud that is quite homogenous in appearance. 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 the 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 /319//374/, including NSP /375/. The colonisation success (the settlement of epiphytes and larvae) will depend on the water depth and the available light and oxygen.

The main part of the proposed NSP2 route will be placed at depths with a predominant occurrence of hypoxia, thereby 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 relevant to the western part of the route in Danish waters (see section 7.8).

The introduction of a hard substrate provides a surface that can be colonised by species that are not normally present in soft sediment environments. It is difficult to evaluate whether potential colonisation of the new hard substrate should be viewed as a positive or a negative impact. International studies have demonstrated "reef effects" on local benthic communities; however, the natural conditions may change and have an effect on the existing benthic communities, which is not well understood.

The colonisation of benthic flora and fauna (when the conditions allow) will attract other organisms, such as mobile crustaceans, gastropods and mussels seeking food and/or shelter /376/. Apart from providing a substrate for colonisation and/or attracting other benthic fauna, the pipelines may impact the surrounding natural environment 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 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 of the region that 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.

In summary, the impact on benthic flora and fauna associated with the change of habitat during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered low.

Based on the low sensitivity and low impact magnitude, the overall impact on benthic flora and fauna from the change of habitat is assessed to be minor.

9.7.2.2 Release of metals from anodes

Release of aluminium from the anodes will not cause ecotoxicological impacts; however, zinc and cadmium 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 be able to avoid exposure with any form of evasive behaviour, and the resilience towards metals released from the anodes is therefore considered to be low. However, the populations are 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 aluminium, zinc and cadmium ions from the aluminium anodes was described in section 8.4.8, and the impact on water quality was assessed to be negligible (see section 9.4.2.2). The amounts of metals released from the anodes are insignificant compared with the existing level of water-borne inflow of metals to the area, even though the 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 fauna would only occur in the immediate vicinity of anodes in sections of the proposed NSP2 route (see 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 to one another. However, elevated concentrations of metals will be localised to the area around the crossing. Although some individuals may be impacted, the concentrations are not expected to be elevated to such a level that would cause a discernible impact on benthic communities.

In summary, the impact on benthic flora and fauna associated with the release of metals from anodes during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on benthic flora and 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 on benthic flora and fauna during the construction and operation of NSP2 are summarised in Table 9-15. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-15 Assessment of the overall impacts on benthic flora and fauna during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance on the 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 into the water column	Medium	Negligible	Negligible	Yes
Operational phase				
Change 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 9-15), the potential impacts on benthic flora and fauna 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 of NSP2 are listed in Table 9-16 and assessed below.

Table 9-16 Sources of potential impacts on fish during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on the 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 into the water column	X	
Generation of underwater noise	X	
Change 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 grounds for different fish species. This comprises spawning areas/nursery areas for cod, sprat and flounder and feeding areas for herring and salmon. In addition, consideration is given to species on the HELCOM Red List, as applicable (see section 7.9).

9.8.1 Construction phase

In the following sections, the identified sources of potential impacts on fish during the construction phase are assessed.

9.8.1.1 Physical disturbance on the seabed

Construction activities, mainly post-lay trenching and rock placement, will result in physical disturbance on the seabed and in the cod spawning area.

Physical disturbance on the seabed has the potential to impact fish species that are demersal or rely on the seabed for spawning. No impacts are anticipated on fish species that spawn 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 (see section 7.9). Whereas adult demersal fish species are resilient to potential impacts due to 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 on the seabed is considered to be medium.

Impacts on demersal fish would be limited to the footprint of the physical disturbance, which will occupy a negligible area compared to the surrounding habitats that are physically uniform and support similar fish communities. Thus, whilst some individuals may exhibit avoidance behaviour and/or demersal larvae or eggs (i.e. turbot and herring) may be killed, physical disturbance from construction activities will not impact fish populations and the ecosystem 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.

Based on this reasoning, it is concluded that the impact magnitude will be negligible.

Cod spawning area
An area north-east of Bornholm is recognised as a main spawning ground for cod, and is closed to fishery between May 1st and Oct 31st. The water mass where spawning may take place, i.e. the reproductive layer, is confined to depths of approximately 42–68 m for cod, and 45-55 m for sprat (see section 7.9). The NSP2 route V1 crosses a 32.6 km stretch through the closure area in the Danish EEZ, and the NSP2 route V2 crosses the closure area along a 37.6 km stretch in the Danish EEZ, at a water depth of 80-90 m. The area closed for fisheries in the Danish section covers approximately 1,940 km^2. The area where the seabed will be directly affected by pipe-lay comprises less than 0.005% of the seabed within the closure area in the Danish sector, both for the proposed NSP2 route V1 and the NSP2 route V2. It should be noted that the total spawning area for cod is larger than the closure area and that pipe-lay therefore affects an even smaller part of the total cod spawning area.

If a DP pipe-lay vessel is used, the thruster-jet-induced currents may possibly displace water down to less favourable and oxygen-depleted depths, thereby potentially displacing cod eggs out from the reproductive layer.

CFD modelling was undertaken for typical DP vessels during NSP. The current velocities from thrusters depend on the distance from the vessel, the depth and a number of other factors such as the position of the thrusters. The velocities decrease with distance, and the CFD modelling showed that the jet is dispersed due to the expansion and forced upwards. Based on this, it has been concluded that the currents that will be produced by the jet-thrusters at 70 m (where the reproductive volume of cod extends to) will be comparable to natural currents /320//419/.

The area affected by construction activities will be of a small spatial extent compared to the total spawning area within the Bornholm Basin, which extends beyond the aforementioned closure area (see section 7.9). The impact duration at any given location will be temporary, as the pipe-lay vessel will be moving continuously at a rate of approximately 3 km/day.

Based on this reasoning, it is assessed that there will be negligible impacts on cod populations arising from potential egg displacement.

In summary, the impact on fish associated with physical disturbance on the seabed during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on fish from physical disturbance on 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 on the seabed. This has the potential to bury fish species that are demersal or rely on 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 food sources for fish. 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, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 - 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. A total area of 0.24 km^2 is expected to experience >200 g/m^2 of deposited sediment due to post-lay trenching and rock placement. Areas that are expected to experience >200 g/m^2 of deposited sediment are associated with intervention works at the NSP crossing (rock placement and post-lay trenching) and the material will be deposited locally. Overall, the sedimentation will thus be local and of low intensity.

It is assessed that such a degree of temporary sedimentation will not directly impact demersal fish, and no smothering of fish eggs or larvae is envisaged. The system will quickly revert to its natural state after the termination of project activities.

As assessed in section 9.7.1.2, no significant impacts on local benthic fauna due to sedimentation are envisaged. Therefore, fish populations will not be impacted by any reduction in food sources.

In summary, the impact on fish associated with sedimentation on the seabed during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on fish from sedimentation on the 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 reducing the viability of larvae or eggs.

The resilience of fish towards suspended sediments varies between species and development stage. Fish eggs fry are less resilient than juvenile and adult fish (as reviewed in /319//320/). Pelagic fish are less resilient to suspended sediment than demersal fish /356/, and they will probably avoid suspended material to a greater extent /357/. 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. 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 the release of sediments into the water column is assessed to be high.

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 /372/. Based on the modelling results (see sections 8.4.1 and 8.4.2), release of sediments during the construction of NSP2 may lead to avoidance reactions in individual fish. 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. With respect to demersal flatfish (e.g. plaice), which are especially resilient to suspended sediment, concentrations of 3,000 mg/l showed no increased lethality during a 14-day period /358/.

Based on the modelling results (see sections 8.4.1 and 8.4.2), release of sediments during the construction of NSP2 will therefore not lead to fish injury and subsequent mortality.

Several fish species, including the commercially important cod and sprat, spawn in the water column within Danish waters. Suspended sediments may result in reduced egg respiration, affect embryonic development, or cause eggs to sink to depths where there is a risk of oxygen depletion /359/.

The expected NSP2 activities that can lead to release of sediment include pipe-lay, pipe-lay vessel movement, trenching and rock placement. The pipe-lay vessel may be either an anchored vessel or a DP vessel. As discussed in section 8.4.2, the movement of pipe-lay vessels and the laying of the pipelines directly on the seabed will only cause a temporary, insignificant increase in suspended sediment concentration.

Increased concentration of suspended sediment may occur in the vicinity of the proposed intervention works (post-lay trenching, rock placement). Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the duration of sediment concentration above 2 mg/l is expected to last up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing (see section 8.4.1).

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 /359//360/.

Sediment spread has been evaluated as a potential source of impact on cod due to the fact that sediment could stick to the eggs, thereby affecting their buoyancy. One study concluded that cod eggs exposed to 5 mg/l of suspended sediment were still able to float, but started to sink after 96 hours in stagnant water /361/. However, extended exposure of this kind (96 hours) will not occur during the NSP2 intervention works, according to the modelling that has been carried out (see section 8.4.1). In the same study, the survival rate of yolk-sac larvae started to decrease at a concentration of 10 mg/l /361/. The limestone concentration in the suspension was high, which is thought to be more harmful compared to clay concentrations expected in the Baltic Sea. The avoidance threshold to suspended sediments of both glacial clay and limestone was found to be approximately 3 mg/l /361/. In turbulent water, however, this effect has been shown to be significantly decreased /360/.

Furthermore, it is noted that suspended sediment from both pipe-lay and rock placement will be limited to the lower 10 m of the water column (see sections 8.4.1 and 8.4.2). Therefore, suspended sediments will generally not come into contact with the water mass where cod and sprat spawning may take place, i.e. the reproductive layer.

In summary, the impact on fish associated with the release of sediments into the water column during construction is assessed to be temporary, local and of medium intensity. Therefore, the impact magnitude is considered negligible.

Cod spawning area
An area north-east of Bornholm is recognised as a main spawning ground of cod, and is closed to fishery between May 1st and Oct 31st. The water mass where cod spawning may take place, i.e. the reproductive layer, is confined to depths of approximately 42–68 m (see section 7.9). The NSP2 route V1 crosses a 32.6 km stretch of the closure area within Danish waters, and the NSP2 route V2 crosses the a 37.6 km stretch of the closure area within Danish waters, and at a water depth of 80-90 m.

Inside the cod spawning area, the expected NSP2 activities that can lead to the release of sediments include pipe-lay and pipe-lay vessels.

As described above, the impacts from release of sediments are assessed to be both temporary and local. Suspended sediments from pipe-lay and pipe-lay vessels will be limited to the lower 10 m of the water column (see sections 8.4.1 and 8.4.2). Therefore, suspended sediments will not come into contact with the water mass where cod spawning may take place, i.e. the reproductive layer, as the water depth is between 80 and 90 m and the spawning occurs between 42–68 m (see section 7.9).

The area affected by construction activities will be of a small spatial extent compared to the spawning area within the Bornholm Basin, as described in section 9.8.1.1. The impact duration at any given location will be temporary, as the pipe-lay vessel will be moving continuously at a rate of approximately 3 km/day.

The impact on the cod spawning area from the release of sediments into the water column during construction is assessed to be temporary, local and of medium intensity. Therefore, the impact magnitude is considered negligible.

Based on the above, it is assessed that overall 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 impact on fish associated with the release of sediments into the water column during construction is assessed to be temporary, local and of medium intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on fish from the release of sediments 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.

The release of contaminants into the water column has 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 Habitats 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 area. 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 column is judged to be medium.

Calculations and modelling have been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column is generally not expected to result in concentrations that exceed thresholds for EQS, with the exception of two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. 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 addition, the majority of the released contaminants will be limited to the lower 10 m of the water column, and most of the released contaminants (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/. Therefore, no acute toxic effect on fish is expected.

In deeper areas north-east of Bornholm, including the 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 the release of contaminants into the water column during NSP2 construction activities.

The major source of contaminants in fish is related to their foraging, e.g. infauna prey, and not their immediate physical surroundings. 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 impact on fish associated with the release of contaminants into the water column during construction is assessed to be temporary, local and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, 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 into the water column

Construction activities, mainly post-lay trenching and rock placement, will result in the release of CWA into the water column, as discussed in section 9.4.1.3. 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 time in an affected area. 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 column is judged 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. As discussed in section 9.4.1.3, the impact on water quality from CWA has been assessed to be negligible, and below applicable PNEC thresholds (see section 8.4.4).

As discussed in sections 9.6 and 9.7, negligible impacts on plankton and benthos as a result of CWA release are anticipated to occur due to NSP2 construction activities. Taking into consideration 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 the release of CWA into the water column during construction is assessed to be temporary, local and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, 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 utilise sounds and may therefore be susceptible to changing noise regimes. Underwater noise has the potential to cause 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 an affected area. Eggs and larvae have a low resilience, however, 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 noise is assessed to be medium.

Underwater noise can affect fish in several ways, including:

- Damage to non-auditory tissue or auditory tissues (generally the sensory hair cells of the ear);
- Hearing loss due to temporary threshold shift (TTS);
- Behavioural effects (e.g. avoidance).

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 /362//363/. Temporary hearing loss (TTS), on the other hand, may occur /364/. 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 /365//366/.

Little information is available on the hearing abilities of species of relevance in 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 the 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. The criteria for PTS and TTS in these two species are presented in Table 9-17 /367/.

Atlantic cod has a gas-filled swim bladder and is likely more sensitive to sound than Atlantic salmon. Experiments with 20 specimens in a tank found the best hearing sensitivity at between 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 pipe-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 /368/.

In order to evaluate the possibility of NSP2 construction activities of causing an impact on fish, underwater noise propagation modelling has been carried out. Modelling has been performed at one location in the Danish waters where rock placement may be performed (considered the noisiest of the project activities in Danish waters, see section 8.4.5). Threshold values for inflicting impact (mortal injury, injury and TTS) have been determined based on an assessment of available values from the most recent scientific literature /367/.

Table 9-17 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. The modelling results show that underwater noise from rock placement did not exceed threshold levels causing injury or mortality, whilst exceedance of threshold levels causing TTS was detected in the vicinity of the proposed NSP2 pipeline route (within 100 m or less, assuming two hours of exposure).

Table 9-17 Assessment level limit distances at two positions where modelling has been undertaken in Denmark /367/ .

Rock placement		Assessment levels	Threshold distances (summer/winter)
		SEL(Cum*)	SEL(Cum*)
Marine group	Effect	dB re 1µPa²s	m
Fish	Mortality (mortal injury)	207 dB	0
	Injury	203 dB	0
	TTS	186 dB	100
Eggs and larvae	Injury	210 dB	0
* Cumulative SEL (two hours of 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 relatively noisy vessels. Other factors, both physical and physiological, play a role in determining the noise level that will trigger an avoidance response from fish /371/.

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 /369//370/.

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 NSP2 construction activities, but the fish population will return within a short time after the cessation of activities.

In summary, the impact on fish associated with underwater noise during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on bathymetry from underwater noise is assessed to be negligible.

Cod spawning area
An area north-east of Bornholm is recognised as a main spawning ground for cod. Inside the cod spawning area, the expected NSP2 activities that can lead to underwater noise include pipe-lay and pipe-lay vessels.

Site-specific modelling has been undertaken for the crossing of NSP, located outside the cod spawning area. The modelling results (Table 9-17) show that underwater noise from rock placement did not exceed threshold levels causing injury or mortality to eggs, larvae or adults. For adult fish, exceedance of threshold levels causing TTS was detected in the vicinity of the proposed NSP2 pipeline route (100 m or less, assuming two hours of exposure). Underwater noise from rock placement is considered a worst-case scenario. Generation of underwater noise from pipe-lay and post-lay trenching will be less than or similar to rock placement and has therefore not been modelled.

In summary, the impact on spawning cod associated with underwater noise during construction is assessed to be temporary, local and of medium intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, it is assessed that overall cod reproduction in the spawning area will not be impacted by NSP2.

9.8.2 Operational phase

In the following sections, the identified sources of potential impacts on fish during the operational phase are assessed.

9.8.2.1 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 seafloor consisting of sand or mud that is quite homogenous in appearance. 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. The mobility of fish makes them highly resilient to local changes in habitats. Therefore, despite the importance of fish, the sensitivity of fish to change 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 are otherwise rare in the region. This is a general observation contained in studies of artificial marine installations /373//374/. Video inspections of the NSP pipelines have confirmed this /375/. The colonisation of epifauna (and epiphytes where light conditions allow) will attract other organisms such as mobile crustaceans and fish seeking food and/or shelter /376/. Therefore, the pipelines will act as an artificial reef and have the potential to increase the local biodiversity.

However, a substantial part of the proposed NSP2 route will be placed at depths with a prevailing occurrence of hypoxia, which prevents the establishment of higher life forms. Even in those areas where higher life forms can exist, their contribution to the overall productivity in the region is very limited and will therefore have a limited impact on the overall abundance of marine life. This is because the pipelines will only occupy a negligible part of the total productive volume of the region and which sustains the ecosystem in this part of the Baltic Sea.

In summary, the impact on fish associated with the change of habitat during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on fish communities from the change of habitat is assessed to be negligible.

9.8.2.2 Release of metals from anodes

Release of aluminium from the anodes will not cause ecotoxicological impacts; however, fish are susceptible to zinc and cadmium 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 time in an affected area, 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 zinc and cadmium in the water, the sensitivity of fish towards metals from anodes released into the water is judged to be medium.

The release of aluminium, zinc and cadmium ions from the aluminium anodes was described in section 8.4.8, and the impact on water quality was assessed to be negligible (see section 9.4.2.2). Elevated levels of anode metals in the water column (above PNEC values) are expected only in the very near vicinity of the anodes (within a few metres). The amounts released from the anodes are insignificant compared with the existing level 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 the potential for multiple anodes to be located in close proximity to one another. However, elevated concentrations of metals will be localised 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 associated with the release of metals from anodes during operation will be long-term, local and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on fish from the release of metals from anodes is assessed to be negligible.

9.8.3 Summary of impacts

The assessments of the potential impacts on fish during the construction and operation of NSP2 are summarised in Table 9-18. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-18 Assessment of the overall impacts on fish during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance on the 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 into the water column	Medium	Negligible	Negligible	Yes
Generation of underwater noise	Medium	Negligible	Negligible	Yes
Operational phase				
Change 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 9-18), the potential impacts on fish during the construction and operation of NSP2, either individually or in combination, are assessed to be not significant.

9.9 Marine mammals

The sources of potential impacts on marine mammals during construction and operation of NSP2 are listed in Table 9-16 and assessed below.

Table 9-19 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 into the water column	X	
Generation of underwater noise	X	
Physical presence of pipelines and structures on the seabed		X
Change of habitat		X
Release of metals from anodes		X

This section describing impact assessment of marine mammals is an extract of reports prepared by DCE, Aarhus University for the base case route and a revised baseline and assessment report prepared for the northern route /209//210/.

9.9.1 Construction phase

In the following sections, the identified sources of potential impacts on marine mammals 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 foraging ability. 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.

Increased concentration of suspended sediment may occur in the vicinity of the proposed intervention works (post-lay trenching, rock placement). Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the duration of sediment concentration above 2 mg/l is expected to last up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing (see section 8.4.1). Potential impacts on water quality from increased 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; nevertheless, the existence of blind but well-nourished seals in the wild has been reported /377/. In addition, studies have explored the importance of vision for harbour porpoises. These have shown that harbour porpoises rely upon echolocation (rather than vision) for orientation in the environment as well as for prey localisation; they have been observed to hunt at night and move into depths of complete darkness with or without an accompanying calf /378//379/. Therefore, at the concentrations anticipated, suspended sediment in the water column is not expected to have a noticeable impact on marine mammal vision.

In summary, the impact on marine mammals associated with the release of sediments into the water column during construction is assessed to be local, temporary, and of low intensity. Therefore, the impact magnitude is considered low.

Based on expert judgement, the overall impact on marine mammals from the release of sediment in the water column is assessed to be negligible[11].

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 would therefore be able to avoid areas of increased turbidity (and thereby the areas where concentrations of contaminants would be the highest). Since marine mammals are considered an important receptor, their sensitivity is assessed to be medium.

Calculations and modelling has been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column is generally not expected to result in concentrations which exceed thresholds for EQS, with the exception of two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. The majority of contaminants will redeposit on the seabed (associated with the sediment particles) within a distance of no more than

[11] The assessment of the overall significance of a given impact is subject to expert judgement that deviates from the matrix presented in the section 8.3.4.

a few kilometres from the proposed NSP2 route. In addition, the majority of the released contaminants would be limited to the lower 10 m of the water column, and most of the released contaminants (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/. 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.

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 9.6-9.8, 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.

In summary, the impact on marine mammals associated with the release of contaminants into the water column during construction is assessed to be temporary, local, and of low intensity. Therefore, the impact magnitude is considered low.

Based on the medium sensitivity and low 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 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 marine mammals, 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 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. As discussed in section 9.4.1.3, the impact on water quality from CWA has been assessed to be negligible, and below applicable PNEC thresholds (see section 8.4.4).

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 their roles within the food web into consideration, it is assessed that no significant bioaccumulation of CWA in marine mammals will occur.

In summary, the impact on marine mammals associated with the release of CWA into the water column during construction is assessed to be temporary, local, and of low intensity. Therefore, the impact magnitude is considered low.

Based on the medium sensitivity and low impact magnitude, the overall impact on marine mammals from the release of CWA 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, including:

- Physical injury and hearing loss (including PTS/TTS);

- Disturbance of animal behaviour;
- Masking of other sounds.

It is widely accepted that 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 low.

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 /384/. 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, but large amounts of TTS can last for hours or even days.

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 PTS 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 exposure 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 established. The thresholds for inducing PTS or TTS are summarised in Table 9-20, 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 9-20 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 TTS from the numerous studies using fatiguing noise of various durations /380//381//382/. These studies have been condensed into one threshold of 188 dB re. 1 $\mu Pa^2 s$ by /383/.

A threshold for inducing PTS in high-frequency cetaceans, including harbour porpoises, was proposed by /384/. However, this threshold was based solely on experimental data from mid-frequency cetaceans (bottlenose dolphins and beluga whales) 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 /385/. 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 /384/, the PTS criterion was here instead extrapolated from the TTS criterion by adding 15 dB, equal to 177 dB re. 1 μPa^{2}s for explosions and 203 dB re. 1 μPa^{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 durations, summarised by /383/ 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 /386/. 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 /387/. 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 μPa^{2}s.

The assessment of potential impact of noise from construction and operation of the Nord Stream 2 pipeline is based on unweighted (broadband) thresholds for inducing temporary and permanent threshold shifts (TTS and PTS) in seals and harbour porpoises. Recent recommendations from the US /388/ advocate for the use of frequency weighted sound levels and thresholds in assessments (referred to as NOAA guidelines). The NOAA guideline thresholds are lower, than shown in Table 9-20. Explanation of the difference in thresholds is given in section 8.4.5.

A sound propagation model was run for rock placement with the NSP2 scenario and source levels, with environmental parameterisation (see section 8.4.5). The criteria for PTS and TTS (as identified in Table 9-20) have been applied in the underwater noise modelling of rock placement.

Table 9-21 summarises the acoustic modelling results in terms of the maximum (in all directions) distances from rock placement (considered the noisiest of the project activities in Danish waters) to the applicable assessment underwater noise threshold levels.

Table 9-21 Assessment threshold distances at the modelling position (RP1).

Receptor	Impact type	Thresholds	RP1 - threshold distances (summer/winter)
		SEL(Cum*) dB re 1μPa^2 s	SEL(Cum*) dB re 1μPa^2 s
Seals	PTS	200 dB	0 m
	TTS	188 dB	80 m
Harbour porpoise	PTS	203 dB	0 m
	TTS	188 dB	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 the specific location where rock placement is proposed.

The nearest seal haul-out site to the proposed NSP2 route is on Ertholmene, located approximately 50 km to the west, though given the mobility of harbour porpoises and grey seals, the NPS2 route does cross areas of regular occurrence for both species (see Figure 7-42, Figure 7-43 and Figure 7-45). Notwithstanding this, individual marine mammals would need to be closer than 80 m from the noise source for any potential of injury, and no impacts at the population level 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 impacts on 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 low sensitivity and the low impact magnitude in relation to hearing loss or injury, the overall impact of underwater noise on marine mammals is assessed to be negligible.

Behavioural response

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 that 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 section 8.4.5.1). In this regard, disturbances are likely to be of a similar magnitude as the disturbance from passing merchant vessels.

Noise from construction activities could potentially disturb and displace seals and especially harbour porpoises from the waters around the pipe-lay vessel. Very little information is available, however, on the behaviour of porpoises in reaction to ship noise. Studies in captivity indicate that porpoises react to the higher frequencies of the noise, above 1 kHz, and at low levels, L_{eq} around 130 dB re. 1 µPa /390/. Other studies on noise from various merchant ships in the outer Baltic Sea have shown that there is considerable energy in the noise also at ultrasonic frequencies up to at least 100 kHz, and out to ranges of at least 1 km /391/. In addition, studies where sound recorders as well as motion detectors (accelerometers) have been placed on free-swimming porpoises have shown short-term (minutes), but nevertheless severe reactions of individual porpoises to ships /392/.

These studies indicate that porpoises could react to ships at considerable distances, possibly several kilometres away. An argument against very long reaction distances is the fact that some of the most heavily trafficked waters of the western Baltic Sea, such as the Kadet Trench, the Great Belt, the northern Sound and the northern tip of Skagen are also some of the areas where the highest concentrations of porpoises are found /393/.

A recent study conducted on porpoises in the Istanbul Strait showed that porpoises are more likely to change behaviour, for example from surface-feeding or travelling to diving, if vessels are within a 400 m radius of the porpoise. Furthermore, vessel speed and distance have a significant effect on the probability of response of the porpoises to the ship /394/. Such changes in behaviour indicate that vessels do disturb the animals at close range, but the study found no overall significant effect of the disturbance on the animals' cumulative (diel) behavioural budget (i.e. total amount of time spent on the different types of behaviour). The correlation between swimming speed and the probability of porpoises responding by changing their swimming direction is illustrated in Figure 9-1. This shows that at any given ship speed there is little probability (<10%) of a behavioural reaction if the boat is more than 400 m away, and furthermore, as ship speed increases from slow (<3 knots) to fast (>9 knots), the probability of reaction to a ship 200 m away increases from about 10% to 40%.

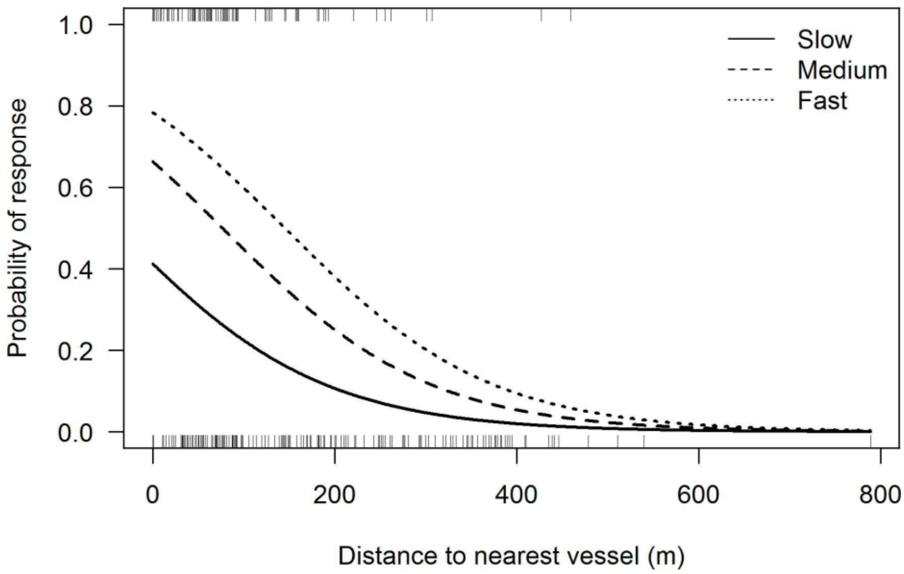

Figure 9-1 Probability of porpoises responding to a ship by a change in swimming direction as a function of the distance to the nearest vessel for slow (<3 knots, solid line), medium (3-9 knots, dashed line) and fast (>9 knots, dotted line) moving vessels. The lines represent the fitted values of the best fitting generalized linear model. The distribution of distance values for responding and non-responding porpoises is shown by the top and bottom rug plots, respectively. n = 305 (from /394/).

No similar studies are available for Baltic harbour porpoises or even porpoises in the Danish Straits, so it is not known whether the same distances apply to porpoises in the Baltic Sea.

DCE has undertaken modelling for habitat displacement based on experience from NSP, with a precautionary threshold for reaction of 200 m assumed and applied to a modelling of the additional disturbance/displacement caused by construction of NSP through the proposed Swedish Natura 2000 site Hoburgs Bank och Midsjöbankarna /210/.

Based on information received from AIS messages transmitted by the vessels and an estimate of the effective disturbance radius of ships (conservatively set to 200 m), the habitat disturbance was estimated. The habitat disturbance (HD) is expressed as a ratio between the disturbed area and the total area of the Natura 2000 sites. The current level of disturbance was estimated from two representative samples of AIS records from commercial ships in the Natura 2000 site. Each sample was one week; one from February 2014 and one from July 2014. The basis for the computation was AIS information obtained during construction of NSP. One pass of the pipe-laying vessel (Castoro Sei) through the Natura 2000 sites was selected. This passage started on the 1st of January 2012 and lasted 64 days. During this period, 12 other vessels took part in the operation. The combined habitat disturbance from the passage of Castoro Sei and support vessels were computed in the same way as for the commercial vessels.

The noise levels around the pipe-laying vessels were clearly elevated during construction, as documented by the NSP monitoring programme /395/. Measurements about 1.5 km from the pipeline corridor indicated an elevation in the low frequency range (below 3 kHz) of about 20 dB, compared to the baseline levels. These measurements indicate that the noise generated by the slow-moving Castoro Sei was higher than from a slow-moving normal ship of the same size, but on the other hand comparable in characteristics and level to the noise of a fast-moving (15-20 knots) merchant vessel /395/. Based on these observations, the reaction distance of porpoises was set at 200 m, similar to the merchant ships modelled above.

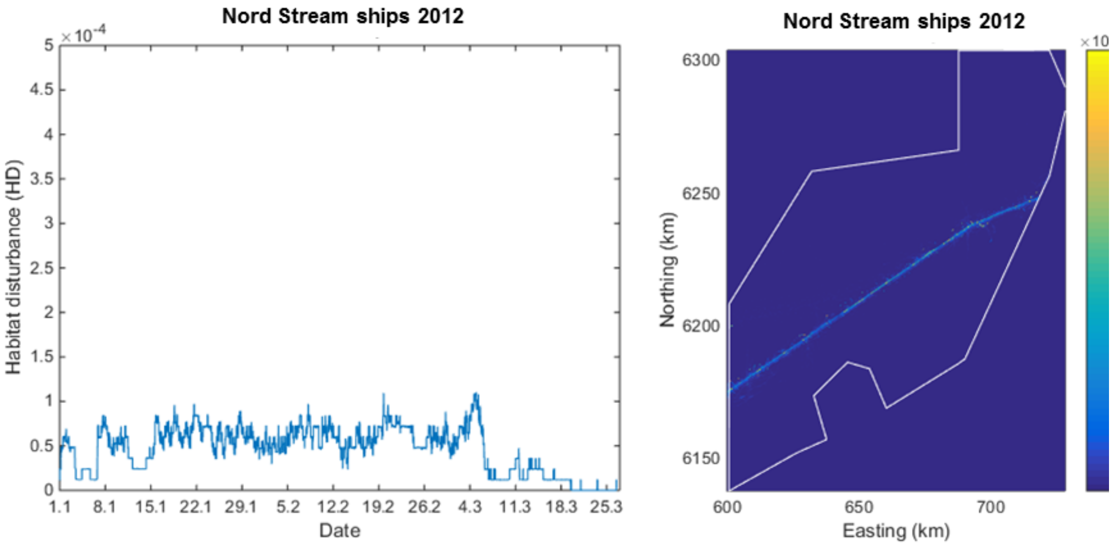

Figure 9-2 Contribution by the pipe-laying vessel and support vessels to the habitat disturbance factor, estimated from actual pipe-laying operations during construction of NSP /210/. Habitat disturbance is expressed as a ratio between the disturbed area and the total area of the Natura 2000 sites.

The results show that habitat disturbance was very constant throughout most of the NSP construction period (Figure 9-2), reflecting the slow, but continuous movement of the pipe-laying vessel through the area. Two periods in the beginning show decreases in disturbance, likely due to bad weather and thus interruption of construction activities. The decrease in disturbance towards the end of the period is likely a reflection of the support vessels operating in front of the pipe-laying vessel beginning to move out of the area, together with still shorter commutes for the service vessels sailing back and forth between harbours and the pipe-laying vessel. From the results it is evident that although there was very busy traffic to and from the pipe-laying area, the main disturbing factor is the slowly moving pipe-laying operation itself. The estimated disturbance caused by existing shipping in the area is very low, and does not appear to change much between summer and winter. On average, far less than 1/1000 of the Natura 2000 site is expected to be disturbed by ships. In relative terms, the construction of NSP is estimated to have caused an increase in disturbance of about 25% on top of the disturbance from regular shipping. However, as the absolute levels are very low, the combined disturbance was still low, and it is considered unlikely that this increase could have translated into significant detrimental effects on the local population of porpoises.

In summary, behavioural reactions to underwater noise from rock placement and other vessel-related activities around the pipeline are expected to occur only in the vicinity of the vessels and remain only for the time when the vessels are present. Reaction distances to ship noise are not known for seals or porpoises, but are assumed to be some hundred metres or less, and the impact is thus temporary, reversible and local. Disturbances are likely to be of a similar magnitude as disturbance from passing merchant vessels, which are very abundant along the pipeline corridor and are likely to be several times larger than the potential impact of the construction vessels, even under worst case assumptions. The disturbance from the construction of NSP2 is expected to be different from the disturbance caused by NSP construction and the construction activities along the south-eastern route may differ from what was done during construction of NSP. The scenario modelled from construction of NSP in the central Baltic Sea can nevertheless serve as an indication of scale. The absolute level of disturbance caused by construction of NSP was very low, likely insignificant. The relative increase in disturbance caused by the construction activities adding to the commercial ship traffic was measureable (about 25% increase).

The intensity and impact magnitude from vessel noise and rock placement is therefore considered low and the overall significance minor. This applies to both seals and harbour porpoises.

Masking

Masking is the phenomenon whereby noise can negatively affect the ability of a marine mammal 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 the short- 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 vessels in the Baltic Sea. In this regard, disturbances are likely to be of a similar magnitude as the disturbance from passing merchant vessels.

Loud noise has the capacity to mask the reception of weaker sounds of importance to porpoises. These sounds can be the animal's own echolocation signals, communication signals from other porpoises, including between mother and calf /396/, or other sounds that the animals may use to find prey or navigate. From studies in captivity, it is well known that a requirement for masking to occur is an overlap in both time and frequency range between the noise and the sound in question. This means that for masking of sonar and communication sounds to take place, the noise must have substantial energy in the frequency range around 130 kHz, the frequency band used by porpoises in echolocation /397/ and communication /396/. Noise from shipping and construction work has a very strong emphasis in the very low frequencies (e.g., /389//398/), but can contain substantial energy above ambient noise levels also at higher frequencies and thus also in the frequency range of porpoise vocalisations. The higher frequencies do not propagate far from the ship, however, due to the increase in absorption with frequency.

Noise from construction activities was measured during construction of NSP /395/. Measurements on the seabed were taken approximately 1.5 km from the pipeline alignment and noise from both the pipe-lay vessel (Castoro Sei) and the subsequent trenching (ploughing) was recorded. Elevated levels were reported during both activities, compared to background levels, see Table 9-22.

Table 9-22 Measurements of noise during construction of NSP, as measured 1.5 km from the pipeline alignment and compared to ambient conditions at the same location. The bandwidth of the recordings was 25 Hz – 3 kHz. From /395/. L95 and L5 indicate the levels exceeded 95% and 5% of the time, respectively.

Noise source	Mean (dB re. 1 µPa)	L95 exceedance level (dB re. 1 µPa)	L5 exceedance level (dB re. 1 µPa)
Ambient	110.9	99.2	116.6
Pipe-lay	130.5	121.4	134.0
Trenching	126.0	118.7	129.8

The noise levels were clearly elevated during construction, about 20 dB, a little less for trenching than pipe-laying. All three indicators, mean and two percentiles, appear equally affected, indicating that the entire noise regime was elevated by 20 dB. Unfortunately, the bandwidth of the recordings were limited to 3 kHz, so it is unknown to what degree noise levels were elevated at higher frequencies, most importantly above 100 kHz where the porpoise vocalisations are located. It is likely that energy was present also in this frequency band, thus giving the potential for masking.

Measurements at a second measuring station about 25 km from the pipeline showed marginally higher noise levels during construction activities compared to ambient, for the pipe-laying possibly partly attributable to the construction activities /395/. Although there is a potential for masking to occur at very close range due to the noise from the construction activities, as noise above ambient and in the relevant frequency range around 130 kHz is likely to be present close to the construction activities, it is close to impossible to quantify the level of masking. Likewise, it is close to impossible to quantify the level of masking due to existing shipping activity. Any attempt to compare the two would be even more difficult. Although some authors have attempted to quantify the possible level of masking, through indices such as the range reduction factor /249/, or otherwise /399/, such quantifications require a much better description of ambient noise and masking noise than what is available and would still be based on poorly founded assumptions about the masking itself.

Therefore, instead of a quantitative approach to masking, some common-sense considerations are presented. These considerations relate to the likely extent of a zone of masking, the likely reaction from porpoises to the masking and the possible consequences of this masking.

Masking occurs every time the ambient noise (natural or man-made) exceeds the hearing threshold in the relevant frequency range. This means that porpoises, just as all other animals with sensitive hearing, may be limited in echolocation range and communication distance by ambient noise, rather than the absolute sensitivity of their hearing, at least for parts of the time. Some natural phenomena, one good example being rain, can generate very high levels of noise and thus expose animals to high levels of natural masking (see section 8.4.5).

As masking is a naturally occurring phenomenon it is reasonable to assume that porpoises and other animals react to masking in an adaptive way. In particular, for a female porpoise with a dependent calf, an appropriate behaviour to noise at levels capable of masking would be to stay closer together, thus compensating for a decrease in maximum communication range. If noise levels increase even further, making communication difficult even at close range, then the adaptive reaction would be for the animals to move away from the noise source.

The worst-case scenario that could happen to a porpoise calf still dependent of its mother is to become separated from its mother, outside communication range. In theory, and perhaps also in practice, this could occur if at a time when the mother and calf are some distance apart, a sudden noise instantly makes communication impossible. Such a noise could be a nearby ship that suddenly turns on the engine at full power, but it could also be natural events, such as the sudden onset of a heavy rain shower, as illustrated above. The fact that such a masking could occur due to natural sources would suggest that mother and calf have evolved some adaptive behaviour to deal with such a possible separation. Such a behaviour has not been described, but could consist of the calf remaining stationary while emitting so-called distress-signals /396/, and the mother at the same time searching the area systematically. Thus, by this line of reasoning, it is far from certain that a break of communication between mother and calf due to masking or otherwise necessarily leads to permanent separation of the two (and likely death of the calf).

The above reasoning suggests that porpoises could react in a sensible way to the presence of ship noise, by avoiding the vicinity of the ship and thus reducing the masking. In fact, one could speculate whether the evasive reaction observed to ships /394/ could be partly explained by such a response. In conclusion, assuming a worst-case scenario of permanent separation as a result of a short break of communication between mother and calf likely relies on a significant underestimation of the abilities of the animals to re-locate each other following a separation.

Comparatively little is known about the effects of ship noise and noise from rock dumping on seals. However, they are generally considered more tolerant towards underwater noise than porpoises /400//401/. Furthermore, the conservation status of the concerned populations is favourable (stable or increasing population size) and the level of protection lower than for porpoises (harbour seal and grey seal are not included in Annex 4 of the Habitats Directive). For these reasons, seals are not assessed in depth, because impact on seals is considered likely to be smaller than the impact on porpoises under all conditions, which means that taking adequate precautions during construction and operation to protect porpoises from impact will automatically provide adequate protection from impact on seals.

Masking of seal communication is very poorly studied, but as communication seems to take place predominantly, perhaps even exclusively, near haul-out and breeding sites on the coast, the likelihood that seal communication will be impeded by masking from the pipeline construction is considered virtually absent.

In summary, masking from construction noise is considered temporary, reversible and local. The impact intensity and magnitude are considered low; thus, the overall significance is minor.

9.9.2 Operational phase

In the following sections, the identified sources of potential impacts on marine mammals during the operational phase are assessed.

9.9.2.1 Presence of pipelines and structures on the seabed (underwater noise)

Gas that flows through the pipeline will generate low levels of noise at low frequencies. 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.

Very few studies are available on noise levels from pipelines in operation, and potential effects from noise on marine mammals have been very poorly documented. In connection with the assessment of NSP, the radiated noise from the pipeline was modelled /154/. This was done at four different distances from the compressor station in Russia and the results are shown in Figure 9-3. The noise was quantified in the modelling as radiated noise power. This can be converted to SPL. The modelled SPL can be compared to actual measurements made from a pipeline in operation, see Figure 9-3, Secret Cove, British Columbia, /402/. This pipeline had a smaller diameter than NSP. Noise levels were measured close to shore and thus also the compressor station. The exact distance to the compressor station is not provided, but is assumed to be in the low tens of kilometres.

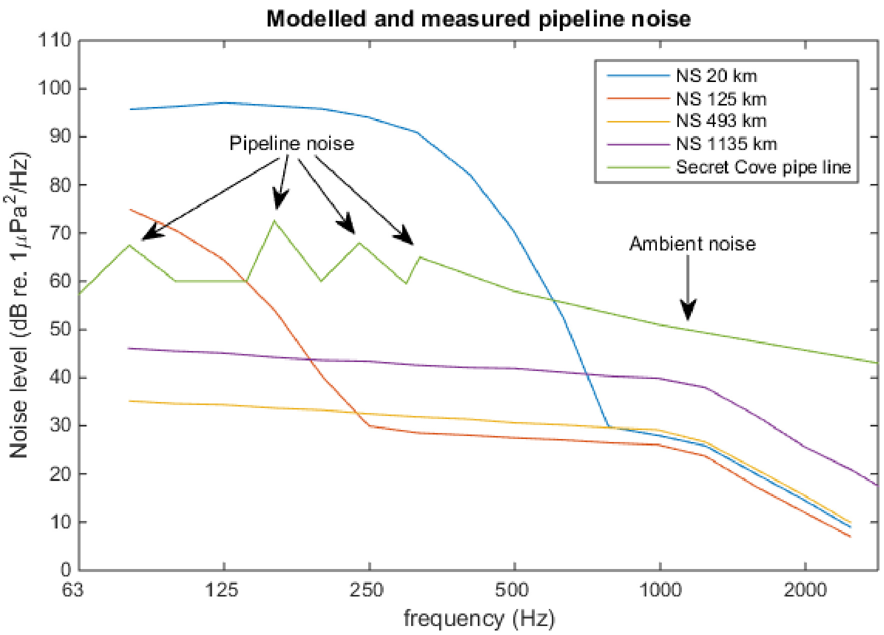

Figure 9-3 Modelled noise levels 1 m above the Nord Stream pipeline /154/, at various distances from the compressor station, together with noise levels recorded from an actual pipeline; Secret Cove /402/, green line, taken from Figure 9-4 below. As the measurements were made close to the compressor station, they should be compared to the modelled noise at the 20 km point, whereas the more distant positions (493 km and 1,135 km) are more indicative of the levels to be expected from NSP2 in Danish waters. Note that the pipeline at Secret Cove had no concrete corrosion protection. The presence of such a concrete cladding is estimated to attenuate the noise by at least 15 dB relative to the unclad condition /402/.

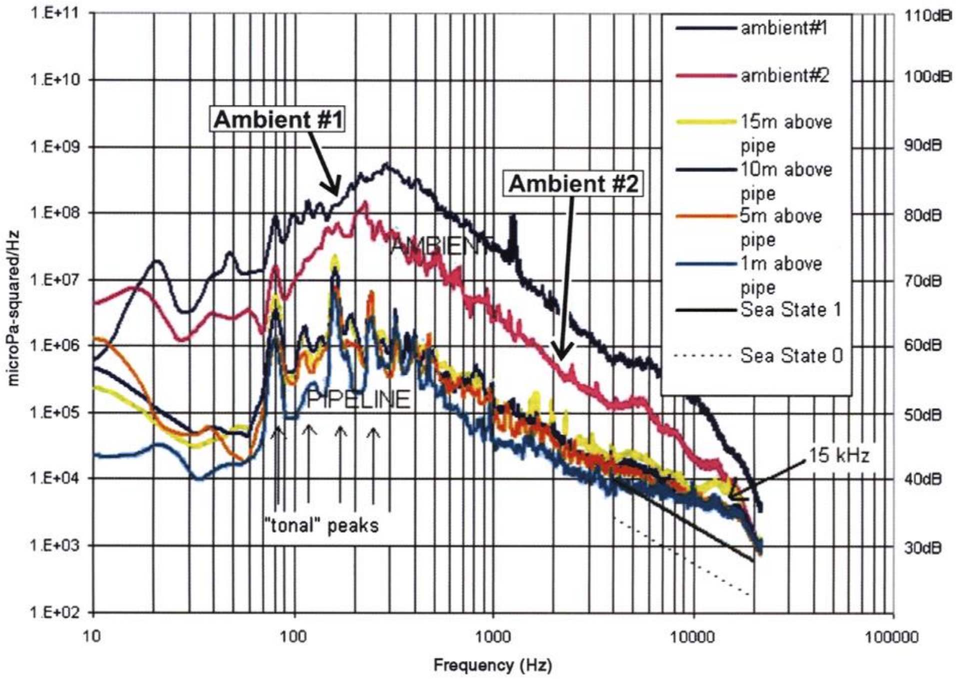

Figure 9-4 Noise levels as measured and accompanying representations of the high frequency portions of oceanic noise expectations for Sea States 0 and 1. Arrows denote the high (15 kHz) and low frequency "tonal" noise component from Secret Cove pipeline, British Columbia. Measurements were made in shallow waters close to shore and thus close to the compressor station. The pipeline consisted of two closely spaced iron pipes with an outer diameter of 25 cm. Ambient noise measurements recorded further away from the pipeline are also included. From /402/.

The measured noise from the Secret Cove pipeline is lower than the modelled levels from NSP, even at the 20 km point from the compressor, despite the absence of a concrete corrosion protection around the pipeline, which, according to /402/, could attenuate the radiated noise by at least 15 dB. The pipe diameter at Secret Cove was considerably smaller than NSP, however.

In any case, the absolute levels of noise are of little concern in relation to impact. It is only when they are compared to ambient noise levels that the possible influence on marine mammals can be assessed. The noise from the pipeline at Secret Cove contained pronounced peaks at low frequencies (highest frequency with a clearly discernible peak was 320 Hz), whereas no noise at higher frequencies could be attributed to the pipeline /402/.

One study looked into the noise from NSP during operation. Recordings of noise levels were undertaken at three different locations in the Bay of Finland close to NSP. Very high levels of shipping noise were recorded at all three stations, so the pipeline noise could not be detected in any of the recordings /403/.

Perhaps more relevant for Danish waters, however, are the noise recordings obtained by FOI /395/. They recorded ambient noise at several stations in the Midsjö Banks region, some of which were close to the proposed location of the NSP2 route. Figure 9-5 shows results of their measurements under conditions where no ships were present within 9 km of the recording station (as assessed by AIS data) and under different wind speeds. Also shown is the average noise spectrum for the station (i.e. including a variable contribution from passing ships) from the baseline period without construction work on NSP taking place.

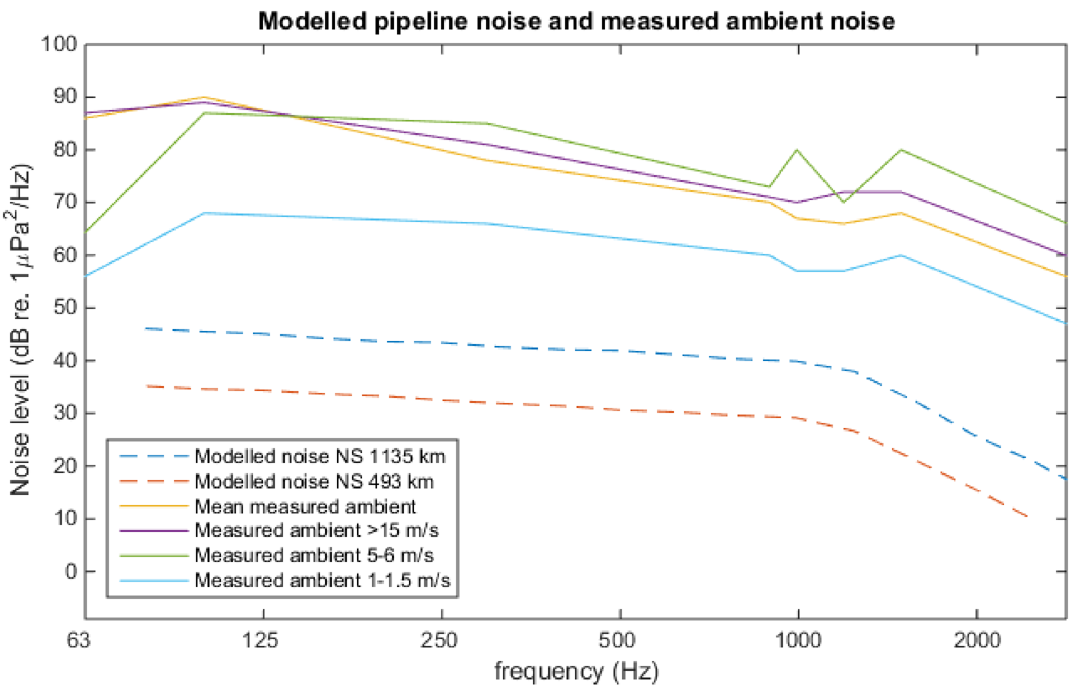

Figure 9-5 Modelled noise levels 1 m from NSP /154/ at distances far away from the compressor station in Russia, similar to the situation in Danish waters. Also shown are ambient noise spectra measured under quiet conditions (no ships within 9 km from recorder) and mean ambient noise (including ships), all at station B1, located close to the proposed NSP2 route (roughly 900 km from the compressor) and inside the Natura 2000 site at the Midsjö Banks /395/ .

When these measurements of ambient noise are compared to the modelled levels from NSP /154/ it is clear that the modelled noise is 20 dB or more below ambient noise levels and thus completely inaudible, even under the quietest conditions. This conclusion is further supported by measurements near NSP in the Gulf of Finland /403/. Measurements at three underwater stations close to the existing baseline failed to detect any noise, which could be attributed to the pipeline. Instead, the noise was dominated by ships in the nearby shipping lane.

In conclusion, the noise emitted from the pipeline itself, due to the gas flow inside, is expected to be of very low intensity and only be audible to both seals and harbour porpoises very close to the pipeline and only close to the compressor station (placed in Russia). Under all conditions, the noise from the pipeline in the Danish EEZ is expected to be below ambient levels.

In summary, the impact on marine mammals associated with the presence of the pipelines and structures on the seabed (underwater noise) during operation is assessed to be local, long-term, and of low intensity. Therefore, the impact magnitude is considered low.

Based on the low sensitivity and low impact magnitude, the overall impact on marine mammals from the presence of the pipelines and structures on the seabed (underwater noise) is assessed to be negligible.

9.9.2.2 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 seafloor consisting of sand or mud that is quite homogenous in appearance. 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 the 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 9.7 and 9.8, change of habitat due to the 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 an increase of food sources for marine mammals. Although the main prey of Baltic Sea marine mammals is fish, a substantial part of the proposed NSP2 route will be placed at depths with a prevailing occurrence of hypoxia, which prevents the establishment of higher life forms. Even in those areas where higher life forms can exist, their contribution to the overall productivity in the region is very limited and will therefore have a limited impact on the overall abundance of marine life. This is because the pipelines only occupy a negligible part of the total productive volume of the region and which sustains the ecosystem in this part of the Baltic Sea.

In summary, the impact on marine mammals associated with change of habitat during operation is assessed to be local, long-term, and of low intensity. Therefore, the magnitude is considered low.

Based on the low sensitivity and low impact magnitude, the overall impact on marine mammals from change of habitat is assessed to be negligible.

9.9.2.3 Release of metals from anodes

As described in section 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 (aluminium, zinc, cadmium) into the water column. Release of aluminium from the anodes will not cause ecotoxicological impacts; however, zinc and cadmium in the water column may be assimilated by plankton and impact survival rates, as well as enter the food chain. Given their high mobility, marine mammals are not likely to spend long periods of time in the affected areas, but they may be susceptible to bioaccumulation through the food chain. Although important species may be present in the project area, the sensitivity of marine mammals towards metals from anodes released into the water is judged to be low.

As discussed in section 9.4.2.2, the release of aluminium, zinc and cadmium 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 (within a few metres). More generally, the total amounts released from the anodes over the lifetime of the project are insignificant compared with the existing level of water-borne inflow of metals to the area, and no discernible impacts on marine mammal populations are expected.

Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity to one another, 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 (within a few metres) around the crossing. Although some individuals may be impacted, the concentrations are not expected to be elevated to such a level that would cause a discernible impact on populations.

It is assessed that a potential impact on marine mammals due to the bioaccumulation of metals through prey is highly unlikely, since no significant impacts on benthos and fish from contaminants in the water column have been identified (see sections 9.7 and 9.8, respectively).

In summary, the impact on marine mammals associated with the release of metals from anodes during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered low.

Based on the low sensitivity and low impact magnitude, the overall impact on marine mammals from the release of metals from anodes is assessed to be negligible.

9.9.3 Summary of impacts

The assessments of the potential impacts on marine mammals during the construction and operational phases of NSP2 are summarised in Table 9-23. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-23 Assessment of the overall impacts on marine mammals 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	Low	Negligible	Yes
Release of contaminants into the water column*	Low	Low	Negligible	Yes
Release of chemical warfare agents into the water column*	Low	Low	Negligible	Yes
Generation of underwater noise – TTS/PTS*	Low	Low	Negligible	Yes
Generation of underwater noise – behavioural response	Low	Low	Minor	Yes
Generation of underwater noise - masking	Low	Low	Minor	Yes
Operational phase				
Physical presence of pipelines and structures on the seabed*	Low	Low	Negligible	No
Change of habitat*	Low	Low	Negligible	No
Release of metals from anodes*	Low	Low	Negligible	No

* The assessment of the overall significance of the given impact is subject to expert judgement that deviates from the matrix presented in the section 8.3.

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 EU Habitats Directive and as such, 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 Seabirds

The sources of potential impacts on seabirds during the construction and operation of NSP2 are listed in Table 9-24 and assessed below.

Table 9-24 Sources of potential impacts on birds 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 into the water column	X	
Sedimentation on the seabed	X	
Physical disturbance above water	X	X
Release of metals from anodes		X

In this assessment, particular consideration has been given to the IBAs DK079 Ertholmene and DK120 Rønne Banke. A separate assessment concerning birds designated for the Natura 2000 sites is presented in section 9.12.

9.10.1 Construction phase

In the following sections, the identified sources of potential impacts on seabirds during the construction phase are assessed.

9.10.1.1 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 the foraging efficiency of birds through decreased water transparency or reduced food availability due to prey avoidance. Birds are mobile and are therefore likely to be exposed to increased turbidity for a short duration. However, the resilience of birds towards suspended sediments and sedimentation varies among 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 (see section 7.11). Therefore, the sensitivity of birds towards suspended sediments is assessed to be high.

Temporary elevated levels of turbidity may cause a decrease in the amount of light that penetrates the water column. Generally, a concentration above 15 mg/l has the potential to impact the vision of diving waterbirds such as the common scoter, long-tailed duck, razorbill and guillemot /404/. Wintering seaducks might use deeper foraging habitats with water depths greater than 20 m, where light penetration in winter is poor /405/. These birds also frequently forage on infaunal bivalves, which cannot be located visually but tactilely. This indicates that seaducks can use foraging techniques that do not rely on vision. During the baseline investigations for the Fehmarn belt tunnel, it was found that common goldeneyes predominately aggregate in the most turbid areas of the Fehmarn belt, such as Rødsand Lagoon and Orth Bight. Therefore, the common goldeneye was considered a species tolerant to changes in water transparency, as it frequently experiences low visibility under natural conditions in the Fehmarn belt. In general, seaducks are probably not very sensitive to changes in water transparency; however, in the case of strong gradients, a preference for clearer water lead to avoidance of areas with poor water transparency /406/.

Increased concentration of suspended sediment may occur in the vicinity of the proposed intervention works (post-lay trenching, rock placement). Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the duration of sediment concentration above 2 mg/l is expected to last up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing (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 time span.

Increased turbidity may also lead to avoidance of affected 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.

Thiamine (vitamin B1) is involved in numerous metabolic processes and thiamine deficiency has been reported for several bird species in the Baltic Sea area. It is suggested that thiamine deficiency can be an explaining factor in declining bird populations /407/. Thiamine is produced by phytoplankton, and production is affected by factors such as light, temperature and salinity /408/. Factors that alter these conditions over a long period, e.g. climate change, could in turn have an impact higher up in the food chain /409/. No NSP2 activities are assessed to cause such long-term differences in light, temperature or salinity. Increased suspended sediment from intervention works will be temporary and a negligible impact on plankton communities is expected, see section 9.6.

Brominated aromatic compounds have been detected in all components of the marine food web in the Baltic Sea. Although similar to flame retardant, the compounds are also produced naturally by certain macroalgae (e.g. *Ceramium tenuicorne*) /410/. When put under stress from changes in salinity or elevated light levels, the release of these compounds is increased /411/. High concentrations of these compounds may cause mussels to become undernourished, which in turn affects the intake of mussel-eating birds. No macroalgae occur along the proposed pipeline route since it is situated below the photic zone. Furthermore, studies on long-tailed ducks, which occur at Rønne Banke and live off mussels, show that the compounds are poorly retained /412/. The activities from NSP2 are not assessed to cause such stress as presented in the literature. Thus, no impact from brominated aromatic compounds is expected.

The NSP2 route V1 passes more than 29 km south-east of the IBA DK079 Ertholmene and the NSP2 route V2 passes at a distance of more than 35 km. Based on the modelling results (see section 8.4.1), it is conservatively assessed that increased turbidity will not reach the IBA due to the distance from the intervention works location and short duration of the impact. Thus, no impacts from suspended sediments are expected on the IBA DK079 Ertholmene or its key species.

The proposed NSP2 route crosses the IBA DK120 Rønne Banke for a total distance of approximately 7 km of the IBA just before entering German EEZ. Release of suspended sediment from post-lay trenching will occur too far from the IBA to cause an increase in turbidity, and suspended sediment resulting from rock placement is expected to decrease to a concentration below 2 mg/l within 4.5 hours (see section 8.4.1). Furthermore, as described in section 9.7, the impact on benthic fauna is negligible, so no impact on the food source for seabirds is expected. Since the impact is temporary and several of the bird species in the area are adapted to foraging in low-visibility conditions or can choose to forage elsewhere, the impact on the IBA DK120 Rønne Banke from suspended sediments is expected to be negligible.

In summary, the impact on seabirds associated with the release of sediments into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on seabirds from the release of sediments into the water column is assessed to be negligible.

9.10.1.2 Release of contaminants into 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 lead to the release of contaminants currently associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide, as discussed in section 8.4.3. 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) (see section 7.11), the sensitivity of birds towards contaminants released into the water column is assessed to be medium.

Calculations and modelling has been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column is generally not expected to result in concentrations that exceed thresholds for EQS, with the exception of two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. The majority of contaminants will redeposit on the seabed (associated with the sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route. In addition, the majority of the released contaminants would be limited to the lower 10 m of the water column, and most of the released contaminants (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/. Therefore, no acute toxic effects on birds are expected.

It is assessed that potential impacts on birds due to bioaccumulation of contaminants through prey is highly unlikely since no impacts on benthos or fish from contaminants in the water column have been identified (see sections 9.7 and 9.8, respectively).

Similarly, it is conservatively assessed that potential release of contaminants into the water column will not impact the IBAs DK079 Ertholmene and DK120 Rønne Banke due to the low intensity of the impact and short duration of the impact.

In summary, the impact on seabirds associated with the release of contaminants into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on seabirds from the release of contaminants into the water column is assessed to be negligible.

9.10.1.3 Release of chemical warfare agents 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 8.4.1.3. The release of CWA into the water column has the potential to impact birds by 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) (see 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. 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. As discussed in section 9.4.1.3, the impact on water quality from CWA has been assessed to be negligible, and below applicable PNEC thresholds (see section 8.4.4). 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 into the water column during the construction phase is assessed to be negligible (see sections 8.4, 9.4.1.3, 9.7.1.5 and 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 IBAs DK079 Ertholmene and DK120 Rønne Banke due to the low intensity of the impact and short duration of the impact.

In summary, the impact on seabirds associated with the release of CWA into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on seabirds from the release of CWA into the water column is assessed to be negligible.

9.10.1.4 Sedimentation on the seabed

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). A number of bird species and areas (IBAs) were identified as important (see section 7.11). Therefore, the sensitivity of birds towards sedimentation is assessed to be high.

As described in section 8.4.1, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 - 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. An area of 0.24 km^2 will experience >200 g/m^2 of deposited sediment associated with post-lay trenching and rock placement. Overall, the sedimentation will thus be local and of low intensity. It has been assessed that the ecosystem, including benthic fauna, will quickly revert to its natural state after the termination of project activities. Therefore, sedimentation on the seabed is unlikely to affect the foraging of benthos-feeding and fish-eating birds.

The NSP2 route V1 passes more than 29 km south-east of the IBA DK079 Ertholmene and the NSP2 route V2 passes at a distance of more than 35 km. Based on the modelling results (see section 8.4.1), it is conservatively assessed that increased sedimentation will not affect the IBA due to the distance from the intervention works location and short duration of the impact. As such, no impacts on the IBA DK079 Ertholmene from sedimentation is expected.

The proposed NSP2 route crosses the IBA DK120 Rønne Banke for a total distance of approximately 7 km of the IBA just before entering German EEZ. Post-lay trenching and rock placement are only expected to result in exceedance of >200 g/m^2 of deposited sediment in an area of approximately 0.24 km^2, up to a few kilometres from the proposed route. The deposition is therefore very local. Exceedance of >200 g/m^2 of deposited sediment is therefore expected to very limited inside the IBA Rønne Banke. The sedimentation corresponds to a layer less than 1 mm thick, which is assessed to be too thin to cover potential food items and as described in section 9.7, the impact on benthic fauna is negligible, which in turn means that the food source for foraging seabirds will remain intact. Thus, the impact on the IBA DK120 Rønne Banke from sedimentation is expected to be negligible.

In summary, the impact on seabirds associated with sedimentation on the seabed during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on seabirds from sedimentation on the seabed is assessed to be negligible.

9.10.1.5 Physical disturbance above water

Construction activities will result in the 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 away from resting and/or foraging areas. Resting and foraging birds will use extra energy when escaping. Taking into account important bird species and areas (IBAs) (see 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 /413//414/. The specific flight distance (the distance at which a species begins to react in the face of approaching danger) differs greatly among species and also depends on behavioural activity (e.g. foraging versus resting). In addition, flight distances for many bird species are unreported /413//414/.

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, but it can also be longer (up to 1.5 km) depending flock size, vessel speed etc. /413/;
- Common scoter: flight distance from ships up to approximately 1,200 m away; one very large flock (500 birds) took flight a distance of 3.2 km /413/;
- Common guillemot: flight distance from ships up to hundreds of metres away /415//416/;
- Black guillemot: flight distance from ships up to hundreds of metres away /415//416/;
- Razorbill: flight distance from ships up to hundreds of metres away /416/;
- Red- and black-throated divers: flight distance from ships up to 1,000 m away /413//417/;
- Common goldeneye: flight distance from ships in the range of 500-1,000 m away /418/.

Based on these examples, it is concluded that impacts on birds from noise and visual disturbances from ships involved in construction works will, in general, be limited to a 1-1.5 km radius around the working area. The working area itself can be up to approximately 3 km wide. The disturbance zone would therefore be approximately 6 km wide if a conservative approach to flight distances is used. Note that most of the birds will return to the area not long after they have been disturbed. One study shows that two hours after disturbance of an area, 57% of the long-tailed ducks and 10 % of the common scoters had returned /413/.

As noted above, the NSP2 route V1 passes more than 29 km from the IBA DK079 Ertholmene and the NSP2 route V2 more than 35 km. Because of the distance, it is assessed that the impact from the presence of vessels and the associated noise disturbances on the IBA will be negligible.

The proposed NSP2 route crosses the IBA DK120 Rønne Banke for a total distance of approximately 7 km of the IBA just before entering German EEZ. 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 common species, observed during February and March /257/. Foraging and resting birds within 1-1.5 km of construction vessels, may be impacted and fly off. However, as construction activities will be of a short duration within any given location, and for a total duration of a few days across Rønne Banke (taking into consideration that the pipe-lay vessel will move with a speed of 3 km/day), any disturbance of birds during construction works will be temporary. Seabirds are therefore expected to return within a couple of hours or choose to relocate and forage elsewhere on Rønne Banke.

In summary, the impact on seabirds associated with physical disturbance above water during construction will be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on seabirds from physical disturbance above water is assessed to be negligible.

9.10.2 Operational phase

In the following sections, the identified sources of potential impacts on seabirds during the operational phase are assessed.

9.10.2.1 Physical disturbance above water

During the operational phase, periodic inspection of the pipeline will be performed, which will result in the increased presence of vessels supporting the inspection activities. The visual presence of moving vessels as well as above-water noise may disturb seabirds and cause them to fly away from resting and/or foraging areas. Resting and foraging birds will use extra energy when escaping. Taking into account important bird species and areas (IBAs) (see section 7.11), the sensitivity of birds towards physical disturbance above water is assessed to be high.

Periodic pipeline surveys are expected to be undertaken with a frequency of every one to two years during the operational phase. The level of ship activity in connection with such pipeline surveys 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 (see section 9.10.1.5).

In summary, the impact on seabirds associated with physical disturbance above water during operation is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on seabirds from physical disturbance above water is assessed to be negligible.

9.10.2.2 Release of metals from anodes

As described in sections 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 (aluminium, zinc, cadmium) into the water column. Release of aluminium from the anodes will not cause ecotoxicological impacts; however, zinc and cadmium in the water column may be assimilated by plankton and impact survival rates as well as enter the food chain. Given their high mobility, seabirds are not likely to spend long periods of time in the affected areas, but they may be susceptible to bioaccumulation through the food chain. Given the presence of important species in the project area and the low resilience towards zinc and cadmium in the water, the sensitivity of seabirds towards metals from anodes released into the water is judged to be medium.

As discussed in section 9.4.2.2, the release of aluminium, zinc and cadmium 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 near vicinity of the anodes (within a few metres). More generally, the total amounts released from the anodes over the lifetime of the project are insignificant compared with the existing level 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 to one another, 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 (within 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 that would cause a discernible impact on populations.

It is assessed that potential impact on seabirds due to bioaccumulation of metals through prey is highly unlikely since no significant impacts on benthos and fish from contaminants in the water column have been identified (see sections 9.7 and 9.8, respectively).

In summary, the impact on seabirds associated with the release of metals from anodes during operation will be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Similarly, it is conservatively assessed that potential release of metals into the water column will not impact the IBAs DK079 Ertholmene and DK120 Rønne Banke.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on seabirds from the release of metals from anodes is assessed to be negligible.

9.10.3 Summary of impacts

The assessments of the potential impacts on seabirds during the construction and operational phases of NSP2 are summarised in Table 9-25. Where potential transboundary impacts are identified, these are further assessed in section 14.

Table 9-25 Assessment of the overall impacts on seabirds 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	High	Negligible	Negligible	Yes
Sedimentation on the seabed	High	Negligible	Negligible	Yes
Release of contaminants into the water column	Medium	Negligible	Negligible	Yes
Release of chemical warfare agents from the seabed	Medium	Negligible	Negligible	Yes
Physical disturbance above water	High	Negligible	Negligible	No
Operational phase				
Physical disturbance above water	High	Negligible	Negligible	No
Release of metals from anodes	Medium	Negligible	Negligible	No

Based on the conclusions in the sections above (see Table 9-25), the potential impacts on seabirds during the construction and operation of NSP2, either individually or in combination, are assessed to be not significant. Likewise, the potential impacts on IBAs Ertholmene and Rønne Banke are assessed to be not significant during both construction and operation of NSP2.

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). Separate impact assessments for IBAs and Natura 2000 sites are presented in sections 9.10 and 9.12, respectively.

The sources of potential impacts on protected areas during construction and operation of NSP2 are listed in Table 9-26 and assessed below. The minimum distances from the NSP2 route V1 to a

Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km independent of the route alternative.

Table 9-26 Sources of potential impacts on protected areas 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 into the water column	X	
Sedimentation on the seabed	X	
Introduction of non-indigenous 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 NIS, 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 sections, the identified sources of potential impacts on protected areas 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 sediments 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 a low resilience. Therefore, taking into consideration the high importance of protected areas and the low resilience of the most vulnerable receptor, the sensitivity of protected areas is assessed to be high.

Increased concentration of suspended sediment may occur in the vicinity of the proposed intervention works (post-lay trenching, rock placement). Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the duration of sediment concentration above 2 mg/l is expected to last up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing (see section 8.4.1).

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km independent of the route. Impacts from suspended sediments are assessed to have a minor impact on water quality and a negligible impact on fish, marine mammals and seabirds (see sections 9.4 and 9.8-9.10, respectively).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the release of sediments into the water column.

9.11.1.2 Release of contaminants into the water column

The release of sediments 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. 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 the release of contaminants is considered to be seabirds, conservatively assessed to have a low resilience (see section 9.10). Therefore, taking into consideration the high importance of protected areas and the low resilience of the most vulnerable receptor, the sensitivity of 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 /154/, 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 (see sections 8.4 and 9.4).

Calculations and modelling have been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column is generally not expected to result in concentrations that exceed thresholds for EQS, with the exception of two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. 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 addition, the majority of the released contaminants will be limited to the lower 10 m of the water column, and most of the released contaminants (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/.

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.

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Impacts from the release of contaminants are assessed to have a minor impact on water quality and a negligible impact on fish, marine mammals and seabirds (see sections 9.4 and 9.8-9.10, respectively).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the release of contaminants into the water column.

9.11.1.3 Release of chemical warfare agents 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 9.4. 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 CWA in 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 a low resilience (see section 9.10). Therefore, taking into consideration the high importance of protected areas and the low resilience of the most vulnerable receptor, the sensitivity of 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 9.4.1.3, the impact on water quality from CWA has been assessed to be negligible, and below applicable PNEC thresholds (see section 8.4.4).

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Impacts from the release of CWA are assessed to have a negligible impact on water quality, fish, marine mammals and seabirds (see sections 9.4 and 9.8-9.10, respectively).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the release of CWA into the water column.

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, thus changing local sediment characteristics and quality and/or depositing an additional sediment layer. This has the potential to impact the species, habitats or ecosystems for which the protected areas are designated (see section 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 a high resilience (see section 9.7). Therefore, taking into consideration the high importance of protected areas and the high resilience of the most vulnerable receptor, the sensitivity of 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 (see section 8.4) is within natural variation and highly localised (with a majority of the suspended material expected to deposit within a few kilometres of the pipelines). Therefore, the 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.

As described in section 8.4.1, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 - 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. Areas that are expected to experience >200 g/m^2 of deposited sediment are associated with intervention works at the NSP crossing (rock placement and post-lay trenching) and the material will be deposited locally. Overall, the sedimentation will thus be local and of low intensity.

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Sedimentation is assessed to have a negligible impact on benthos, fish, marine mammals and seabirds (see sections 9.7-9.10, respectively).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from sedimentation on the seabed.

9.11.1.5 Physical disturbance above water

Construction activities will result in the increased presence of vessels along the proposed NSP2 route during the construction phase. The visual presence of moving vessels as well as above-water noise has the potential to impact the species, habitats or ecosystems for which the protected areas are designated (see section 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 a medium resilience, with some variation between species (see section 9.10). Therefore, taking into consideration the high importance of protected areas and the medium resilience of the most vulnerable receptor, the sensitivity of 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 (see section 8.4.6). Beyond this distance, noise was modelled to be comparable with ambient noise levels (approx. 33 dB). As the protected areas designated for birds (Ramsar sites) are located at least 29 km from the NSP2 route V1 and more than 35 km from the NSP2 route V2, they will not experience any increase in noise levels as a result of the propagation of airborne noise. Protected seabirds may also exhibit disturbance and flight reactions within a distance of approximately 1-2 km from vessels; these impacts have been assessed to be negligible (see section 9.10).

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Impacts from physical disturbance above water are assessed to have a negligible impact on seabirds (see section 9.10).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from physical disturbance above water.

9.11.1.6 Introduction of non-indigenous species

Vessel movements during construction have the potential to introduce NIS into Danish waters. The potential impact is highly dependent on the NIS introduced, which can be either positive or negative, and may impact the species, habitats or ecosystems for which protected areas are designated (see section 7.12).

The most sensitive receptor in relation to introduction of NIS is considered to be ecosystems (see section 9.13). Taking into consideration the high importance of 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 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, Ballast Water Management Plans requested from contractors involved in the relevant construction activities 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 as required 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 (see section 9.13).

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative.

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the introduction of NIS.

9.11.2 Operational phase

In the following sections, the identified sources of potential impacts on protected areas during the operational phase are assessed.

9.11.2.1 Physical disturbance above water

Planned maintenance activities will result in the 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 impact the species, habitats or ecosystems for which protected areas are designated (see section 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 (see section 9.10). Therefore, taking into consideration the high importance of protected areas and the medium resilience of the most vulnerable receptor, the sensitivity of the protected areas is assessed to be high.

Modelling of pipe-lay, 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 (see section 8.4.6). Beyond this distance, noise was modelled to be comparable with ambient noise levels (approx. 33 dB). As the protected areas designated for birds (Ramsar sites) are located at least 29 km from the NSP2 route V1 and more than 35 km from the NSP2 route V2, they will not experience any increase in noise levels as a result of propagation of airborne noise. Protected seabirds may also exhibit disturbance and flight reactions within a distance of approximately 1-2 km from vessels; these impacts have been assessed to be negligible (see section 9.10).

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Impacts from physical disturbance above water are assessed to have a negligible impact on seabirds (see section 9.10).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from physical disturbance above water.

9.11.2.2 Physical presence of pipelines and structures on the seabed

The presence of the pipelines on the seabed has 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 that determine the life within the Baltic Sea, which can in turn impact the species or habitats for which the protected areas are designated (see section 7.12).

The most sensitive receptors in relation to the physical presence of pipelines and structures on the seabed are considered to be benthic habitats and ecosystems (see sections 9.7 and 9.13, respectively). 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.

Thorough reviews of the hydrographic impacts on the Baltic Proper for NSP and the NSP2 base case route concluded that there would be no impacts on hydrographical bulk flow or sediment accretion/erosion /73//420//421/, and impacts on hydrography were therefore assessed to be negligible (see section 9.3). The results of the 2016 evaluation of the NSP2 base case route have been re-examined with respect to the proposed NSP2 route and are assessed to remain valid.

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 (see sections 9.4 and 9.8-9.10).

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Impacts from the physical presence of structures and pipelines on the seabed are assessed to have a negligible or minor impact on benthos, fish, marine mammals and seabirds (see sections 9.7-9.10, respectively).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the physical presence of pipelines and structures on the seabed.

9.11.2.3 Introduction of non-indigenous species

During 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 receptor in relation to the introduction of NIS is considered to be ecosystems, conservatively assessed to have a low resilience (see 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 operational phase is connected to maintenance activities, where ballast water is rather taken in from the Baltic Sea than released there, or survey activities, where no release or 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 hypoxia/anoxia) will function as a barrier that will prevent migration of species along the NSP2 pipelines.

Project vessels will be compliant with the provisions of the Ballast Water Management Convention (September 2017), including:

- Holding and implementing a Ballast Water Management (BWM) plan;
- Recording all ballast water operations in a BWM record book;
- Conducting ballast water exchange before entering the Baltic Sea Area and in compliance with D-1 standards of exchange;

- Compliance with D-2 (treatment) requirements as applicable and in accordance with renewal of MARPOL International Oil Pollution Prevention (IOPP) certification.

To further reduce the risk of NIS spread through ballast water, ballast tanks will be cleaned as required and washing water delivered to reception facilities in line with IFC EHS Guidelines on shipping and the International Convention for the Control and Management of Ships' Ballast Water and Sediments.

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the NSP2 route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative.

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the introduction of NIS.

9.11.2.4 Release of metals from anodes

The release of metals from anodes is discussed in section 8.4.8. Release of aluminium from the anodes will not cause ecotoxicological impacts, but zinc and cadmium 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 a low resilience (see section 9.7). Therefore, taking into consideration the high importance of protected areas and the low resilience of the most vulnerable receptor, the sensitivity of protected areas is assessed to be high.

The release of aluminium, zinc and cadmium ions from the aluminium anodes was described in section 8.4.8, and the impact on water quality was assessed to be negligible (see section 9.4). The amounts released from the anodes will be insignificant compared with the existing level of waterborne inflow of metals to the area, even though 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.

The minimum distances from the NSP2 route V1 to a Ramsar site is more than 29 km and more than 35 km for the route V2. The distance to the nearest HELCOM MPA is approximately 18 km, independent of the route alternative. Impacts from the release of metals are assessed to have a negligible impact on water quality, benthos, fish, marine mammals and seabirds (see sections 9.4 and 9.7-9.10, respectively).

Based on the above, it is assessed that there will be no or negligible impacts on protected areas from the release of metals from anodes.

9.11.3 Summary of impacts

The assessments of the potential impacts on protected areas during the construction and operational phases of NSP2 are summarised in Table 9-27.

Table 9-27 Assessment of the overall impacts on protected areas during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Overall impact	Potential transboundary impact
Construction phase			
Release of sediments into the water column	High	No or negligible	No
Release of contaminants into the water column	Medium	No or negligible	No
Release of chemical warfare agents into the water column	Medium	No or negligible	No
Sedimentation on the seabed	Low	No or negligible	No
Introduction of non-indigenous species	High	No or negligible	No
Physical disturbance above water	High	No or negligible	No
Operational phase			
Physical disturbance above water	High	No or negligible	No
Physical presence of pipelines and structures on the seabed	High	No or negligible	No
Introduction of non-indigenous species	High	No or negligible	No
Release of metals from anodes	High	No or negligible	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, are assessed to be not significant.

Note that this section focuses on Ramsar sites and HELCOM MPAs (as described in section 7). Separate impact assessments for IBAs and Natura 2000 sites are presented in sections 9.10 and 9.12, respectively.

9.12 Natura 2000 sites

If a project is likely to have a significant effect on Natura 2000 sites, an assessment of whether the project may result in adverse effects on the integrity of Natura 2000 sites is required in accordance with Article 6(3) of the Habitats Directive and Danish legislation (see section 4). The Natura 2000 assessment is following a designated methodology described in section 8.3.7. The initial step of the assessment is a Natura 2000 screening, which identifies the potential impacts of a project on 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. If significant impacts are likely or some degree of uncertainty remains, further appropriate assessment should be carried out.

This Natura 2000 screening assesses the potential for activities within 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 neighbouring countries are described under transboundary impacts (see section 14).

Natura 2000 screenings 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 of NSP2 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 nearest Danish Natura 2000 site is N252 Adler Grund and Rønne Banke, which is located approximately 18 km from the proposed NSP2 route at the nearest point. At N252 Adler Grund and Rønne Banke, there are designated sandbank and reef habitats, but no designated species.

The Natura 2000 site Ertholmene is located approximately 45 km from the NSP2 route V1 and approximately 30 km from the NSP2 route V2. Due to the distance of this site from the proposed NSP2 route alignments, it is assessed to be outside the range of potential impact from the NSP2 project. On the basis of the modelling results and assumptions presented in section 8.4 and the application of professional judgement, Natura 2000 sites located at least 20 km from the proposed NSP2 route are considered to be outside the range of potential impact from the NSP2 project.

Given that there are no other Natura 2000 sites in Danish waters within 20 km of the proposed NSP2 route, the below assessment focuses on potential impacts on N252 Adler Grund and Rønne Banke.

Table 9-28 Preliminary identification of potential sources of impacts on Danish Natura 2000 sites during the construction and operational phases of NSP2, including reasoning for including or excluding the potential impact in the Natura 2000 screening.

Source of potential impact	Construction phase	Operational phase	Assessed in Natura 2000 screening?
Physical disturbance on the seabed	X		No. There is no disturbance of the seabed in the Natura 2000 sites, as the minimum distance to a Natura 2000 site is 18 km.
Release of sediments into the water column	X		Yes. Assessed for habitats
Release of contaminants into the water column	X		Yes. Assessed for habitats
Release of chemical warfare agents into the water column	X		Yes. Assessed for habitats
Sedimentation on the seabed	X		Yes. Assessed for habitats
Generation of underwater noise	X		No. The nearest Natura 2000 sites have no designated species
Physical disturbance above water (e.g. from presence of vessels, noise and light)	X	X	No. The nearest Natura 2000 sites have no designated specie
Imposition of safety zones around vessels	X	X	No. Not relevant to designated habitats.
Emissions of air pollutants and greenhouse gases	X	X	No. Not relevant to designated habitats.
Introduction of non-indigenous species	X	X	No. Not relevant to designated habitats.
Physical presence of pipelines and structures on the seabed		X	No. There will be no physical presence of the pipelines or structures in or near the Natura 2000 sites, as the minimum distance to a Natura 2000 site is 18 km.
Change of habitat		X	No. There will be no changes to habitats in the Natura 2000 sites, as the minimum distance to a Natura 2000 site is 18 km.
Generation of heat from gas flow through the pipeline		X	No. The potential impact is local to the pipeline (within a few metres), and the minimum distance to a Natura 2000 site is 18 km.
Release of metals from anodes		X	No. The potential impact is local to the pipeline (within a few metres), and the minimum distance to a Natura 2000 site is 18 km.

9.12.1 Habitat types

The designated marine habitat types in the relevant Natura 2000 site (N252 Adler Grund and Rønne Banke) are sandbanks and reefs (see section 7.13). The following sources of potential impact have been included in the Natura 2000 screening for these marine habitat types: release of sediments, contaminants and CWA into the water column and subsequent sedimentation (from e.g. post-lay trenching). Each identified source of potential impact is assessed in the sections below.

9.12.1.1 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. Increased turbidity could e.g. impact the species associated with habitat types. Modelling results show that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary, as the suspended sediment concentration will decrease to below 2 mg/l within 4.5 hours in the vicinity of post-lay trenching south of Bornholm and within 0.5 hours in the vicinity of rock placement at the NSP crossing (see section 8.4.1). 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 (see section 9.4). Modelling results demonstrate that the change in suspended sediment in the nearest Natura 2000 site, Adler Grund and Rønne Banke (approx. 18 km from the proposed NSP2 route), is within the range of ambient background concentrations (less than 2 mg/l), see section 8.4.1. Furthermore, increases in suspended sediment will be temporary. In other Danish Natura 2000 sites, the concentration and duration are predicted to be even smaller.

Monitoring of the sediment plume caused by post-lay trenching during NSP construction has shown that suspended sediment concentration was highest near the plough (up to 20 mg/l), while the observed concentrations 500 m behind the plough were less than 4 mg/l. Suspended sediment concentrations resulting from rock placement were of the same magnitude. In general, monitoring has shown that an area of less than 1 km^2 was impacted by suspended sediment concentrations of >10 mg/l for several hours. No spreading of suspending sediments to the Natura 2000 sites was observed (see section 8.4, /316/).

Increases in suspended sediment and changes in turbidity would not alter the character of the habitat types and so the tolerance of sandbanks and reefs is assessed as high and recovery is assessed as high. Flora and fauna associated with the biotopes are adapted to a high-energy environment where the levels of suspended sediments are greater than in more sheltered environments. As the sandbank and reef structures (sandy seabed) are also present outside the Natura 2000 site, with a similar species composition, there is a potential for recruitment of benthic flora and fauna. Any impact would thus be reversible.

Due to the temporary nature of the release of sediment, the high tolerance, the large distance to the Natura 2000 site, and the reversibility of the impact, the release of sediment is assessed to have no significant impact on the designated habitat types sandbanks and reefs in Adler Grund and Rønne Banke.

9.12.1.2 Release of contaminants into the water column

Suspension and dispersion of sediment during the construction phase may result in the release of contaminants currently associated with the sediment.

A calculation of the amounts of nutrients and contaminants which may potentially be released into the water column was undertaken as part of NSP /154/, based on the measured concentrations of the contaminants in the sediment and modelling of 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 (see 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.

Calculations and modelling have been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. In summary, the levels of contaminants in the sediment along the proposed NSP2 route were generally below threshold levels, which limits impacts on the marine environment. Impacts on water quality have been assessed to be local, temporary and of a negligible magnitude; therefore, the overall impact has been assessed to be negligible (see section 9.4).

Based on the temporary nature of the increase, the limited amount and bioavailability of the released nutrients and contaminants, as well as the distance between the habitat types and the proposed NSP2 route, the release of contaminants is assessed to have no risk of adverse impact on the designated habitat types sandbanks and reefs in Adler Grund and Rønne Banke.

9.12.1.3 Release of chemical warfare agents 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 8.4.1.3. The release of CWA into the water column has the potential to impact species associated with the habitat types through direct exposure or bioaccumulation. The release of CWA currently associated with the sediment is discussed in section 8.4. The concentrations along the proposed NSP2 route in Danish waters have been assessed to be below applicable PNEC thresholds (see section 8.4.4). In addition, the CWA present in the Baltic Sea are poorly dissolvable in water and as such exist mainly as particulate material that will resettle 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, which 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 (see section 9.4).

Based on the temporary nature of the increase, the expectation that CWA will be below applicable thresholds, as well as the distance between the habitat types and the proposed NSP2 route, release of CWA is assessed to have no risk of adverse impact on the designated habitat types sandbanks and reefs in Adler Grund and Rønne Banke.

9.12.1.4 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 9.2, the levels of metals, CWA and organic contaminants in sediment along the proposed NSP2 route were generally below threshold levels. Furthermore, the sedimentation will be temporary, within natural variation and highly localised. Therefore, the predicted levels of sedimentation are not considered sufficient to alter the sediment quality in terms of chemistry, the 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 of negligible magnitude; therefore, the overall impact has been assessed to be negligible (see section 9.2).

As described in section 8.4.1, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 - 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. According to the modelling, a total area of 0.24 km^2 will experience >200 g/m^2 of deposited sediment due to post-lay trenching and no area will experience >200 g/m^2 of deposited sediment due to rock placement. Overall, the sedimentation will thus be local and of low intensity. Based on monitoring of the resulting sediment plumes during NSP construction, it can be concluded that no sedimentation will occur within Natura 2000 sites as a result of NSP2 construction (see section 8.4, /316/).

The marine habitat types designated within the Natura 2000 site are in a dynamic environment, with natural sedimentation caused by natural physical disturbance, and they are considered resilient to temporary, small increases in sedimentation.

Due to the temporary nature of the impact, the potential 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.

Conclusion
A screening of the potential impacts on the habitat types designated within the Danish Natura 2000 sites has been undertaken with respect to the following: release of sediments and contaminants to the water column, release of CWA and subsequent sedimentation (from e.g. trenching). In conclusion, it is assessed that 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 Summary of impacts

An assessment of whether a project may result in significant impacts on Natura 2000 sites has been undertaken in accordance with the Habitats Directive and Danish legislation (see section 4). The results are presented in Table 9-29 below.

Table 9-29 Results of the assessment of potential impacts from NSP2 on Natura 2000 sites.

Natura 2000 site	SPA and/or SAC	Designated marine species and habitat types	Natura 2000 assessment
N252 Adler Grund and Rønne Banke (DK00VA261)	SAC 261	1110 sandbanks 1170 reefs	No risk of significant impact

As the Natura 2000 screening (N252) has demonstrated, there will be no risk of significant impact on the designated habitats and no significant impacts on the integrity of the Natura 2000 site N252. Therefore, the coherence of the Natura 2000 network, including spatial and functional connections, will not be affected.

9.13 Biodiversity

By assessing impacts on biodiversity, the EIA supports the realisation of the targets of the Convention on Biological Diversity (CBD),i.e. stopping biodiversity loss and the degradation of ecosystem services by 2020.

The sources of potential impacts on biodiversity during construction and operation of NSP2 are consistent with those identified in sections 9.6-9.12, as summarised in Table 9-30.

Table 9-30 Sources of potential impacts on biodiversity during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance 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 into the water column	X	
Sedimentation on the seabed	X	
Generation of underwater noise	X	
Physical disturbance above water	X	X
Introduction of non-indigenous species	X	X
Emission of air pollutants and greenhouse gases	X	X
Physical presence of pipelines and structures on the seabed		X
Change of habitat		X
Generation of heat from pipelines		X
Release of metals from anodes		X

Each potential source of impact on species and habitats has been assessed in sections 9.6-9.10, and they are therefore not represented here. With due consideration of these assessments, this section provides an assessment of the potential for 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 Danish waters have been assessed with a focus on the different trophic levels of the food web and on both abiotic and biotic components of the ecosystem, including the introduction of NIS.

Given the low biodiversity within 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 sections 9.6-9.12, NSP2 will not result in significant impacts on species (at the individual or population level), 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 habitats, 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 and 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, the construction of NSP2 will not result in a significant impact on two of the main pressures on biodiversity (i.e. eutrophication and physical loss/disturbance).

The potential for introduction of 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. Ballast tanks will also be cleaned as required 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 the species or habitat level during construction 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 introduction of NIS and based on a conservative approach, it is considered that impacts on biodiversity (and ecosystem functioning) during construction will be local, temporary and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the high sensitivity and negligible impact magnitude, 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 (at the individual or population level), habitats nor the integrity of protected areas during the operational phase. Impacts at these levels are generally assessed to be negligible, except for 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 habitats, 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 and 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 on the pressures on biodiversity, including the main pressures (i.e. eutrophication and 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 will be associated with 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 that 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 hypoxia/anoxia) will function as a barrier that will prevent migration of species along the NSP2 pipelines.

With due consideration of the above, it has been assessed that impacts at the species or habitats level during operation would not combine to result in impacts that would be sufficient to cause a change in biodiversity or ecosystem functioning. However, taking into account the potential for the spread of NIS and based on a conservative approach, it is considered that impacts on biodiversity (and ecosystem functioning) during operation will be local, long-term and of low intensity. Therefore, the impact magnitude is assessed to be negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on biodiversity during the operational phase is assessed to be negligible.

9.13.3 Summary of impacts

The assessments of the potential impacts on biodiversity during the construction and operational phases of NSP2 are summarised in Table 9-31.

Table 9-31 Assessment of the overall impacts on biodiversity during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Sources of potential impacts during construction	High	Negligible	Negligible	No
Operational phase				
Sources of potential impacts 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 sources of potential impacts on shipping and shipping lanes during construction and operation of NSP2 are listed in Table 9-32 and assessed below.

Table 9-32 Sources of potential impacts on shipping and shipping lanes during construction and operation of NSP2.

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 that will have associated safety exclusion zones, e.g. the pipe-lay vessel and inspection vessels. The remaining construction-related ship traffic, such as service vessels or pipe-carrying vessels sailing from storage yards to the pipe-lay vessel, will move with a normal sailing speed and obey the same navigational rules as all other commercial ships sailing in the Baltic Sea. These vessels will therefore not impose any restrictions on the existing ship traffic.

9.14.1 Construction phase

In the following section, the 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 be limited in their ability to manoeuvre (i.e. those involved in pipe-lay activities) such that a safety exclusion zone will be imposed. For construction activities, Nord Stream 2 AG will apply to the DMA for the implementation of a safety zone in the order of 3 km (approximately 1.5 nm) for the anchored pipe-lay vessel, 2 km (approximately 1 nm) for the DP pipe-lay vessel, and 500 m radius for other vessels that are restricted in their manoeuvrability. Details including shape, size and marking of the exclusion zones are to be agreed with the authorities. The imposition of the exclusion zones will be temporary at any given location as the construction activities progress.

Only vessels involved in the construction of NSP2 will be allowed inside the safety zone; therefore, all other vessels not involved in construction activities will be required to plan their journeys around the safety zone. In this regard, diving, anchoring, fishery or work on the seabed will also be prohibited within the safety zone. Nord Stream 2 AG, 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. Furthermore, 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.

For communication, a temporary, local notification system can be established in order to increase the alertness of approaching ships. This system can be set up with a local vessel that calls to other vessels. Such a temporary system was established during the construction of NSP, where a person local to the area was used to ensure efficient communication with other vessels.

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. Of note, the proposed NSP2 route crosses the TSS Adlergrund near the Danish-German EEZ border. In this area, safety exclusion zones will be imposed around slow-moving construction vessels, which will lead to a minor restriction on the west bound traffic in the shipping lane within Danish waters. The restriction will extend from the traffic separation zone in the middle of the TSS area and into the one-directional shipping lane, with a total width of 4 km. In any situation, there will be a free width of more than 2 km for safe navigation in the east bound lane. Potential transboundary impacts on ship traffic in Germany are discussed in section 14.2.2.

In addition, a review of ship movements during the construction of NSP showed that navigators on the commercial ships made course adjustments well in advance to safely pass the pipe-lay vessel and the exclusion zone /422/. The sensitivity of ship traffic to the impact from the imposition of safety exclusion zones around construction vessels is therefore in general assessed to be low.

The pipe-lay vessel and its support vessels will move along the proposed pipeline alignment. The anticipated lay rate with a DP vessel will be approximately 3 km/day, while an anchored pipe-lay vessel would have a lay rate of approximately 1-2 km/day. With only up to 3 km of movement per day, the pipe-lay vessel will in practice appear as stationary for passing vessels. The direction of pipe-lay is therefore assessed to be insignificant. In total, the lay of the two pipelines in Danish waters is expected to last approximately 115 days if the combination of the proposed NSP2 route with V1 is selected, or 125 days if the combination of the proposed NSP2 route with V2 is selected.

In summary, the impact on shipping and shipping lanes associated with the imposition of safety zones around vessels during construction is assessed to 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 considered low.

Based on the low sensitivity and low impact magnitude, the overall impact on shipping and shipping lanes from the imposition of safety zones around vessels is assessed to be minor.

9.14.2 Operational phase

In the following section, the potential impacts on shipping and shipping lanes during the operational phase are assessed.

9.14.2.1 Imposition of safety zones around vessels

During normal operation of the pipelines, no project-related vessels will be present along the pipeline route. However, external surveys of the NSP2 pipelines by project-related inspection vessels are expected to be carried out in 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 initial survey results. The inspection vessels will be relatively small and travel along the proposed NSP2 route at a speed of around two to four 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 journeys around the safety zone. This safety zone will be significantly smaller than that required for the pipe-lay vessel during the construction phase, and it will also be temporary (moving with the inspection vessel). As described in section 9.14.1.1, navigators of commercial ships are, in general, observed from a review based on NSP to make course adjustments in good time to safely pass safety exclusion zones. On the basis of the significantly reduced safety zone radius around project vessels, the sensitivity of ship traffic to the imposition of safety zones during the operational phase is assessed to be low.

In summary, the impact on shipping and shipping lanes from the imposition of safety zones around survey vessels during operation will be local, temporary, and of low intensity (because the impact does not lead to any permanent change in the structure or function of ship traffic). Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on shipping and shipping lanes from the imposition of safety zones around vessels is assessed to be negligible.

9.14.3 Summary of impacts

The assessments of the potential impacts on shipping and shipping lanes during the construction and operational phases of NSP2 are summarised in Table 9-33.

Table 9-33 Assessment of the overall impacts on shipping and shipping lanes during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary 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 sources of potential 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 during construction and operation of NSP2.

Source of potential impact	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 countries bordering the Baltic Sea. In this section, focus is given to potential impacts on the Danish commercial fishery in the area. It should, however, be noted that any identified impacts 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 identified 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 contributes in varying degrees to the livelihoods of the fishermen who use it, and may be the primary source of income for some fishermen. However, given the availability of alternative fishing grounds that can provide the same service, the sensitivity of the fishery is assessed to be medium. 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 highest number of registered fishing vessels (30 vessels in 2016), which are dominated by trawlers. Other important harbours in relation to the value of catches, such as Tejn, Hasle and Rønne, had between 8-14 registered fishing vessels in 2016, also primarily using trawls.

For construction activities, Nord Stream 2 AG will apply to the DMA for the implementation of a safety zone in the order of 3 km (approximately 1.5 nm) for the anchored pipe-lay vessel, 2 km (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 1-3 km/day, depending on the type of vessel, the imposition of the safety zone at any given location will be temporary. Construction activities in Danish waters for the lay of the two pipelines are expected to last approximately 115 days if the combination of the proposed NSP2 route with V1 is selected, or 125 days if the combination of the proposed NSP2 route with V2 is selected.

Nord Stream 2 AG, 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. These measures were implemented successfully during the construction of NSP. Fishermen have confirmed on several occasions that they do not consider construction activities to be a significant issue, as they can simply avoid construction-related vessels.

In summary, the impact on commercial fishery associated with the imposition of safety zones around vessels during construction is assessed to be local, temporary and of low intensity (because the impact does not lead to any permanent change in the structure or function of the fishery). Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on commercial fishery from the imposition of safety zones around vessels is assessed to be negligible.

9.15.1.2 Physical disturbance above water - presence of vessels

On the basis of 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 transport pipes and other supplies to the pipe-lay vessel. The increased traffic in the project area has the potential to damage fishing gear, particularly longlines located 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 increased project-specific traffic is minor compared to the normal ship traffic in the area and any potential impact would be local (along the supply line route) and temporary (during supply vessel movements). Approximately 20 vessels based on Bornholm periodically use this type of equipment (some of which fish for cod close to the seabed, and therefore the lines would not be disturbed by traversing vessels) and as such the impact intensity is assessed to be low.

In summary, the impact on commercial fishery associated with physical disturbance above water (presence of vessels) during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the medium sensitivity and negligible impact magnitude, the overall impact on commercial fishery from physical disturbance above water (presence of vessels) is assessed to be negligible.

9.15.2 Operational phase

In the following section, the identified 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 the physical presence of pipelines and structures on the seabed is assessed to be medium, and the fishermen most affected by activities in Danish waters will be those from Bornholm.

During operation, the physical presence of pipelines and structures on the seabed has the potential to impact fishing activities either through the imposition of protection zones (loss of opportunity) or through obstruction (potential damage or loss of gear). Offshore pipelines in Danish waters automatically receive a 200 m protection zone along each side of the pipeline, within which certain activities, e.g. bottom trawling, are not allowed[12]. However, the NSP2 pipelines to be installed in Danish waters have been designed to be resistant to impacts from any interaction with fishing gear and other larger objects. As such, Nord Stream 2 AG will apply for a dispensation to remove the fishery restriction zone around the pipelines to allow fishing activities during the operation of the pipeline. Therefore, the following paragraphs focus on impacts from obstruction.

Obstruction-related impacts will essentially be limited to bottom trawling activities, as the use of gear such as gill nets, pound nets, seine nets and longlines will allow for fishery in the area without the risk of incidence or obstruction. Furthermore, pelagic trawlers will be able to avoid the 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 m. 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 has shown that five years after installation, the pipelines have become embedded at least 50% in many locations. A similar level of embedment is expected for the NSP2 pipelines.

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 do not become naturally embedded in the seabed, fishermen will need to cross the pipelines at as steep an angle as possible – preferably 90 degrees – to reduce the risk of the trawl boards becoming stuck. Therefore, fishermen will be required to adapt their trawling patterns in the immediate vicinity of the pipelines. Experience from the NSP pipelines has shown

[12] Order no. 939 of 27 November 1992 - Order on Protection of Submarine Cables and Pipelines.

that fishermen can coexist with the pipeline system, and thus far no gear has been reported lost or damaged.

Where NSP2 crosses the NSP pipelines, rock placement will be performed (see section 6.4.2.2). The height of the rock berms is assumed to be up to approximately 4-5 m above the seabed at this location. The separation distance between the NSP and NSP2 pipelines will be sufficient enough to allow for fishermen to trawl between the pipelines, apart from in the immediate vicinity of the pipeline crossing. In this area, however, bottom trawling has been recorded at a rather low intensity (see Figure 7-70).

In summary, the impact on commercial fishery associated with the physical presence of pipelines and structures on the seabed during operation is assessed to 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 overall fishery patterns). Therefore, the impact magnitude is considered low.

Based on the medium sensitivity and low impact magnitude, the overall impact on commercial fishery from the physical presence of pipelines and structures on the seabed is assessed to be minor.

9.15.3 Summary of impacts

The assessments of the potential impacts on commercial fishery during the construction and operational phases of NSP2 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 on commercial fishery during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary 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 and structures 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 sources of potential impacts on marine cultural heritage during construction and operation of NSP2 are listed in Table 9-36 and assessed below.

Table 9-36 Sources of potential impacts on cultural heritage during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on the 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 will be performed, see section 7.17. Objects of potential cultural importance that are identified will, where required, be subject to further gradiometric and visual inspection at a later stage of the project. The need for further inspection will be agreed on in consultation with the relevant Danish authorities.

9.16.1 Construction phase

In the following section, the identified source of potential impact on cultural heritage during the construction phase is assessed.

9.16.1.1 Physical disturbance on the seabed

Due to the high importance of CHOs or sites, their protection under the Danish Museum Act[13] as well as their 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 CHOs or sites or render them inaccessible for future research during the operational lifetime of the pipeline.

Upon receipt of the results of the geophysical surveys, a recognised marine archaeology agency will additionally 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 Danish Agency for Culture and Palaces.

During construction of NSP, a number of wrecks were identified in the route corridor and, as such, several mitigation measures were implemented, including controlled pipe-lay and a suitable exclusion zone around identified wrecks and possible CHOs. Furthermore, a wooden rudder was identified and salvaged for preservation prior to beginning construction of NSP /287//423/. The post-lay wreck monitoring programme for NSP consisted of visual inspection of the two wrecks located closest to the pipeline route in Danish waters and confirmed that neither of them were affected by the installation of the pipeline /424//425/.

In the pipeline routing process for NSP2, an initial avoidance buffer of up to 200 m (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 on 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 rerouting 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 a geophysical survey of the highest standard 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 /426/ .

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[13] § 29g of Consolidation Act no. 358 of 08/04/2014.

Should an anchored pipe-lay vessel be used for pipeline installation, anchor handling and the sweep of anchor wires could potentially damage 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 further.

In the event that an anchored pipe-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 CHOs. 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 procedures described above, no impacts on cultural heritage are expected.

Conservatively, the impact on cultural heritage associated with physical disturbance on the seabed during construction is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on cultural heritage from physical disturbance on the seabed is assessed to be negligible.

9.16.2 Operational phase

In the following section, the identified source of potential impact on cultural heritage during the operational phase is assessed.

9.16.2.1 Physical presence of 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 has 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, sedimentation will be confined to the immediate vicinity of the pipeline route and the local currents will not change due to the presence of the NSP2 pipelines. Furthermore, as the NSP2 pipelines have 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 to be determined in consultation with individual regulations), no impacts from erosion around CHOs are anticipated.

The cultural heritage monitoring programme undertaken for NSP showed that the presence of the pipeline on the seabed did not disturb any identified wrecks /287/. On the basis of the results from the NSP monitoring survey, in combination with the proposed routing of the NSP2 pipelines, no impacts on cultural heritage are expected.

Conservatively, the impact on cultural heritage associated with the physical presence of pipelines and structures on the seabed during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and the negligible impact magnitude, the overall impact on cultural heritage from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.16.3 Summary of impacts

The assessments of the potential impacts on cultural heritage during the construction and operational phases of NSP2 are summarised in Table 9-37.

Table 9-37 Assessment of the overall impacts on cultural heritage during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance on 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 sources of potential impacts on people and health during construction and operation of NSP2 are listed in Table 9-38 and assessed below.

Table 9-38 Sources of potential impacts on people and health during construction and operation of NSP2.

Source of potential impact	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 identified sources of potential impacts on people and health during the construction phase are assessed.

9.17.1.1 Physical disturbance above water - noise

Construction activities have the potential to result in airborne noise, which may lead to health impacts on the residents of Bornholm and Ertholmene by e.g. disturbing sleep. People are inherently considered a receptor of high sensitivity with respect to noise.

The municipality of Bornholm does not have specific guidelines for construction noise, but the WHO recommends that in order to protect all individuals from health impacts, night-time noise levels should not exceed 40 dB (A) /427/. The noise distribution at night is considered most critical (and conservative), as night-time noise is generally associated with higher levels of annoyance, and physical and mental health impacts occur at lower noise levels compared with during the day.

As illustrated in Figure 8-13, the noise levels from pipe-lay activities (which are considered as the 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. The anticipated lay rate with a DP vessel will be approximately 3 km/day, while an anchored pipe-lay vessel would have a lay rate of approximately 1-2 km/day. As the proposed NSP2 route passes within approximately 24 km and 37 km (shortest distances) from the coasts of Bornholm and Ertholmene, respectively, the pipe-lay activities will not result in noise levels on land that exceed the recommendation of 40 dB from the WHO /427/. Furthermore, it is unlikely that the noise will be heard above ambient levels on land.

In summary, the impact on people and health from physical disturbance above water (airborne noise) during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on people and health from physical disturbance above water (airborne 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 with respect to light pollution.

High light intensities can disturb the sleep of people close to the light source, and if the impact is persistent, long-term sleep disturbances can result in 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 depend on the meteorological situation; on days with very good visibility, it is possible to see 19 km or more across the Baltic Sea /428/. Therefore, even when visibility is good, the spotlight is unlikely to be visible from either Bornholm or Ertholmene, which are located approximately 24 and 37 km from the proposed NSP2 route (shortest distances), respectively. Furthermore, although construction activities will occur on a 24-hour basis, the vessel will move continuously along the proposed NSP2 route (at a rate of 1-3 km/day, depending on the vessel type) such that any potential impacts will be temporary.

In summary, the impact on people and health associated with physical disturbance above water (light) during construction is assessed to be regional, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and the negligible impact magnitude, the overall impact on people and health from physical disturbance above water (light) is assessed to be negligible.

9.17.2 Operational phase

The pipeline itself will not have an impact on people and health during the operational phase. However, during operation, internal/external pipeline inspection activities will be required, which may lead to the generation of temporary airborne noise or light pollution from vessels. The inspection frequency is expected to be every one to two 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, of a lower magnitude than predicted during the construction phase. It is therefore assessed that the overall impact on people and health during the operational phase will be negligible.

9.17.3 Summary of impacts

The assessments of the potential impacts on people and health during the construction and operational phases of NSP2 are summarised in Table 9-39.

Table 9-39 Assessment of the overall impacts on people and health during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary 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 sources of potential impacts on tourism and recreational areas during construction and operation of NSP2 are listed in Table 9-40 and assessed below.

Table 9-40 Sources of potential impacts on tourism and recreational areas during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Imposition of safety zones around vessels	X	X
Physical disturbance above water - noise	X	
Release of sediments into the water column	X	

This section covers both onshore and offshore tourism and recreation. Based on the findings of the baseline description, the assessment focuses on impacts on accommodations, attractions, activities and recreational areas on the eastern and southern parts of Bornholm and on Ertholmene, as well as offshore activities east and south of the islands.

9.18.1 Construction phase

In the following sections, the identified sources of potential impacts on tourism and recreational areas during the construction phase are assessed.

9.18.1.1 Imposition of safety zones around vessels

As previously noted, Nord Stream 2 AG will apply to the DMA for the implementation of a safety zone in the order of 3 km (approximately 1.5 nm) for the anchored pipe-lay vessel, 2 km (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 leisure activities on the water, such as recreational diving or fishing, will be prohibited within the safety zones.

Generally, recreational divers use the waters close to the coast and only visit sites of special interest further offshore, e.g. a shipwreck or other cultural heritage interest. 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 by location; as such, multiple areas within Danish waters are used. Furthermore, recreational fishing is considered by its nature to be a leisure activity that is not meant to sustain a household. Recreational fishing is therefore assessed to have a low sensitivity in regard 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 progress along the route with a speed of approximately 1-3 km/day, depending on the type of vessel, 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 maximum radius of 3 km (approximately 1.5 nm).

In summary, the impact on tourism and recreational activities (i.e. fishing) associated with the imposition of safety zones around vessels during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on tourism and recreational areas from the 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 tourism and recreational activities that could be susceptible to impacts from increased noise levels 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 physical and mental well-being /429/. In many instances, the quality of a recreational area is influenced by its composition of ambient noise (i.e. natural or mechanical sounds). Studies have shown that noise levels above 50 dB decrease how pleasant the soundscape of a recreational area is perceived by the people visiting it /430/.

As illustrated in Figure 8-13, airborne noise arising from construction activities will not reach levels near or above 50 dB at any time on Bornholm or Ertholmene. Indeed, noise above ambient levels is not expected, and the intensity of the impact will therefore be low. Furthermore, as the pipe-lay vessel will be moving continuously along the proposed NSP2 route, any impact in a given area will be temporary.

In summary, the impact on tourism and recreational areas associated with physical disturbance above water (noise) during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on tourism and recreational areas from physical disturbance above water (noise) is assessed to be negligible.

9.18.1.3 Release of sediments into the water column

As described in section 9.4, water turbidity may increase in the close vicinity of the proposed NSP2 route during the construction phase. This can potentially impact tourism and recreation in relation to diving activities. Recreational diving is usually associated with visits to interesting locations such as wrecks or other CHOs. 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 undertaken in waters impacted by increased turbidity. Furthermore, as there are many suitable diving sites within Danish waters, the sensitivity of tourism and recreational areas to the release of suspended sediments into water column is assessed to be low.

Recreational divers will not be allowed within the safety zone (which will vary in radius from between 500 m for support vessels to approximately 2 km for the DP pipe-lay vessel and approximately 3 km for the anchored pipe-lay vessel), where turbidity will be at its highest. Suspended sediment concentrations beyond the safety zone will be lower (see section 8.4.1); therefore, the impact intensity is assessed to be low. Moreover, the highest increase in suspended sediment concentrations will be associated with intervention works such as trenching and rock placement (see section 8.4.1). These construction activities will be limited to a total distance of less than 5 km alongthe proposed NSP2 route, and suspended sediments are expected to settle in close proximity to the pipelines within a few hours.

In summary, the impact on tourism and recreational areas associated with the release of sediments into the water column during construction is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact on tourism and recreational areas from the release of sediments into the water column is assessed to be negligible.

9.18.2 Operational phase

In the following section, the identified source of potential impact on tourism and recreational areas during the operational phase is assessed.

9.18.2.1 Imposition of safety zones around vessels

As noted in section 9.18.1.1, tourism and recreational areas are assessed to be of low sensitivity to the imposition of safety zones.

No project-related vessels will be present along the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2 during normal operation of the pipelines. However, it may be necessary to impose temporary safety zones around survey vessels used during periodic inspections of the pipeline system. Inspections are expected to be carried out every one to two years during the first years of operation, with potential subsequent adjustments to the inspection frequency based on experience and requirements. The safety zones will prevent other ships (including recreational sailing vessels) from entering the waters around the inspection vessel, and any recreational activities on the water will be prohibited from entering the safety zones.

During operation, potential impacts on tourism and recreational areas from inspection activities (requiring safety zones around vessels) will be of a lower magnitude than those predicted during the construction phase due to a reduced safety zone radius. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact of the imposition of safety zones around vessels on tourism and recreational areas is assessed to be negligible.

9.18.3 Summary of impacts

The assessments of the potential impacts on tourism and recreational areas during the construction and operational phases of NSP2 are summarised in Table 9-41.

Table 9-41 Assessment of the overall impacts on tourism and recreational areas during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Imposition of safety zones around vessels	Low	Negligible	Negligible	No
Physical disturbance above water – noise	High	Negligible	Negligible	No
Release of sediments into the 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 recreational areas 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 sources of potential impacts on existing and planned infrastructure (specifically, offshore infrastructure comprising primarily cables, pipelines and wind farms) during construction and operation of NSP2 are listed in Table 9-42 and assessed below. 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 during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance on the seabed	X	
Physical presence of pipelines and structures on the seabed		X

As shown in Figure 7-80, 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, the NSP2 route V1 or the NSP2 route V2. Therefore, no possible conflicts have been identified. Given that the construction and operation of NSP2 would not prevent future wind farm projects from being realised, no further consideration is given in relation to wind farms in this impact assessment. Instead, this section focuses on the existing cables and existing NSP pipelines that are crossed by the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 within Danish waters, as well as the proposed Baltic Pipe pipeline (see section 7.21).

9.19.1 Construction phase

In the following section, the identified source of potential impact on existing and planned installations during the construction phase is assessed.

9.19.1.1 Physical disturbance on the seabed

Construction activities have the potential to damage localised areas of existing infrastructure that will be crossed by the NSP2 pipeline. However, where the pipeline crosses existing infrastructure such as cables and pipelines, Nord Stream 2 AG will agree designs for safe crossing with the owners 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 for cables and advance dialogue with the relevant authorities regarding potential conflicts, the sensitivity of existing and planned infrastructure is assessed to be low.

Conservatively, the impact on existing and planned infrastructure associated with physical disturbance on the seabed during construction can be considered to be local, long-term and of low intensity. Subject to the implementation of the above measures, the construction of NSP2 is not expected to cause measurable damage to existing installations. Therefore, the impact magnitude is assessed to be negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact on existing and planned installations from the physical disturbance on the seabed is assessed to be negligible.

9.19.2 Operational phase

In the following section, the identified source of potential impact on existing and planned installations during the operational phase is assessed.

9.19.2.1 Physical presence of pipelines and structures on the seabed

In the Danish section, the NSP2 pipelines will occupy a corridor of approximately 147 km if the combination of the proposed NSP2 route with V1 is selected, or approximately 164 km if the combination of the proposed NSP2 route with V2 is selected, within which the seabed will be of limited availability to existing and planned installations. At crossings, the presence of the NSP2 pipelines and support structures has the potential to hinder possible repairs of existing pipelines and cables. This may have a financial implication for the owners and/or operators of the infrastructure.

However, subject to the implementation of the agreed crossing methods and advance dialogue with the authorities, the sensitivity of existing and planned installations is assessed to be low.

As described in section 7.21, the Baltic Pipe is a planned natural gas pipeline that would run through the Baltic Sea between landfalls in Denmark and Poland. The proposed Baltic Pipe route passes within both the Danish EEZ and TW, and crosses the proposed NSP2 route south-east of Rønne Banke /303/. Potential cumulative impacts are assessed in section 12.

During the construction of NSP, flexible concrete mattresses were placed over existing cables at 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 shallower 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 hindrance in the operation or maintenance of existing installations has been reported. Therefore, a similar approach is planned for NSP2.

Subject to implementation of best practice measures, the impact on existing and planned infrastructure associated with the physical presence of pipelines and structures on the seabed during operation will be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and the negligible impact magnitude, the overall impact on existing and planned installations from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.19.3 Summary of impacts

The assessments of the potential impacts on existing and planned installations during the construction and operational phases of NSP2 are summarised in Table 9-43.

Table 9-43 Assessment of the overall impacts on existing and planned installations during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary 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 sources of potential impacts on raw material extraction sites during construction and operation of NSP2 are listed in Table 9-44 and assessed below.

Table 9-44 Sources of potential impacts on raw material extraction sites during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical presence of pipelines and structures on the seabed		X

Given that the proposed NSP2 route does not cross any areas in Danish waters that are currently being used for the exploration or extraction of natural resources (see section 7.22), it is assumed that there will be no impacts on existing raw material extraction sites during construction.

9.20.1 Operational phase

In the following section, the identified source of potential impact on raw material extraction sites during the operational phase is 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 147 km if the combination of the proposed NSP2 route with V1 is selected, or approximately 164 km if the combination of the proposed NSP2 route with V2 is selected, 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 of potential importance for raw material extraction, see section 7.22, in combination with the availability of several designated raw material extraction sites in the surrounding environment, the sensitivity of raw material extraction sites is assessed to be low.

The proposed NSP2 route in Danish waters will be located at depths greater than 20 m, where it is generally not considered feasible (due to technical and mechanical constraints) to establish new raw material extraction sites.

In summary, the impact on raw material extraction sites associated with the physical presence of pipelines and structures on the seabed during operation is assessed to be local, long-term and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on raw material extraction sites from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.20.2 Summary of impacts

The assessments of the potential impacts on raw material extraction sites during the construction and operational phases of NSP2 are summarised in Table 9-45.

Table 9-45 Assessment of the overall impacts on raw material extraction sites during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary 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 sources of potential impacts on military practice areas during construction and operation of NSP2 are listed in Table 9-46 and assessed below.

Table 9-46 Sources of potential impacts on military practice areas during construction and operation of NSP2.

Source of potential impact	Construction phase	Operational phase
Physical disturbance above water - presence of vessels	X	
Physical presence of pipelines and structures on the seabed		X

9.21.1 Construction phase

In the following section, the identified source of potential impact on military practice areas during the construction phase is assessed.

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, Nord Stream 2 AG 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 the presence of project-related vessels is therefore assessed to be low.

In summary, the impact on military practice areas associated with physical disturbance above water (presence of vessels) during construction is assessed to be local, temporary and of low intensity. Subject to communication and coordination with the appropriate authorities (e.g. the Danish Navy), the impact magnitude is assessed to be negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on military practice areas from physical disturbance above water (presence of vessels) is assessed to be negligible.

9.21.2 Operational phase

In the following section, the identified source of potential impact on military practice areas during the operational phase is assessed.

9.21.2.1 Physical presence of pipelines and structures on the seabed

During operation, the pipelines and related support structures will be present on the seabed, which may restrict the use of the area around the pipeline route for military practice exercises. In particular, submarine exercises carried out by the German military east of Bornholm may be impacted depending on how close to the seabed the activities are carried out.

However, on the basis of correspondence received from the German Armed Forces, it has been confirmed that bottoming does not occur in the area to be occupied by the pipelines /305/. Furthermore, the German Armed Forces have stated that there would generally be no objections against laying the pipeline through the mapped submarine areas to be crossed by the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2.

The sensitivity of military practice areas towards disturbance from the physical presence of pipelines and structures on the seabed is therefore assessed to be low.

In summary, the impact on military practice areas associated with the physical presence of pipelines and structures on the seabed during operation is assessed to be local, long-term and of low intensity. Subject to continued communication and coordination with the appropriate authorities (e.g. German Armed Forces), the impact magnitude is assessed to be negligible.

Based on the low sensitivity and negligible impact magnitude, the overall impact on military practice areas from the physical presence of pipelines and structures on the seabed is assessed to be negligible.

9.21.3 Summary of impacts

The assessments of the potential impacts on military practice areas during the construction and operational phases of NSP2 are summarised in Table 9-47.

Table 9-47 Assessment of the overall impacts on military practice areas during construction and operation of NSP2.

Source of potential impact	Receptor sensitivity	Impact magnitude	Overall impact	Potential transboundary impact
Construction phase				
Physical disturbance above water - presence of vessels	Low	Negligible	Negligible	No
Operational phase				
Physical presence of pipelines and structures on the seabed	-	-	Negligible	-

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 sources of potential impacts on environmental monitoring stations during construction and operation of NSP2 are listed in Table 9-48 and assessed below.

Table 9-48 Sources of potential impacts on monitoring stations 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	
Sedimentation on the seabed	X	

9.22.1 Construction phase

In the following sections, the identified sources of potential impacts on environmental monitoring stations during the construction phase are assessed.

As described in section 8.4, construction activities may result in increased suspended sediment and contaminants in the water column and subsequent sedimentation in close proximity 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 could potentially affect data collection covering years of sampling. The sensitivity is therefore considered high for all sources of potential impact.

As shown in Table 7-50, there are five environmental monitoring stations within 10 km of the Danish section of the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. None of the stations are located less than 1 km from the NSP2 route V1 and one of the stations is located less than 1 km from the NSP2 route V2. In order to exclude any potential impact on historical and future data acquired by long-term monitoring stations, Nord Stream 2 AG will consult with the relevant authority and/or organisation operating the station to minimise potential interference. On this basis, it is assessed that there will be limited potential for impacts on environmental monitoring stations.

9.22.1.1 Release of sediments into the water column

The release of sediments into the water column will be greatest in the areas where seabed intervention works, i.e. post-lay trenching and rock placement, are to be carried out. Modelling indicates that in connection with post-lay trenching, an area of 12.9 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 4.5 hours, with concentrations of up to 14.1 mg/l at a distance of 1 km from the intervention works (see section 8.4.1). In connection with rock placement, an area of 0.04 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 0.5 hours, with no measurable concentration at a distance of 1 km from the intervention works (see section 8.4.1)

In summary, the impact on environmental monitoring stations associated with the release of sediments into the water column during construction is assessed to be local, temporary and of low intensity. Given that no seabed intervention works are planned in the vicinity of environmental monitoring stations, the impact magnitude is thus assessed to be negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on environmental monitoring stations from the release of sediments into the water column is assessed to be negligible.

9.22.1.2 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 associated with the sediment, including metals, organic contaminants and nutrients (N and P), as discussed in section 9.4.1.2.

Calculations and modelling have been undertaken for the release of contaminants into the water column as a result of post-lay trenching and rock placement, see section 8.4.3. The calculations are considered worst case and are based on the maximum measured concentrations in sediment. The results show that the release of contaminants into the water column is generally not expected to result in concentrations that exceed thresholds for EQS, with the exception of two PAH substances (BghiPer and Ipyr), for which concentrations in the water may exceed threshold levels for a duration of up to 4.5 hours in the vicinity of post-lay trenching south of Bornholm and up to 0.5 hours in the vicinity of rock placement at the NSP crossing. The majority of contaminants will re-deposit on the seabed (associated with sediment particles) within a distance of no more than a few kilometres from the proposed NSP2 route. In addition, the majority of the released contaminants would be limited to the lower 10 m of the water column, and most (including PAHs) will remain adsorbed to the sediment particles, and will therefore not be bioavailable /136/.

In summary, the impact on environmental monitoring stations associated with the release of contaminants into the water column during construction is assessed to be local, temporary and of low intensity. Therefore the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on environmental monitoring stations from the release of contaminants into the water column is assessed to be negligible.

9.22.1.3 Sedimentation on the seabed

As described in section 8.4.1, sedimentation associated with construction of NSP2 has been modelled. For comparison, the natural sedimentation rate in the Bornholm Basin is in the range of 1.5 – 4.5 mm/year (see section 7.3.2). Sedimentation of 200 g/m^2 corresponds to a fine sand sediment layer of less than 1 mm. Modelling indicates that as a result of trenching, a total area of 0.24 km^2 may experience sedimentation that exceeds >200 g/m^2, corresponding to a sediment layer of approximately 1 mm. Rock placement will not result in sedimentation exceeding 200 g/m^2.

In summary, the impact on environmental monitoring stations associated with sedimentation on the seabed during operation is assessed to be local, temporary and of low intensity. Therefore, the impact magnitude is considered negligible.

Based on the high sensitivity and negligible impact magnitude, the overall impact on environmental monitoring stations from sedimentation on the seabed is assessed to be negligible.

9.22.2 Summary of impacts

The assessments of the potential impacts on environmental monitoring stations during the construction and operational phases of NSP2 are summarised in Table 9-49.

Table 9-49 Assessment of the overall impacts on environmental monitoring stations 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	High	Negligible	Negligible	No
Release of contaminants into the water column	High	Negligible	Negligible	No
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 resources and receptors assessed in this EIA are 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.

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	Seabirds	Protected areas***	Natura 2000	Biodiversity
Construction phase	Physical disturbance on the seabed													
	Release of sediments into the water column													
	Release of contaminants into the water column													
	Release of chemical warfare agents into the water column													
	Sedimentation on the seabed													
	Generation of underwater noise									**				
	Physical disturbance above water*													
	Emissions of air pollutants and greenhouse gases													
	Introduction of non-indigenous species													
Operational phase	Physical presence of pipelines and structures on the seabed									****				
	Change of habitat													
	Physical disturbance above water*													
	Emissions of air pollutants and greenhouse gases													
	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, airborne noise and light.
** Impact on marine mammals from underwater noise is assessed to be "Negligible" for PTS/TTS and "Minor" for behavioural response and masking.
*** Protected areas include Ramsar sites and HELCOM MPAs.
**** This impact refers to the noise of the gas flowing through the pipeline.

Negligible impact | Minor impact

Table 9-51 Summary of the overall impacts caused by the NSP2 project on socio-economic resources or receptors.

Source of potential impact		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
Construction phase	Physical disturbance on the seabed			Negligible			Negligible			
Construction phase	Release of sediments into the water column					Negligible				Negligible
Construction phase	Release of contaminants into the water column									Negligible
Construction phase	Physical disturbance above water		Negligible		Negligible	Negligible			Negligible	
Construction phase	Imposition of safety zones around vessels	Minor	Negligible			Negligible				
Construction phase	Sedimentation on the seabed									Negligible
Operational phase	Physical presence of pipelines and structures on the seabed		Minor	Negligible			Negligible	Negligible	Negligible	
Operational phase	Physical disturbance above water				Negligible					
Operational phase	Imposition of safety zones around vessels	Negligible				Negligible				

Negligible impact   Minor impact

For details on the assessments, please refer to the relevant sections 9.1 to 9.22.

10 MARINE STRATEGIC PLANNING

In addition to analysing potential impacts on specific receptors in accordance with the EU 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 regarding the legal framework under the MSFD and WFD as well as the BSAP;
- 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 MSFD and the WFD together with the BSAP are closely interlinked. Together, they aim to improve the quality of the European waters as set out in the Maritime 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 GES of marine waters and Good Ecological/Good Chemical Status of surface waters, respectively. Significant levels of overlap exist with respect to chemical quality, eutrophication and other aspects of ecological quality as well as hydromorphological quality. Where geographical overlap occurs (in coastal waters up to 12 nm), see Figure 10-1, the MSFD is generally applied to those aspects which are not already covered by the WFD.

Both the MSFD and WFD are also inter-related to the Habitats and Birds Directives. However, the scope of the 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 Directives focus on the conservation of particular habitats and species, respectively, 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 Directives has been addressed in sections 9.10-9.12.

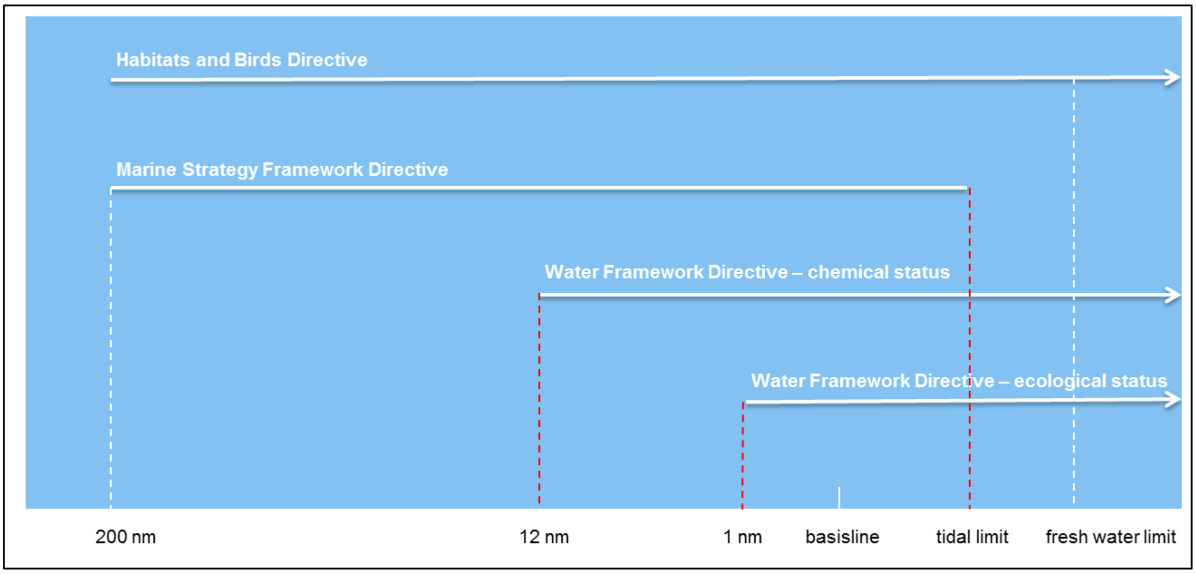

Figure 10-1 Marine areas covered by EU marine legislation.

The MSFD requires that, in developing their marine strategies, Member States use existing regional cooperation structures to coordinate their actions with those of other countries in the same region or sub-region. The HELCOM BSAP 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 /22/) 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 Member State must take the necessary measures to achieve or maintain 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 initially produced a set of criteria and methodological standards for GES to help Member States measure progress of the status /431/. In 2017, an EU Commission Decision further specified detailed criteria and methodological standards on GES of marine waters and specifications and standardised methods for monitoring and assessment /432/.

As noted in section 4.3, the MSFD is implemented in Danish law through the Marine Strategy Act /25/. In accordance with this legislation, the Danish Agency for Water and Nature Management (today the Danish Environmental Protection Agency) has prepared a detailed assessment of the current environmental status (for each descriptor) with a definition of GES at regional levels /27/. The first volume of the Danish Marine Strategy was issued in 2012 and covered the years 2012-2018. The first part of the draft second volume of the Danish Marine Strategy, which covers the years 2018-2024, was in public consultation from November 29, 2018 to February 21, 2019 /26/. After the consultation deadline, the Ministry of Environment and Food makes a decision on the first part of the Danish Marine Strategy vol. II, which thereby replaces the Danish Marine Strategy vol. I from 2012. The Danish Marine Strategy vol. II will be followed up by a monitoring program in 2020, and in 2021, Denmark must notify the European Commission of which measures that will be included in the coming programme of measures.

As part of the Danish Marine Strategy vol. I from 2012, 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 /433/. Indicators are specific attributes of each GES criterion that can either be qualitatively described or quantitatively assessed to determine whether each criterion meets GES, 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 the 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 Basins) 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 MSFD /431/. Where information in the Danish Marine Strategy was insufficient to determine the current environmental status, reference has been made to the information from HELCOM /434/.

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" or "bad", this results 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" /27/, 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 7.7-7.14
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	Sections 7.7-7.14
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 • P3 • P5 • P8	Sections 7.9, 7.16
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	• Productivity of key species or trophic groups • Proportion of selected species at the top of food webs	"Not good"[2]	All pressures	Sections 7.7-7.14

Descriptor	Description of GES	Relevant condition criteria	Current environmental status	Relevant pressures	EIA baseline information
	of their full reproductive capacity.	• Abundance/distribution of key trophic groups/species			
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.	• Nutrient levels • Direct effects of nutrient enrichment • Indirect effects of nutrient enrichment	"Not good"[1]	• P7	Section 7.5
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 ecosystems, in particular, are not adversely affected.	• Physical damage having regard to substrate characteristics • Condition of benthic communities	GES reached[2]	• P1 • P2	Sections 7.3, 7.8
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 7.4
D8 Contaminants*	Concentrations of contaminants are at levels not giving rise to pollution effects.	• Concentration of contaminants • Effect of contaminants	"Not good"[1]	• P5	Sections 7.3, 7.5
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	Sections 7.3, 7.5 (precursors), and 7.9
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 7.7-7.14

Pressures identified in the MSFD annex III	Impacts associated with the pressures in MSFD annex III) (NSP2 relevancy are underlined)
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 /27/.
2: Information from HELCOM /434/.
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 designed to achieve or maintain GES has been sent into public hearing in 2016. The measures are primarily of an 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 proposed NSP2 route and will not be of relevance to NSP2. No further measures have been identified to date.

10.1.2 Water Framework Directive

The Water Framework Directive (WFD) /29/ is a key initiative that contains purpose descriptions designed to improve 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 freshwater, the WFD also covers transitional and coastal waters up to one nautical mile off the coast for ecological status and 12 nm miles for chemical status. The objective of the WFD was to achieve "good ecological and good chemical status" for surface water bodies by 2015. In 2016, a new management period started with the same target for 2021.

As noted in section 4.2.6, the WFD is implemented in Denmark by the Act on Environmental Objectives /30/ and the Act on Water Planning /31/ and a number of associated orders. In accordance with this legislation, the Danish Agency for Water and Nature Management (today the Danish Environmental Protection Agency) published a management plan for each sub-region covering the period 2015 – 2021 in June 2016, including area 3.1 covering Bornholm /435/.

The Marine Strategy reports (basis analysis /27/ and target report /433/) 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, Executive Order no. 1521 of 15 December 2017 on programmes of measures for water basins (*bekendtgørelse om indsatsprogrammer for vandområdedistrikter*) sets out a specific programme of measures designed to maintain or improve the environmental status of relevant water basins, and is legally binding.

Furthermore, Executive Order no. 1521 of 15 December 2017 on programmes of measures for water basins 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 GES by 2021.

The proposed NSP2 route is located within the Danish EEZ, where water management plans are not valid. However, the Management plan area 3.1, "Bornholm", is reviewed in this section in relation to the NSP2 project; particularly the 12-nm zone from Bornholm and Christiansø (see Figure 10-2). This is due to the proximity of the outer limit of this zone to the proposed NSP2 route in Danish waters, as some impacts related to construction and/or operation of the pipeline have the potential to cross into the 12-nm zone.

The current chemical status within this 12-nm zone is "good" based on measurements of benzo[a]pyrene and fluoranthene levels in mussels /435//436/. The current environmental status is "poor" around Bornholm and "moderate" around Ertholmene based on phytoplankton biomass (chlorophyll-*a*), the depth limit of where eelgrass occur and the Danish quality index for benthic fauna /435//436/.

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) /435//436/.

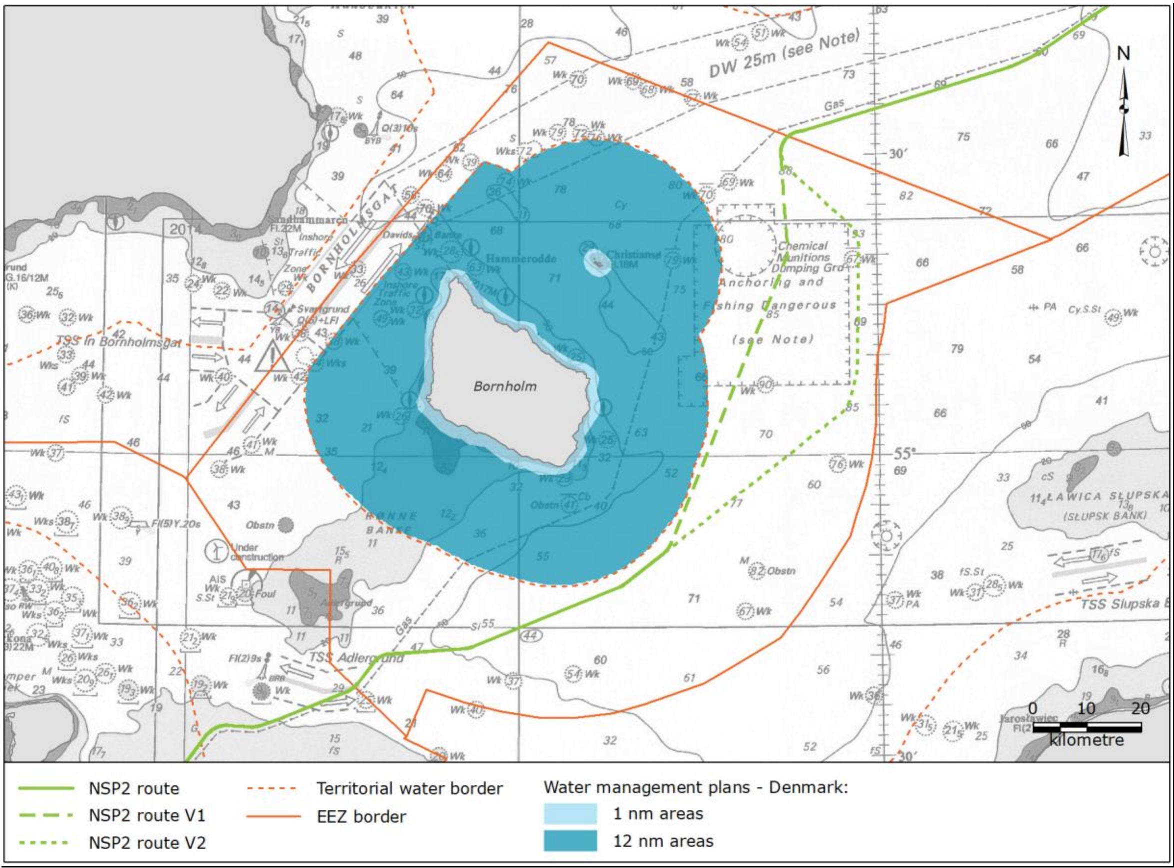

Figure 10-2 Management Area 3.1: Bornholm.

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, and the area is expected to meet the targets for 2021 through existing management measures /435//436/. The water quality along the proposed NSP2 route is described in section 7.5.

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 HELCOM BSAP was adopted; the contracting parties are Denmark, Estonia, Finland, 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 /69/. 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 the 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 targets for monitoring and evaluation of the BSAP /69/.

As noted in section 4.3.3.8, 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 section 9. The assessments have been undertaken assuming implementation of identified mitigation measures (see section 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)

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) 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, vessels will be compliant with the provisions of the Ballast Water Management Convention (September 2017). Implementation of these measures will reduce the risk of introducing NIS into Danish waters via vessel movements to a very low level.

With respect to operation, the NSP2 pipelines will introduce a hard substrate where there was previously sand, thereby 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, impacts during construction and operation (individually or in combination) will not result in significant impacts on the abundance or 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 is 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 are of particular relevance to shellfish. There is no physical loss in the Danish water management area, as the proposed NSP2 route and both NSP2 route variants (i.e., the NSP2 route V1 and the NSP2 route V2) are located within the EEZ. The level of sedimentation below 1 mm, which has the potential to cause physical disturbance, will be limited (see sections 8.4.1, 9.7, 9.8 and 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 or extent. There are no restrictions during the operational 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 (see sections 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 stock 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 relates to human-induced pressures. Eutrophication has the potential to increase primary production (also including toxic algal blooms) and to 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 section discusses the potential for NSP2 to impact existing pressures on D5, and concludes (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 into the water column is assessed to have a negligible impact on turbidity, and based on this, it is assumed that there will also be a 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 are expected on pelagic and benthic communities (see sections 9.6 and 9.7, respectively).

No release of nutrients is expected during 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 (criterion 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 the operational 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, including 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 the assessments presented in sections 9.2 and 9.4) on the potential for impacts on each condition criterion.

Hazardous substances (P5) will be released from NSP2 activities during both the construction and operational phases due to release from sediments (construction phase) and anti-corrosion measures (operational phase). Management plans for all vessel activities will ensure that no impacts on water quality will occur as a result of discharges from vessels.

With the exceptions of BghiPer and Ipyr, the ERL threshold levels established by HELCOM are not exceeded in the sediment along the proposed NSP2 route (see sections 9.2 and 9.4). Such exceedance occurs in deep parts of the NSP2 route where no benthos are present, thereby preventing the compounds from bioaccumulating in the food chain (see sections 9.2 and 9.4). 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 and 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 (see sections 9.4 and 9.6-9.9).

During the operational phase, the release of metals from sacrificial anodes, composed of an aluminium alloy with small amounts of other metals including zinc and cadmium, will result in slightly elevated concentrations of metals in the water column. This will, however, be measurable only within a few metres of the pipeline, and the impact is therefore 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 levels of contaminants in exploited fish and shellfish, thereby resulting in a 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; 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 the movement and feeding of marina fauna.

The target is to prevent marine litter from impacting the marine ecosystem and the socio-economic services provided by the ecosystem, as well as to prevent the litter from acting as a vector for NIS. The following section discusses the potential for NSP2 to impact existing pressures on D10, and conclude the potential for impacts on each criterion.

On the basis of section 6.7 and the NSP2 HSES MS management plans, it is assessed that for both the 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 a negligible impact on the amount of litter in the water column, in by-catch 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 marine fauna or cause avoidance behaviour, whilst sound pulses have the potential to cause temporary or permanent damage to hearing apparatuses.

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 8.4.5) on 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 is not expected to include acoustic impulses, i.e. from munitions clearance, in Denmark.

The intensity of the predicted noise levels will not cause permanent damage to the auditory organs of marine fauna and hence no long-term or permanent impacts are anticipated. The underwater noise from rock placement may result in TTS within a zone of 80-100 m. Behavioural, TTS and masking impacts on fish and marine mammals from underwater noise is assessed to be negligible to minor (see sections 9.8 and 9.9, respectively).

No underwater noise is anticipated during 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 on the species, population and habitats levels and to ensure that the structures and functions of ecosystems 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)) are 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. There is no physical loss in the Danish water management area, as the NSP2 pipeline route is in the EEZ. The maximum level of sedimentation (>200 g/m^2, which is equivalent to approximately 1 mm), which may have the potential to cause physical disturbance, will also be limited to an area of approximately 0.24 km^2. The resulting sedimentation (1 mm) is within the natural annual sedimentation rate of the Baltic Sea (1.5 - 4.5 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 or minor impacts are also predicted for all other species and habitats along the NSP2 route in Danish waters (see sections 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 the biomass nor the 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); reduce 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 2 mg/l will be limited to a duration of up to 4.5 hours, within a limited area. 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 sections 9.7-9.10).

NSP2 construction activities also have the potential to cause the 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, with the exception of two organic compounds that will be released in deeper sections of the route, and will hence not cause any impact on biodiversity and food webs. Release of nutrients in oxygenated sections will result in oxygen consumption; however, 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 or minor (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 only occur in close proximity to the noise source (i.e. the pipe-lay vessel), which will be moving along the NSP2 route at a rate of approximately 3 km/day. As such, the impact can be considered local and temporary. Worst-case impacts from rock placement, which is planned for up to two locations in Denmark, is modelled to result in TTS for fish and marine mammals within a zone of only 80 m 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 (i.e. fish and marine mammals) are assessed to be negligible or minor (see sections 9.8.1.6 and 9.9.1.4).

The construction of NSP2 will result in negligible impacts on abiotic conditions (including hydrological processes, P4), except for minor impacts on water quality, and as discussed in sections 9.6-9.13, 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 NIS into the Baltic Sea (P8). However, subject to the implementation of standard mitigation measures (see section 15.3), 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 Descriptor D2 Non-indigenous species in section 10.2.1.1.

In summary and as described in section 9, impacts at the species or habitat level would not combine to result in impacts which would be sufficient to cause a change in biodiversity or ecosystem functioning. Therefore, it can be concluded that impacts during construction, either individually or in-combination, will not result in significant impacts at the 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 expected 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 and 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 describe 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.

No permanent impacts on hydrography are expected during the construction phase.

The presence of the pipelines on the seabed during the operational phase will constitute a limited interference with local hydrological processes (P4) by introducing a small change in bathymetry (see sections 9.1 and 9.3). However, given the scale of such change and the fact that exchange of water in the Baltic Sea primarily takes place in the upper levels of the water column, the impact on hydrographical conditions is assessed to be negligible.

In summary and on the basis of the above, although there are no clear criteria for this descriptor, impacts during construction and operation (individually or in combination) will not result in significant permanent 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.

10.2.1.9 NSP2 impact on national compliance with MSFD

Construction and operation of 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.

10.2.2 The Water Framework Directive

Construction and operation of NSP2 does not enter either the one nautical mile area nor the 12-nm area of Denmark.

However, an assessment has been undertaken to assess whether NSP2 will be contrary to the objectives and initiatives set out in the WFD.

As described in section 10.1.2, the main pressures on the marine environment in relation to the WFD comprise eutrophication (particularly related to nitrogen), fishery and pollutants (e.g. metals). The following section discusses the potential for NSP2 to impact existing pressures.

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. Therefore, no impacts on water quality as a result of discharges from project vessels (e.g. sewage) are assessed to occur (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) have the potential to disturb the seabed and cause the release of contaminants and nutrients into the water column (thereby reducing water quality).

Turbidity and sedimentation have been modelled for trenching and rock placement activities (see section 8.4.1) and indicate that the concentration of suspended sediment in the water column will exceed 2 mg/l within an area of 13 km^2 around the proposed NSP2 route, for a duration of up to 4.5 hours. Therefore, the impacts on water quality associated with suspended sediment release (contaminants and nutrients) will be temporary. On this basis, impacts within the 12 nm area designated under the WFD are assessed to be negligible.

Anodes will prevent corrosion of the pipelines during the operational phase. 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 for within a few metres around the pipelines. The release of metals is assessed to have negligible impact in Danish waters (see 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.

10.2.3 HELCOM Baltic Sea Action Plan

The HELCOM BSAP sets out four key focus topics in order to achieve the goal of the Baltic Sea being of GES before 2021. The BSAP has formed the basis for the targets of both the MSFD and WFD, and consequently the focus topics of the BSAP overlap with the goals of both the MSFD and WFD. The topics comprise:

- Eutrophication;
- Hazardous substances;
- Nature conservation and biodiversity;
- 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.

10.2.3.1 Eutrophication

As noted above, disturbance of the seabed by intervention works, pipe-lay and/or anchor handling will cause resuspension of sediment and the associated release of nutrients from the sediment pool.

The impact of NSP2 regarding eutrophication is assessed in section 9.4, and though seabed intervention works may cause local and temporary releases of nutrients transferred from the sediments into the water column, the impact is assessed to be negligible due to the presence of the overlying halocline. In section 9.6 it is further assessed that the small release of nutrients will not result in an algal bloom.

Based on these assessments, it is concluded that NSP2 will not impact water clarity and it is concluded that NSP2 would not prevent Member States from reaching the target for eutrophication.

10.2.3.2 Hazardous substances

Nord Stream 2 AG’s handling of hazardous substances is described in section 15.13 and the release of substances into the water column is assessed in section 9.4.

Hazardous substances may be released from the sediment during pipe-lay and rock placement. Furthermore, metals will be released from anodes on the pipeline (anti-corrosion measures) during the 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 a negligible impact on the TBT levels in sediment and biota as well as a negligible impact on imposex, and that NSP2 will have no impact on the trends in concentrations of organic contaminants or metals.

Based on this, it is concluded that NSP2 will not prevent Member States from reaching the targets for hazardous substances.

10.2.3.3 Nature conservation and biodiversity

The impact of NSP2 in regard to 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 intervention works will release nutrients from the seabed. However, the resuspension of sediments will be restricted to the lower parts of the water column, where photosynthesis does not occur, and the impact is temporally and spatially limited. The impacts are therefore 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 distance from the activity. The impact is assessed to be negligible for fish and minor for marine mammals (see sections 9.8 and 9.9, respectively). As the impact on predators is temporary and no impacts are expected in regard to primary production, it is assessed that NSP2 will result in a negligible impact on trends in trophic structures and diversity of species.

On the habitats level, NSP2 would result in negligible impacts on habitat-forming species. Specifically, NSP2 would result in negligible impacts on the abundance and distribution of rare or threatened habitats and a 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 will not be impacted by NSP2.

No impacts on targets in regard to 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 the conservation status of species included in the HELCOM lists of threatened/declining species/habitats, and NSP2 will not impact the abundance or diversity of any element of the marine food web. The project will have no impacts on the number or biomass of NIS. NSP2 will have no impact on the possibility for eel migration and no impact on the possibility 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.

10.2.3.4 Maritime activities

Vessels emit combustion products of fossil fuels and use anti-fouling agents in coatings, and the presence of vessels increases the 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 10.2.1.1).

The potential impacts from vessel activities are mitigated through NSP2 management plans (see sections 6.7 and 17), and the overall assessment has concluded that the impact is negligible.

In summary, NSP2 will have a negligible impact on pollution, risk of e.g. oil spills and introduction of NIS. Based on this, it is concluded that NSP2 will not impact indicators or targets set for maritime activities.

10.2.3.5 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 BSAP.

11 DECOMMISSIONING

As described in section 6, NSP2 is designed to operate for at least 50 years. A decommissioning programme will be developed during the operational 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 the NSP2 infrastructure may also influence the preferred decommissioning method and relevant mitigation measures.

This section highlights the currently applicable 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 4 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 taking all practicable steps to prevent pollution of the sea resulting from dumping of wastes and other matter;

- International Convention for the Prevention of Pollution from Ships (MARPOL) – which 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 only limited specific Danish legislation and no established policies for the decommissioning of offshore installations or pipelines at this point in time.

Under Danish law, permits and approvals of installations related to the exploitation of the Danish subsoil and its natural resources must be accompanied by decommissioning plans, which are to be submitted to the DEA under section 32a of the Act on the Use of the Danish Subsoil (*lov om anvendelse af Danmarks undergrund*) /15/. The DEA has prepared a guidance document on decommissioning plans /437/, which specifies the requirements on the content of decommissioning plans and the procedure for submission and approval of the plans under s. 32a of the Act on the Use of the Danish Subsoil. Section 32a of the Act on the Use of the Danish Subsoil does not apply to transit pipelines for transportation of gas on the Danish continental shelf.

The construction permit for NSP2 may include terms and conditions regarding the decommissioning of pipelines, cf. section 4, subsection 2, of the Administrative Order on Certain Pipeline Installations /8/.

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 UK 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 /438/;
- 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 maritime spatial planning impacts as well as overall cost /439/;
- 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 /440/;
- 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 /441/.

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 with respect to technical, environmental and socio-economic criteria (including those relevant to maritime 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 with respect to deterioration, exposure and/or burial (both in terms of potential implications for the preferred 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 /440/, 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. It is expected that burial or trenching to a minimum depth of 0.6 m above the top of the pipeline will be necessary in most cases;
- 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;
- Pipelines where trenching and burying at the time of decommissioning can be considered as an acceptable solution.

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 UK 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, e.g. the cutting and removal of exposed pipeline ends to minimise snagging risk /441/ and is in accordance with the guidelines highlighted in section 11.1.

11.4 Decommissioning options for NSP2 and potential impacts

As noted above, at present there is no certainty as to which decommissioning method will be applied to the offshore structures of NSP2. Therefore, a detailed impact assessment for the decommissioning phase has not been carried out within this report. However, a review of decommissioning options for NSP2 and potential associated impacts is provided below.

11.4.1 Potential decommissioning options

The decommissioning plan for the offshore structures of NSP2 will be developed during the latter years of the operational 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 would 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 would 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 pipeline up using a pipe-lay 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 pipeline and 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, depending on the degree of natural embedment of the pipeline. 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 piece-by-piece to a pipe-carrier. This method can be performed with the use of a ROV and a diamond cutter or a high-powered water jetting 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 impacts 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 /442/ 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 decommissioned 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 operational 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/surveys) 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 UK, leaving *in situ* is likely to be the preferred option for both the 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;
- 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 section 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 operational 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 /15//441/.

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, e.g. 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".[14]

12.1 Methodology

This section sets out the parameters within which the cumulative impact assessment has been undertaken. This section has been prepared considering current good practice and established practice, as well as the IFC guidance note on cumulative impact assessment[15].

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 planned or existing project within defined spatial and temporal boundaries relevant to NSP2. 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.

The spatial boundaries have been defined as projects within a distance, which is assessed to be the maximum distance at which there is the potential for cumulative impacts to occur. The spatial extent of potential impacts from specific project activities differs depending on impact type (e.g. the spatial extent of noise propagation or sediment dispersion). The potential impact on a given receptor further differs depending on the receptor type (e.g. the potential impacts on marine mammals and water quality). The assessment of which projects to include has thus been based on the areas defined within the various impact assessments in section 9 in combination with professional judgement and previous experience from similar projects (e.g. experience from the construction of the existing NSP pipelines).

The temporal boundaries have been defined as projects which have the potential to result in impacts during the construction (including pre-commissioning) and operational phases of the NSP2 pipeline. The potential for cumulative impacts has been considered only for the relevant project phase, i.e. construction and/or operation.

Projects have been identified and scoped into the cumulative assessment based on the following criteria:

- Whether they are located within the spatial boundaries as set out above;

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[14] IFC Performance Standard 1.

[15] IFC Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets.

- Whether they will result in impacts during the temporal boundaries as 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.

Assessments of transboundary impacts resulting from cumulative impacts have been carried out where applicable.

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 Baltic Pipe project and the raw material extraction areas south of Bornholm.

Table 12-1 Planned projects considered as part of the cumulative assessment.

Planned project name and details	Approximate distance from the NSP2 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
Baltic Pipe An EU "project of common interest" that comprises a proposed subsea natural gas pipeline spanning approx. 250 km between Denmark and Poland.	0 km Potentially crossing NSP2 south-west of Bornholm.	Construction expected to be initiated in 2020, with anticipated completion in 2021 /303/.	EIA process and pre-investigations initiated.	Seabed intervention works, pipe-lay activities. Presence of pipelines and presence of vessels.	Yes	-
Kriegers Flak Wind Farm A proposed 600 MW offshore wind farm (72 turbines).	>80 km	Expected to be operational before the end of 2021 /444/. In accordance with the concession agreement signed on 22 December 2016, grid connection must occur	Signing of concession agreement and granting of pre-investigation license and construction license on 22 December 2016. According to the concession agreement,	Seabed intervention works, installation activities. Presence of wind farm, including inter-array and landfall cables, and presence of vessels.	No	The construction site is located more than 80 km from the proposed NSP2 route and as such there is no spatial overlap and no significant cumulative impacts (related to construction or operation) are expected to occur.

Planned project name and details	Approximate distance from the NSP2 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
		before 1 January 2022.	construction works must commence before 1 June 2021.			
Offshore wind farms proposed within the Swedish EEZ Various proposed offshore wind farms in different stages of the planning process.	>80 km	Unknown	Concept to consent authorised.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm and vessels.	No	The construction sites are located more than 80 km from the proposed NSP2 route and as such there is no spatial overlap 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 stages of the planning process.	>25 km	Commissioning between 2019 and 2023.	Consent authorised to partial generation/under construction.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm and vessels.	No	The construction sites are located more than 25 km from the proposed NSP2 route and as such there is no spatial overlap and no significant cumulative 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.	>16 km	Unknown	Concept to consent authorised.	Installation of wind turbines, inter-array and landfall cables. Presence of wind farm and vessels.	No	The construction sites are located more than 16 km from the proposed NSP2 route and as such there is no spatial overlap and no significant cumulative impacts (related to construction or operation) are expected to occur. Given that the projects are in the early stages of planning, there is also a low risk of temporal overlap of construction activities.
DK Reserved area for offshore wind	0.25 km	Unknown	Area reserved.	Installation of wind turbines,	No	The project is not sufficiently progressed within

Planned project name and details	Approximate distance from the NSP2 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
farms – Rønne Banke				inter-array and landfall cables. Presence of wind farm and vessels.		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.
Raw material extraction areas south of Bornholm	>6 km	Unknown	Areas reserved for extraction and potential areas for extraction of raw materials	Extraction and transport of sediment	No	The nearest area of raw material extraction is located more than 6 km from the proposed NSP2 route/ and as such there is no spatial overlap and no significant cumulative impacts (related to construction or operation) are expected to occur.

12.2.1 Cumulative impact assessment – the Baltic Pipe project

The proposed NSP2 route crosses a proposed subsea natural gas pipeline spanning approximately 250 km between Denmark and Poland, the Baltic Pipe. The Baltic Pipe project is in the planning stage and the EIA process and pre-investigation phase have been initiated. The preferred route for the Baltic Pipe project has been identified as passing within both the Danish EEZ and TW and crossing the proposed NSP2 route south-west of Bornholm /303//443/.

According to the Espoo report for the Baltic Pipe /485/, pre-lay seabed intervention work is anticipated to begin in November 2020 and the actual installation of the Baltic Pipe is expected to be carried out within the period April – August 2021. The NSP2 pipelines are scheduled to be laid at the start of 2020 in order to facilitate testing and commissioning of the system within the second half of 2020. Therefore, there should be no temporal overlap and therefore no cumulative impacts are foreseen for the construction phases of the two projects.

During operation of the Baltic pipe project, however, the following sources of potential cumulative impacts are considered:

- Physical presence of pipelines and structures on the seabed;
- Change of habitat;
- Physical disturbance above water (e.g. from presence of vessels);
- Release of metals from anodes;
- Imposition of safety zones around vessels.

Potential cumulative impacts between NSP2 and the Baltic Pipe project are described below.

Table 12-2 Assessment of sources of potential cumulative impacts from NSP2 and the Baltic Pipe project.

Source of potential impact	NSP2	Baltic Pipe	Potential cumulative impacts
Physical presence of pipelines and structures on the seabed (operation)	During operation, NSP2 will be present on the seabed (more or less embedded), which may result in impacts on bathymetry, hydrography and commercial fishery.	Given the similarity of the two projects, the Baltic Pipe would entail the same potential impacts as NSP2.	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.
Change of habitat (operation)	During operation, NSP2 will potentially create a new hard-bottom substrate (a reef effect from pipelines and rocks), which may result in impacts on benthic flora and fauna and fish.	Given the similarity of the two projects, the Baltic Pipe would entail the same potential impacts as NSP2.	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.
Physical disturbance above water (e.g. from presence of vessels) (operation)	During operation, ship traffic will be limited to inspection vessels, which are expected to conduct surveys every one to two years. Impacts are expected to be of a short duration, localised and of negligible significance.	Given the similarity of the two projects, the Baltic Pipe would entail the same potential impacts as NSP2.	Given the limited frequency of inspection, no potential cumulative impacts are anticipated.
Release of metals from anodes (operation)	During operation, the release of metals from anodes will take place.	Given the similarity of the two projects, the Baltic Pipe would entail the same potential impacts as NSP2.	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.
Imposition of safety zones around vessels (operation)	During operation, vessels will be present along the NSP2 route undertaking maintenance activities, which are expected to consist of surveys every one to two years.	Given the similarity of the two projects, the Baltic Pipe would entail the same potential impacts as NSP2.	Due to the local and temporary extent of the impacts for each project, no potential cumulative impacts are expected. Impacts on existing ship traffic are assessed in section 9.14.

As discussed in Table 12-2, the presence of two pipeline systems on the seabed may lead to cumulative impacts. The resources or receptors susceptible to cumulative impacts are identified as bathymetry, hydrography, benthic flora and fauna, fish and commercial fishery, as identified in section 8. No cumulative impacts on Natura 2000 sites or other protected areas have been identified.

Bathymetry

The presence of NSP2 and the Baltic Pipe will lead to long-term impacts on the bathymetry of the seabed, as the pipelines and any rocks which are placed as part of seabed intervention works will alter the original seabed.

Post-lay trenching (which is planned to be carried out in Danish waters) will displace the sediment from the trench and deposit sediment on the sides of the trench. Although the trench is left open, monitoring of the installation of NSP showed that the impact on bathymetry was insignificant. As assessed in this EIA, the changes in bathymetry caused by the sedimentation of suspended material on the seabed will not be 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 (see section 9.1). In addition, the area affected by the construction works will be localised to the immediate vicinity of the pipeline and very small compared to the surrounding region. The Baltic Pipe project is expected to cross NSP2 pipelines in the area east of the NSP crossing, i.e. in water depths greater than 46 m. Spatially, the supporting structures at the crossings with NSP and the Baltic Pipe will not overlap. Furthermore, given the relatively great water depth at which the Baltic Pipe will cross NSP2, no potential impacts due to a reduction in water depth in the area of the crossing have been identified.

Based on the above, it is assessed that negligible cumulative impacts will arise because of NSP2 in combination with the Baltic Pipe during operation.

Hydrography

Potential cumulative impacts on hydrography from NSP2 and the Baltic Pipe include changes in seabed topography as well as changes to deep water current patterns resulting from changes in the seabed topography.

By installing the NSP2 and Baltic Pipe pipelines, a potential cumulative impact from a total of three pipelines is generated. Since the pipeline routes will not cross in the area of the Bornholm Strait or the Stolpe Channel (on the basis of available information), the main gateways for inflowing seawater to the Baltic Proper, there will be no hydraulic effect on the bulk flow, see section 9.3.

The cumulative impact as a result of NSP2 in combination with the Baltic Pipe is therefore assessed to be negligible.

Water quality

If the Baltic Pipe crosses NSP2, there is a potential for multiple anodes to be located in close proximity to one another. However, elevated concentrations of metals will be localised to the area around the crossing (within 15 m), and it is assessed that the combined impact from the two pipeline systems on water quality, as well as local flora and fauna, will be negligible.

Benthic flora and fauna

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 are otherwise rare in the region, and can be considered an artificial reef. However, as described in section 9.7, the beneficial impact of the pipeline on the ecological conditions in the region must not to be overestimated. Because the pipelines will only occupy a negligible part of the total productive volume of the region and which sustains the ecosystem in this part of the Baltic Sea, no cumulative impacts on benthic fauna are expected to 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 are otherwise rare in the region, and can be considered an artificial reef. However, as described in section 9.8, the beneficial impact of the pipeline construction on the ecological conditions in the region must not to be overestimated. Because the pipelines will only occupy a negligible part of the total productive volume of the region and which sustains the ecosystem in this part of the Baltic Sea, no cumulative impacts on fish are expected to occur.

Commercial fishery

During operation, the presence of NSP2 will present a cumulative impact together with the Baltic Pipe, as there will be three pipelines relatively close to each other in the area of the crossing of the Baltic Pipe with NSP2.

This will have an impact on the fishermen in the area. Experience from NSP shows that fishermen can co-exist with the pipeline system. Thus 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.

Transboundary impacts

It is assessed that no transboundary impacts will occur due to potential cumulative impacts arising from the presence of the two pipeline systems on the seabed during the operational phase.

12.3 Existing projects

Only existing projects which are of particular relevance to the assessment have been considered (summarised in Table 12-3), determined 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 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 12-3 Existing projects whose impacts have the potential to combine with those of the NSP2 project.

Existing project name and details	Distance from NSP2	Status	Anticipated activities	Considered further in this assessment	Justification for scoping out of this assessment
Existing cables See section 7.21	0 km Crossing the cables	Existing Cables are either operational or out of service.	Presence of cables on the seabed. Periodic maintenance surveys.	Yes	-
NSP Existing pipeline system which runs parallel to the majority of the proposed NSP2 route, except for the section in Danish waters.	0 km Crossing of NSP2 in the Danish EEZ	Existing Operational since 2011/2012. Will remain in operation during the construction and operation of NSP2.	Presence of pipelines on the seabed. Survey vessels undertaking monitoring every one to two 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 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 7.21. The cables are either active or out of service. As described in section 9.19, Nord Stream 2 AG will liaise with infrastructure owners as relevant prior to construction, as relevant.

Potential cumulative impacts between NSP2 and existing cables are identified in Table 12-4 below, based on the findings of section 9.19. 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 12-4 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 pipeline undertaking maintenance activities, which are expected to consist of surveys every one to two years.	Survey and maintenance vessels may be present along cable routes.	Due to the local extent of the impacts for each project, no potential cumulative impacts are expected. Impacts on existing ship traffic are assessed in section 9.14.
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 are expected to be highly localised, of a low magnitude and 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 a low magnitude.	As the NSP2 pipelines will cross some of the existing cables, there is the potential for the established benthic habitat to spread onto the NSP2 pipelines. However, the impact is anticipated to be localised and of a low magnitude. Therefore, the overall cumulative impact would be of a negligible significance.

As discussed in Table 12-4, there are negligible potential cumulative impacts on the marine environment from existing cables and NSP2. Therefore, no detailed description of the cumulative impacts to receptors is required.

Transboundary impacts

It is assessed that no transboundary impacts will occur as a result of potential cumulative impacts from the presence of NSP2 and existing cables during operation of the systems.

12.3.2 Cumulative impact assessment – Existing NSP pipeline

The only pipeline system near NSP2 is NSP, a dual pipeline system which runs approximately parallel for the majority of the route from Russia to Germany, with a crossing proposed within the Danish EEZ close to the German EEZ. NSP is in operation and, as described in section 9.19, Nord Stream 2 AG will liaise with infrastructure owners prior to construction, as relevant.

Potential cumulative impacts between NSP2 and NSP are identified in Table 12-5, based on the findings of section 9.19. 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 9.19.

Table 12-5 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. Impacts are expected to be long-term, local and of low intensity. Therefore, the impact magnitude is considered negligible and the overall impact is assessed to be negligible.	The NSP pipelines are present on the seabed. Monitoring performed during the operation of NSP2 has not revealed any unexpected impacts on the environment compared to the assessment performed in the EIA for the project. Therefore, the impact magnitude is considered negligible.	A crossing of NSP is planned close to the EEZ border with Germany, which will result in a local reduction in water depth of approximately 4-5 m at the crossing. For the main part in Danish waters, however, the two pipeline systems are separated by several kilometres. Due to the large distance between the two systems, no potential cumulative impacts are anticipated.
Presence of vessels (construction and operation)	During construction of the NSP2 project, various vessels will be present for construction activities. During operation, ship traffic will be limited to maintenance activities, which are expected to consist of surveys every one to two years. Impacts are expected to be of a short duration, localised and of low intensity. Therefore, the impact magnitude is considered negligible and the overall impact is assessed to be negligible.	Survey vessels will be periodically present along the NSP pipeline route. Monitoring performed during the operation of NSP2 has not revealed any unexpected impacts on the environment compared to the assessment performed in the EIA for the project. Therefore, the impact magnitude is considered negligible and the overall impact is assessed to be negligible.	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 distance between the NSP and NSP2 pipelines and the length of the entire route, no potential cumulative impacts are anticipated.
Release of metals from anodes (operation)	During operation, release of metals from anodes will take place. Impacts are expected to be long-term, localised to the very near vicinity of the anodes (within a few metres) and of low intensity. Therefore, the impact magnitude is considered negligible and the overall impact is assessed to be negligible.	During operation, release of metals from anodes will take place. Monitoring performed during the operation of NSP2 has not revealed any unexpected impacts on the environment compared to the assessment performed in the EIA for the project. Therefore, the impact magnitude is considered negligible and the overall impact is assessed to be negligible.	Where NSP2 crosses NSP, there is a potential for multiple anodes to be located in close proximity to one another. However, elevated concentrations of metals will be localised 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 12-5, there are negligible potential cumulative impacts on the marine environment from the crossing of the NSP. Therefore, no detailed description of the cumulative impacts on receptors is required.

Transboundary impacts
It is assessed that no transboundary impacts will occur as a result of potential cumulative impacts arising from the presence of the two pipeline systems on the seabed during operation of the systems.

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 defined as the overall impacts from the NSP2 project in addition to potential impacts from other planned or existing projects in the area.

The assessment of the potential cumulative impacts is summarised in Table 12-6.

Table 12-6 Assessment of the potential cumulative impacts arising during construction and operation of NSP2.

Project name	Status	Overall cumulative impact	Potential transboundary impact
Planned projects			
Baltic Pipe	Planned, EIA process ongoing	Negligible	No
Existing projects			
NSP	Existing, in operation	Negligible	No
Existing cables	Existing, in operation	Negligible	No

13 UNPLANNED EVENTS AND RISK ASSESSMENT

The construction and operation of NSP2 may give rise to a number of hazards that could present risks to the environment, the public/third parties[16] or workers. The focus of this section is to describe the risk assessments that have been undertaken to evaluate the risks to the environment and to the public during construction and operation of NSP2. Risks to workers have also been assessed; however, these risks and the necessary mitigation measures will be addressed within the safety management systems of Nord Stream 2 AG and its project and corresponding 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.

Risks to the environment and the 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 incidents. Based on the risk assessment, Nord Stream 2 AG has prepared a strategy for emergency preparedness, which is summarised in section 13.4.

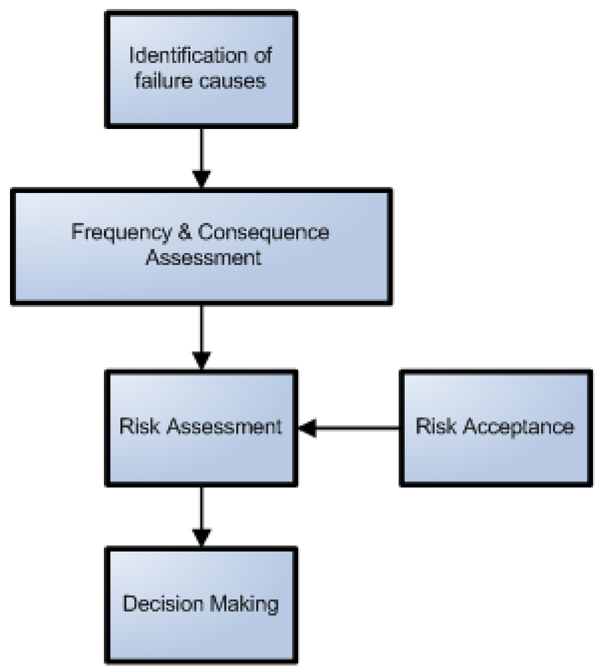
Unplanned events, such as munitions encounter and maintenance works, are presented separately. These are events where related risks are described at a high level together with the potential consequences and mitigation measures, i.e. a detailed quantitative risk assessment has not been undertaken.

13.1 Risk assessment methodology

The risk assessment addressing risks to the environment and the 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 evaluated with respect to the risk acceptance criteria, and if acceptable criteria are exceeded, a mitigation strategy is developed in order to reduce the risks to a level as low as reasonably practicable (ALARP). This includes applying mitigation measures where required to avoid or reduce the risk.

Together these components form a maritime risk analysis, outlined in accordance with the IMO Formal Safety Assessment (FSA) methodology in applicable parts.

[16] The public and third parties are used interchangeably in this section to refer to people who are not directly linked to the project, e.g. 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 DNV-RP-H101 /452/ and IMO guidelines for risk management and formal safety assessment in marine and subsea operation /453/ (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 /454/ for pipeline integrity and DNV-RP-F107 /455/ for potential environmental risks in the operational 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 risk-reducing measures must be implemented to lower the risk. Risks in the middle region are considered tolerable (or ALARP). For these risks, effort should be made to reduce the risk, and it should be justified in the event that possible risk-reducing measures are grossly disproportional to the achieved risk reduction and therefore not implemented. Risks in the lower region are considered broadly acceptable, and further risk-reducing measures are in general not required.

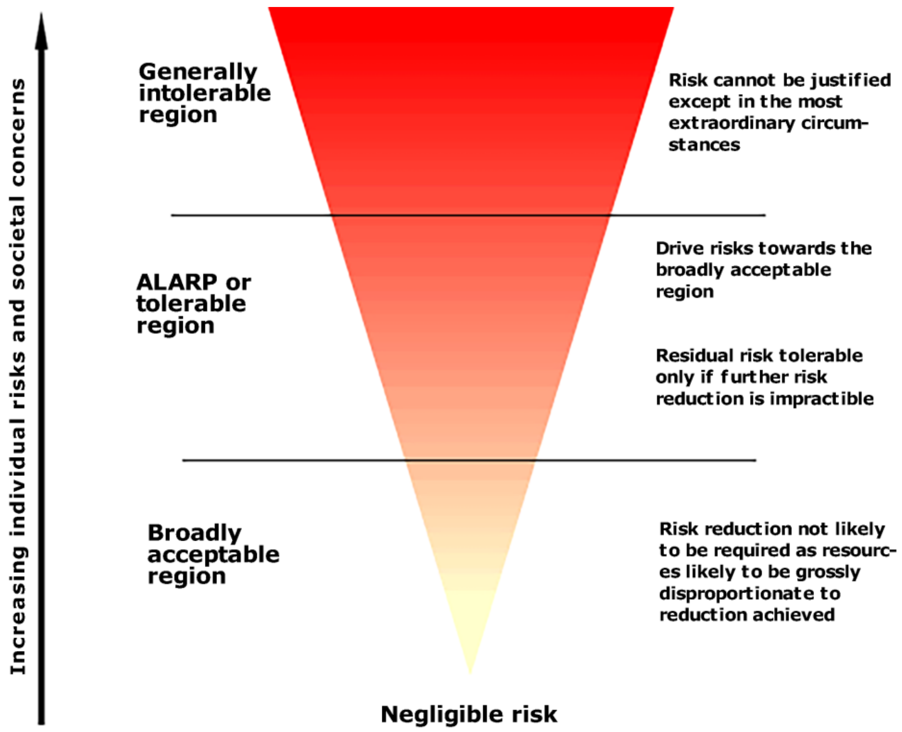


Figure 13-2 The ALARP triangle defines three regions for risks: intolerable, tolerable and acceptable.

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 (see section 13.2.1);
- Gas release modelling (see section 13.3.1).

13.2 Construction phase risks

A risk assessment has been undertaken for the construction phase /456/ covering the following activities:

- Preparation of the landfall facilities including dredging (not relevant in 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 (post-lay trenching) / rock placement including vessel loading operations;
- Pre-commissioning operations.

The construction risk assessment considers risks to the environment and risk to humans; i.e. vessel crews, onshore crews, third-party personnel on passing ships and onshore. The results of the assessment of risks to the environment and risks to the public are presented in sections 13.2.1 and 13.2.2, respectively.

The quantitative risk assessment considers the following pipeline construction hazards:

- Passing vessel collision with construction vessels;
- Construction vessel fire;
- Construction vessel grounding;
- Construction vessel sinking or capsize;
- Oil spills during bunkering operations for construction fleet;
- Helicopter accidents – flights to/from construction vessels;
- Vessel position loss – moored and DP vessels;
- Dropped objects (pipe joints);
- Dropped objects (anchors);
- Pipe-lay vessel tensioner failure;
- Pipe-lay abandonment and recovery (A&R) winch/wire failure;
- Diving operations;
- Munitions.

An important hazard is the presence of third-party ship traffic; i.e. passing vessel collision with construction vessels. Therefore, a dedicated ship-ship collision frequency study has been performed and provides background collision frequencies for the risk assessment /457/. The collision frequencies are based on a slightly different route, which contains about 16% more ship traffic. However, this is a minor difference and does not significantly influence the results or conclusions. The combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2 cross the same traffic routes and the collision risk is considered to be the same for the two route alternatives.

13.2.1 Environmental risks

The ALARP principle as presented in section 13.1 is applied, and a DNV-GL risk matrix has been used for the qualitative assessment of all hazards and for the quantitative assessment of environmental hazards.

13.2.1.1 Identification of environmental hazards

Hazards related to environmental consequences are identified in subgroups as follows:

- Passing vessel collision;
- Construction vessel collision;
- Vessel fire (construction vessel);
- Vessel grounding (construction vessel);
- Vessel sinking (construction vessel);
- Oil spill – bunkering (construction vessel).

The first subgroup covers hazards involving collisions with third-party vessels, whereas the remaining subgroups include hazards related to construction vessels. All identified environmental hazards could be reasonably expected to result in an oil spill.

13.2.1.2 Risk assessment

The hazard occurrence frequencies per year for each of the identified hazards related to environmental consequences are evaluated together with an estimate of the potential oil spill quantity in tonnes. The occurrence frequencies are estimated from collision frequencies based on the ship-ship collision frequency study /457/ in combination with a number of conditional probability factors for oil spills and oil spill size following a collision /456/. The summarised results are shown in Table 13-1.

Table 13-1 Results of the environmental quantitative risk assessment for the entire NSP2 pipeline route.

Item	Hazards	Probability of oil spill (per year)	Potential spill quantities (t)
	Passing vessel collision		
a	Third-party vessel collision 1-10 t spill	2.2×10^{-5}	1 – 10
b	Third-party vessel collision 10-100 t spill	4.4×10^{-5}	10 – 100
c	Third-party vessel collision 100-1,000 t spill	6.4×10^{-5}	100 – 1,000
d	Third-party vessel collision 1,000-10,000 t spill	3.0×10^{-5}	1,000 – 10,000
e	Third-party vessel collision >10,000 t spill	8.4×10^{-6}	> 10,000
	Construction vessel collision		
f	DP Pipe-lay Vessel	2.2×10^{-5}	750 – 1,250
g	Trench Support Vessel	2.8×10^{-6}	500 – 850
h	Rock placement Vessel	1.5×10^{-5}	500 – 850
i	Pipe Carrier & Supply Vessel	7.0×10^{-5}	300 – 500
j	Anchor Handler Tug	7.3×10^{-6}	300 – 500
k	Shallow water lay	7.3×10^{-6}	300 – 500
	Vessel fire		
l	Pipe Carrier / Supply Vessel	8.7×10^{-5}	100
m	Rock placement Vessel	5.9×10^{-5}	170
n	DP Pipe-lay Vessel	8.7×10^{-5}	250
o	Trench support	1.1×10^{-5}	250
p	Shallow water lay	2.7×10^{-5}	100
	Vessel grounding		
q	Pipe Carrier	1.2×10^{-4}	300 – 500
r	Rock placement Vessel	1.6×10^{-5}	500 – 850
s	Supply Vessel	4.8×10^{-5}	300 – 500
	Vessel sinking		
t	Trench Support Vessel	3.2×10^{-7}	700 – 1,250
u	Pipe Carrier / Supply Vessel	2.5×10^{-6}	300 – 500
v	DP Pipe-lay Vessel	2.5×10^{-6}	700 – 1,250
w	Rock placement Vessel	1.7×10^{-6}	500 – 850
x	Shallow water lay	8.3×10^{-7}	300 – 500
	Oil spill – bunkering		
y	Anchor Handler Tug	1.5×10^{-3}	0 – 10
z	DP Pipe-lay Vessel	4.1×10^{-2}	0 – 10
aa	Shallow water lay	1.3×10^{-2}	0 – 10

Note that only a smaller fraction of the total number of ship-ship collisions will lead to an oil spill, see /456/. Therefore, the frequencies in Table 13-1 concerning ship-ship collisions (items "a" to "k") only include those ship-ship collisions that result in an oil spill. Typically, in a ship-ship collision, one vessel is the striking ship and one vessel is the struck ship, and normally only the struck vessel is at risk of releasing oil to the environment.

All items from "a" to "aa" are represented in the DNV-GL risk matrix in Figure 13-3. The results cover the entire NSP2 pipeline route.

Consequences		Probability (increasing probability)			
Description	**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.	e, t, v	d, f		
3 Moderate	Restoration time > 1 month. Restoration cost > USD 1 K	g, j, k, u, w, x	c, h, i, m, n, o, q, r, s		
4 Minor	Restoration time < 1 month. Restoration cost < USD 1 K		a, b, 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 for: > d Passing third-party vessel collision leading to an oil spill of 1,000-10,000 t > f DP Pipe-lay vessel collision leading to an oil spill of 750 – 1,250 t				
LOW	The risk is considered tolerable and no further actions are required				

Figure 13-3 Assessment of environmental hazards using the DNV-GL risk matrix. Not all hazards are relevant for the Danish sector.

The two environmental hazards "d" and "f", which are related to ship collisions resulting in an oil spill, include risk levels that fall in the ALARP region.

To mitigate the consequence, it will be necessary to respond quickly to any oil spills. NSP2 contractors are responsible for responding to Tier 1 oil spills, and will do so using an approved Shipboard Oil Pollution Emergency Plan (SOPEP). Nord Stream 2 AG is responsible for handling Tier 2 and Tier 3 spills according to an established oil spill contingency plan, see section 13.4.2.

To reduce the probability, mitigation measures such as safety zones will be enforced around the pipe-lay vessel in agreement with the DMA. Notices to Mariners, NavTex messages and VHF broadcasts will be used to inform and safeguard separation from the pipe-lay vessel, with limited ability to manoeuvre.

13.2.1.3 Spill frequency and consequence assessment (oil spill)

For the Danish area, the spill frequencies related to passing vessel collisions are provided in Table 13-2, along with the spill frequencies for the other countries along the NSP2 route. The frequencies relevant to the Danish sector are indicated in bold.

Table 13-2 Spill frequencies (pollution frequency per year) for individual countries along the NSP2 route. Results for Denmark are indicated in bold /450/.

Country	Spill size				
	1 – 10 t	10 – 100 t	100 – 1,000 t	1,000 – 10,000 t	> 10,000 t
Russia	4.0×10^{-7}	8.0×10^{-7}	1.2×10^{-6}	5.5×10^{-7}	1.5×10^{-7}
Finland	2.5×10^{-6}	5.0×10^{-6}	7.4×10^{-6}	3.5×10^{-6}	9.7×10^{-7}
Sweden	1.3×10^{-5}	2.6×10^{-5}	3.8×10^{-5}	1.8×10^{-5}	5.0×10^{-6}
Denmark	**7.4×10^{-7}**	**1.5×10^{-6}**	**2.2×10^{-6}**	**1.0×10^{-6}**	**2.8×10^{-7}**
Germany	5.0×10^{-6}	1.0×10^{-5}	1.5×10^{-5}	7.0×10^{-6}	1.9×10^{-6}

Ship-ship collisions happen even without NSP2 construction activities. The observed number of ship-ship collisions in the Baltic Sea area, involving vessels of similar size as in the current assessment, in the period from 2007-2013 has on average been 24 ship-ship collisions per year /458//459/. However, not all collisions result in oil spill, and applying a causation factor as described in /456/, it is estimated that the number of oil spill accidents in the Baltic Marine Area resulting from ship-ship collisions averages at about 2.5 to 3 per year. In addition, there are accidents related to grounding and obstacle collisions.

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. However, the theoretical relative 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 increase in oil spill frequency. Furthermore, the amount of traffic caused by the activities related to the construction of NSP2 will occur within a limited time period, and the implementation 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 may potentially be spilled from NSP2 construction vessels and third-party vessels.

Type of vessel	Fuel type	Cargo
NSP2 construction vessel	Fuel oil, diesel	-
Third-party vessel	Fuel oil, diesel	Oil products or crude oil

Potential spill quantities are listed in Table 13-1. When oil is spilled, it is subject to physical processes such as evaporation, spreading, dispersion in the water column and sedimentation on 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 a collision (see section 13.2.1.4). Various mitigation measures developed by Nord Stream 2 AG will be implemented to minimise the risk of oil spill caused by accidents (see section 15.13).

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, thereby minimising impacts on the marine environment. The HELCOM countries have adopted a recommendation on the development of national ability to respond to accidental spills of oil and other harmful substances. The recommendation specifies response times for combating 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 two medium risks, including third-party vessel collision and pipe-lay 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 assumptions 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 t 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 /460/.

Oil spill locations in the Baltic Sea have been chosen for the oil spill simulations (see 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 (Route O, see Figure 7-59), close to Natura 2000 sites.

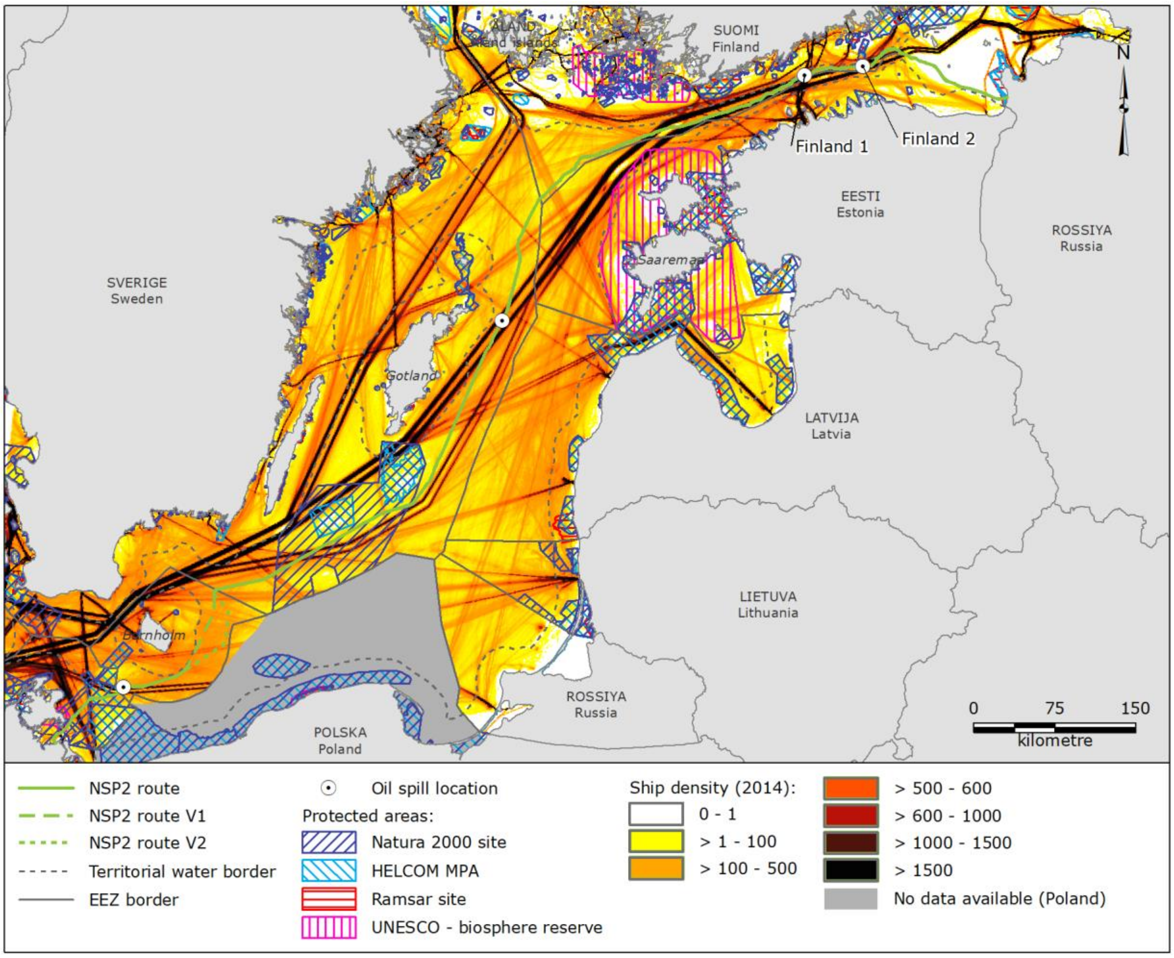


Figure 13-4 Positions of accidental oil spill simulations, planned pipeline route, ship traffic intensity and protected areas in the Baltic Sea.

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 t 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 locations in Denmark.

Area coverage for concentration: >1 mg/l		Area coverage for concentration: >15 mg/l	
Mean [km²]	Max [km²]	Mean [km²]	Max [km²]
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 Table 13-5.

Table 13-5 Calculated oil concentrations after two days, KP 40.

	Bornholm, southern coastline	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 on 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, as described in section 13.2.2.3.

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 /461/.

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 /461/.

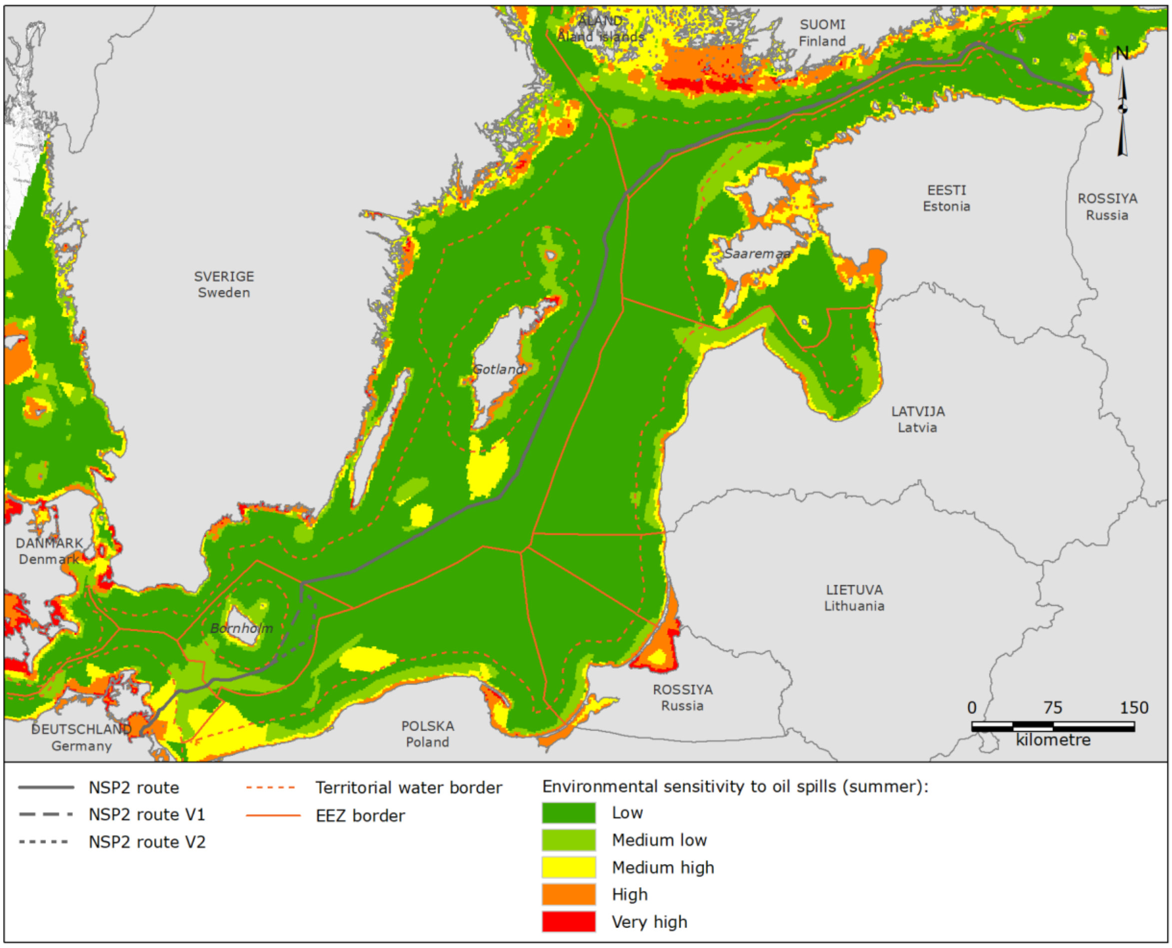


Figure 13-5 Environmental sensitivity to oil spills during summer /461/.

13.2.1.6 Potential impacts on the environment

No discharges to the environment are planned during construction or operation of NSP2 in Danish waters, but there is a potential risk of accidents leading to oil spill due to the presence of vessels during construction or operation. Currently, approximately 50,000 vessel movements per year are observed in the TSS Bornholmsgat, travelling into and out of the Baltic Sea, see section 7.15. During the construction phase, 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 a ship collision during the construction phase.

Oil spills pose a risk to marine organisms and may damage offshore and coastal ecosystems. Many of the petroleum-related chemicals that could be spilled are potentially toxic or can bioaccumulate 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 /462/.

Marine organisms may be affected by oil in several ways:

- As a result of physical contamination (smothering);
- By the toxic effects of chemical components;
- By accumulation of substances in tissues, leading to physiological effects.

Potential impacts on fish, birds and marine mammals from an oil spill are further described below.

Fish

Fish may be exposed to spilled oil in different ways. The water column may contain volatile componentes of oil that may be absorbed by fish at various 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 /462/.

Fish eggs and larvae are much more sensitive to oil 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 on fish populations in cases of oil spills, 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 /463/. Fish spawning and nursery areas may be particularly vulnerable, depending on the species.

Marine mammals

A major oil spill may impact marine mammals that 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 oil slicks. However, marine mammals such as seals that breed on shorelines are more likely to encounter oil. Impacts on 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 /462/.

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 /461/.

Seabirds

Often the most visible victims of an oil spill are seabirds, which spend significant amounts of time on the water surface or along the shoreline. The primary effect on seabirds from 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 ceases 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. auks, ducks and divers) that are at risk of being smothered in oil, but all groups of birds can be affected /461/.

Secondary impacts on seabirds include ingestion and/or inhalation of oil while preening or ingestion of contaminated food. As a consequence of such intake, seabirds may suffer short- or long-term effects, such as damage to the lungs, kidneys and liver, as well as gastrointestinal disorders /462/.

13.2.1.7 Conclusion

As a consequence of the increased traffic in the construction phase, and the presence of offshore construction activities, NSP2 will cause a minor increase in the risk of an accidental oil spill. The conclusion in the construction risk assessment /456/ is that there are no high-risk events, but two medium risk events related to third-party vessel collision and DP Pipe-lay vessel collision. Risk-reducing measures for both consequence and probability have been implemented to reduce the risk from third-party vessel collision (see section 13.2.1.2).

Oil spill modelling was undertaken based on scenarios with a spill of bunker oil. The results show that there is a risk of impacts on coastal areas, Natura 2000 sites and other protected areas in the case of an accidental oil spill. However, the probability for an oil spill has only marginally increased, and the spill scenarios are similar to those which would be generated even without NSP2 as a result of the existing shipping in the area.

The potential transboundary impacts of unplanned events are addressed in section 14.3.

13.2.2 Risks to the public

The risk assessment results presented in this section cover risks to the public. As there are no land operations in the Danish sector, risk to the public is limited to crews and passengers of passing vessels which may collide with the construction vessels.

13.2.2.1 Identification of hazards

The pipeline route will cross several existing ship traffic routes in the Baltic Sea. In the Danish sector, the construction of the pipeline will interact with the existing ship traffic as described in section 7.15. Before and during the construction of NSP2, there will be a slight increase in ship traffic in the Baltic Sea due to the movements of the intervention work vessels, pipe carriers and pipe-lay vessels. There is a risk of a ship-ship collision when a construction vessel crosses an existing shipping route.

13.2.2.2 Frequency and consequence assessment

An assessment of the frequency of ship collisions between the construction vessels (pre-lay/post-lay intervention work vessels, pipe carriers and pipe-lay vessel) and the general ship traffic is presented in the ship-ship collision report /457/.

The annual 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 for each country. Results for the Danish sector are provided in Table 13-6 and further details on the specific results for the Danish section of the pipeline are provided in /456/.

Table 13-6 Frequency of ship collisions in the Danish sector /456/.

Denmark	Cargo ship	Tanker	Passenger ship	Total
Frequency of collisions per year	3.6×10^{-5}	1.1×10^{-5}	2.3×10^{-6}	4.93×10^{-5}

The total increase in the annual ship collision frequency in the Danish sector during construction of NSP2 is calculated to be 4.93×10^{-5} collisions per year, which is equivalent to one collision in about 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 close 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 current assessment, in the period from 2007-2013 has on average been 24 ship-ship collisions per year /458//459/. Comparing this with the estimated increased frequency of ship-ship collisions introduced during the construction phase, it can be concluded that construction of NSP2 will have a low impact on the current frequency of ship-ship collisions, and that the increase in the collision frequency due to the construction of 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 /464/.

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 /456/.

Denmark	Cargo ship	Tanker	Passenger ship
Individual risk – fatalities per year	1.0×10^{-7}	2.6×10^{-8}	4.4×10^{-10}

13.2.2.3 Risk assessment

Individual risk and group risk for third-party fatalities have been calculated and assessed towards the tolerability criteria /456/.

The individual risk (probability for third-party fatalities) is shown in Table 13-7 for the Danish sector. The tolerability criteria for individual risk in the offshore industry (probability of a fatal accident) are defined as given in Table 13-8. The individual risks for third-party fatalities are below the project's tolerability criteria, and the risk is therefore considered acceptable /456/.

Table 13-8 Tolerability criteria for individual risk in the offshore industry /456/.

	Tolerability criteria for individual risk
Maximum risk of fatality for the public	10^{-4} per person per year
Broadly acceptable risk	10^{-6} per person per year

The 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 13-6. This criterion is applied to evaluate the risk for third-party fatalities.

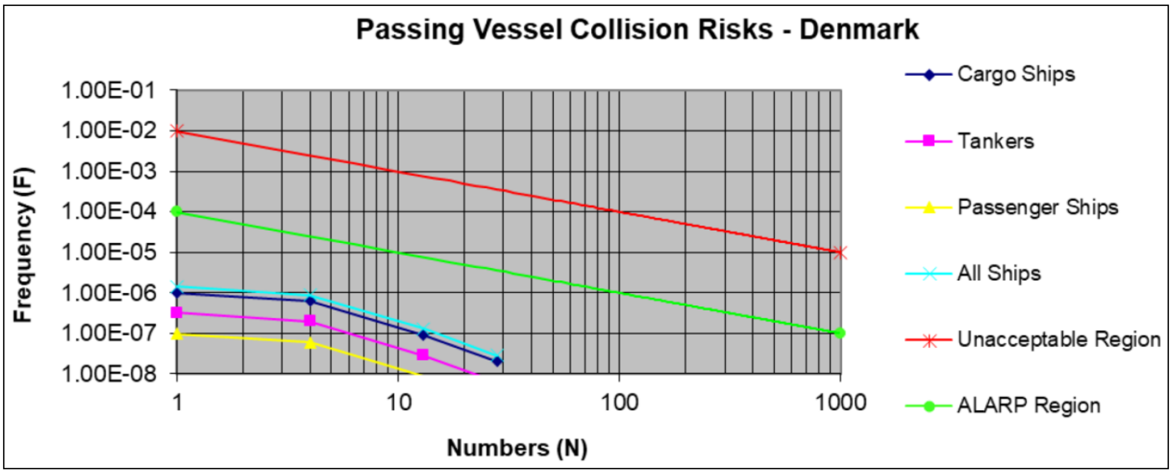


Figure 13-6 Group risk for third-party person fatalities from ship-ship collisions in the Danish sector during the construction phase of NSP2.

The F-N curve in Figure 13-6 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 lines are in the tolerable region (ALARP). For these risks, effort should be made to reduce the risk, and it should be justified in the event that possible risk-reducing measures are grossly disproportional to the achieved risk reduction and therefore not implemented. 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 /456/.

As can be seen from Figure 13-6, 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.

For the entire NSP2 route in the Baltic Sea, it is noted that the group risks to cargo ship crews are just inside the ALARP region, and that collision avoidance measures carried out by the main construction vessels are likely to reduce this risk. Vessel collision is the highest risk that third-party and construction vessels will encounter, and it is concluded that collision risk reduction measures will need to be implemented in areas of high traffic /456/.

Where relevant and in conjunction with the DMA, the installation contractors will prepare specific procedures for crossing shipping lanes and areas of high traffic density. As required, Nord Stream 2 AG will provide native speakers on the pipe-lay vessel in order to allow communication with local vessels such as fishing vessels and coasters.

13.2.2.4 Conclusion

The assessment considers risks to the public, i.e. vessel crews, onshore crews, third-party personnel (e.g. on passing ships). The frequency of ship-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 for the NSP2 route through the Danish section that the group risk to the public during the construction phase is within the broadly acceptable region /456/. It is also concluded that the individual risk for a person on a third-party vessel is below the tolerability criteria. In conclusion, the risk to the public is considered acceptable.

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 /465/, /466/ and /467/. The damage assessment (/466/) is based on an earlier route (D5), which is very similar to the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2 and crosses the same traffic streams.

13.3.1 Risk assessment

A risk assessment has been undertaken for a set of identified hazards which may lead to a gas release. The risk assessment, its main steps and the results are described in the following subsections. The overall residual risk of the installation shall be evaluated against the risk tolerability criteria /467/; see also section 13.1. The tolerability of risk criteria for environmental risks is implemented in the form of a risk matrix, and the asset risk is evaluated according to DNV-GL acceptance criteria /454/ for assets (medium safety class):

- Maximum overall annual failure frequency per kilometre of pipeline: 10^{-5} per year; or if criterion per kilometre is not met
- Maximum overall annual failure frequency per sensitive section: 10^{-4} per year.

Risks to the public are addressed and evaluated using an F-N diagram and F-N curves. The resulting environmental risks and risks to the public are summarised independently.

13.3.1.1 Identification of environmental hazards

Possible failure causes leading to unplanned releases of gas are identified on the basis of literature data on offshore gas pipeline incidents, /469/, and in a HAZID study carried out during the Basic

Design Phase and included in the HAZID report, /470/. The following failure causes are identified and considered for the 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 following failure causes that may threaten the integrity of the pipeline are managed adequately through the application of the relevant DNV-GL standards relating to the design of the pipeline. The following failure causes are therefore not further described in the present report.

- Natural hazards due to current and wave action – DNV RP-F109;
- Pipeline freespan sections – DNV RP-F105;
- External interference with fishing activities – DNV RP-F111;
- Operating temperature and pressure conditions – DNV RP-F110.

13.3.1.2 Frequency estimation

Frequency estimation for corrosion, mechanical defects, natural hazards, seismic activity and other/unknown failure causes are addressed in Table 13-9. The estimation of these failure causes is based on literature data and the HAZID report and are all evaluated to be negligible. Hazards related to interactions with third-party ship traffic are separately addressed later in this section.

Table 13-9 Frequency estimation for corrosion, mechanical defects, natural hazards, seismic activity and other/unknown failure causes.

Hazard cause	Comments and reasoning
Corrosion (internal and external)	In the PARLOC 2001 database, /469/, 11 leakages due to corrosion are reported for midline operating steel pipelines during an operating experience of 292,745 km*y. However, only two leakages involved steel gas pipeline longer than 5 km (operating experience of 182,272 km*y) and have been recorded for small diameter pipelines (< 12”). In PARLOC 2012, /471/, the number of incidents due to corrosion reported for midline operating steel pipeline is nine (this includes also incidents due to other material defects), however only one leakage involved a steel gas pipeline with a diameter >16”. For NSP2: • The diameter of NSP2 offshore pipelines is very large (i.e. 48”); • 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; • The wall thickness of NSP2 pipelines (i.e. between 26.8 and 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 foreseen.
Mechanical defects	According to the PARLOC 2001 database, /469/, the mechanical failure frequency can be divided into material defects and construction faults. No loss of containment due to construction faults are

Hazard cause	Comments and reasoning
	reported for operating steel pipelines in the PARLOC 2001 database, /469/, even if two incidents caused damage to the external coating. Two loss of containment incidents due to material defects are recorded for midline operating steel pipelines for an operating experience of 292,745 km*y and only one of these involved a large diameter pipeline (i.e. ≥ 30”). In the PARLOC 2012 database, /471/ , the classification of incidents is slightly different. Therefore, direct comparison cannot be made: material defects are included in the same class as internal and external corrosion under “material” causes while mechanical failure due to construction faults are reported under “construction” category separately. Only one incident is recorded for steel pipeline in the midline area. This means that release due to material defects is a “rare” event, particularly for modern pipelines where advanced pipe technology and quality control, as well as welding technology and control procedures are applied. For NSP2: • All materials, manufacturing methods and procedures will comply with recognised standards, practices or purchaser specifications; • NDT examinations at fabrication site will be performed according to DNV standards.
Natural hazards (storm, scour)	According to the PARLOC 2001 database, /469/, 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, /471/, natural hazards are included in the category “Others”. No incidents are reported for steel pipelines in the midline section under this category.
Seismic activity and geotechnical instability	A probabilistic seismic hazard analysis was prepared, for the entire route and region, during the planning of NSP, concluding that the seismicity in the region is very low to low. The same was concluded for the risk of seismic hazard. With respect to geotechnical instability, it is mentioned in the HAZID report, /470/, 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.
Other / unknown (sabotage, etc.)	Other / unknown causes include all the incidents for which no specific causes where identified. However, no leakage has been recorded for large diameter operating steel lines. For NSP2: • The design systematic failures will be reduced to negligible level applying appropriate QA/QC procedure, design review meeting and dedicated HSE reviews and studies; • Only sabotage, military exercises and/or accidental transported mines are identified as possible “other/unknown” causes, but are considered very unlikely for this section of pipeline within Danish EEZ; • Other interferences that may derive from surveys and construction of nearby/crossing installations foreseen to be installed once NSP2 will be in operation are considered to be negligible as they will be addressed with dedicated interfaces between project teams at design stage.

Ship traffic data for the year 2014 and forecasted traffic data for the year 2025, which account for a possible future increase, have been considered /279/.

For offshore pipelines, interaction with third-party activities is related to commercial ship traffic (excluding interference with fishing activities, see above). The following initiating events are identified:

- Sinking ships;

- Dropped objects;
- Dropped anchors;
- Dragged anchors.

Pipeline failure probability (according to DNV-GL /454//455/) due to interaction with third-party activities related to commercial ship traffic is evaluated by means of statistical and mathematical modelling in the frequency of interaction assessment /465/ and pipeline damage assessment /466/. Release frequencies and residual risk for human safety, environment and economical losses are evaluated by means of mathematical modelling in the offshore pipeline risk assessment /467/.

Initially, four sensitive pipeline sections have been identified along the combination of the proposed NSP2 route with V1, and five sensitive pipeline sections have been identified along the combination of the proposed NSP2 route with V2. The sensitive pipeline sections are those where the frequency of ships crossing the pipeline exceeds a criterion value of 250 ships per km per year. The criterion value corresponds to less than one ship per km/day. Sensitive sections shall be at least 10 km long and shall be spaced by at least 5 km long pipeline sections with fewer than 250 ships crossing per kilometre per year. For each sensitive area, the interaction frequency is evaluated in further detail. The sensitive pipeline sections within Danish waters for year 2025 are shown in Table 13-10 and Table 13-11, and outlined in Figure 13-7 and Figure 13-8.

Table 13-10 Sensitive pipeline sections related to ship traffic threats within Danish waters for the combination of the proposed NSP2 route with V1 /465/.

Section	From KP (km)	To KP (km)	Section length (km)
1	4	13	10
2	19	28	10
3	62	83	22
4	137	146	10

Table 13-11 Sensitive pipeline sections related to ship traffic threats within Danish waters for the combination of the proposed NPS2 route with V2 /465//467/.

Section	From KP (km)	To KP (km)	Section length (km)
1	4	13	10
2	30	39	10
3	62	71	10
4	93	108	16
5	155	164	10

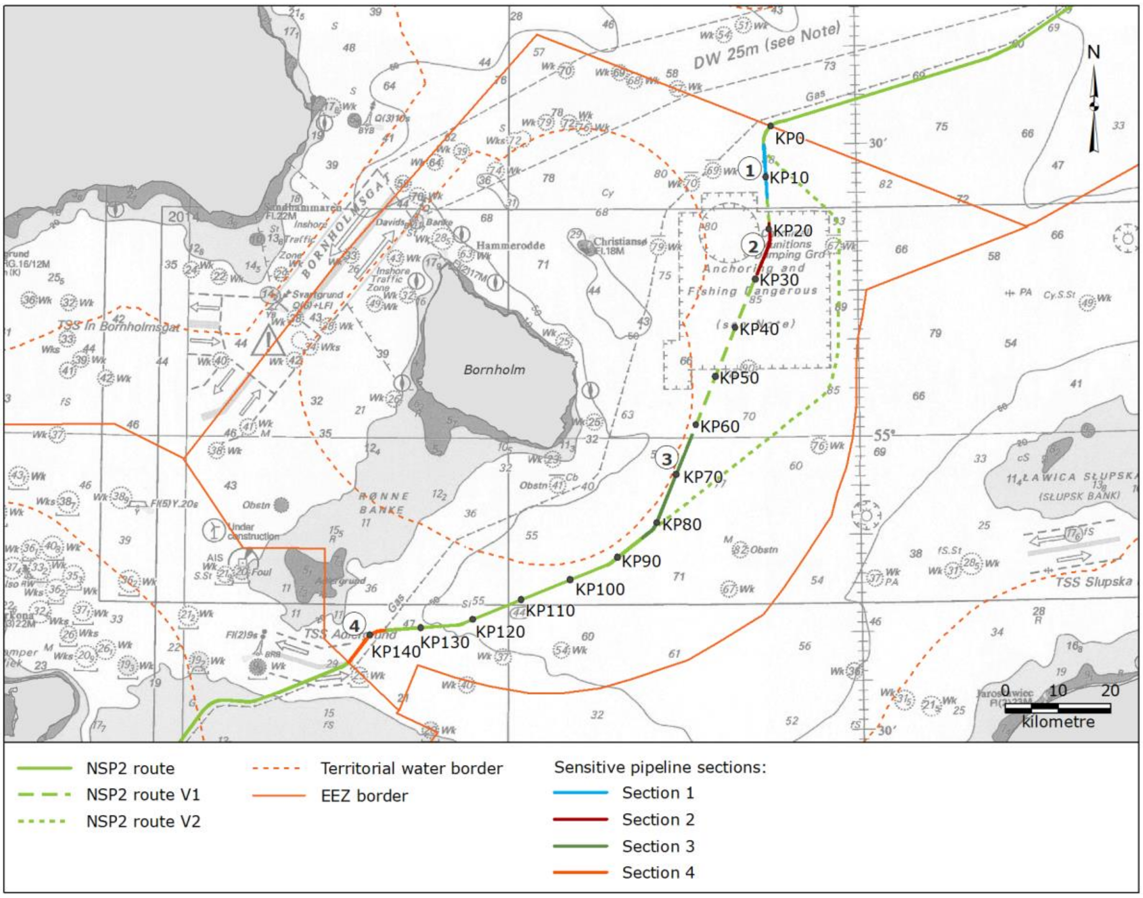


Figure 13-7 Sensitive pipeline sections along the combination of the proposed NSP2 route with V1 in Danish waters. The sensitive pipeline sections are those where the frequency of ships crossing the pipeline exceeds a criterion value of 250 ships per km per year.

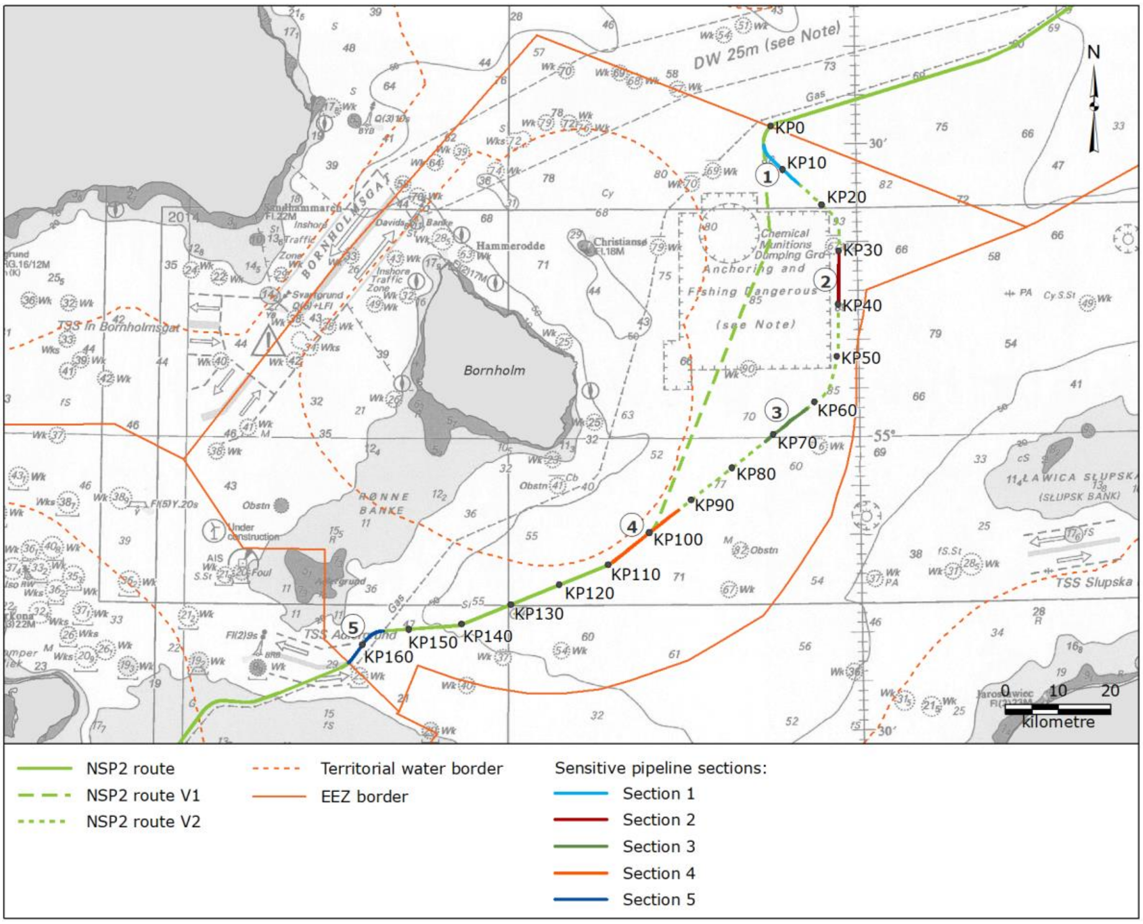


Figure 13-8 Sensitive pipeline sections along the combination of the proposed NSP2 route with V2 in Danish waters. The sensitive pipeline sections are those where the frequency of ships crossing the pipeline exceeds a criterion value of 250 ships per km per year.

For each of the sensitive sections, the annual pipeline failure frequency has been assessed for the combination of the proposed NSP2 route with V1 and the combination of the proposed NSP2 route with V2 /467/. A summary of the corresponding results is shown in Table 13-12 and Table 13-13. For all sensitive sections, the total failure frequency is below the DNV-GL maximum overall failure frequency of 10^{-4} per year.

Table 13-12 Failure frequency per section per year for the Danish area along the combination of the proposed NSP2 route with V1 /467/.

Section	Dropped objects	Dropped anchors	Dragged anchors	Sinking ships	Total
	(failures per section per year)				
1	6.01×10^{-9}	1.36×10^{-12}	5.95×10^{-7}	3.17×10^{-7}	9.18×10^{-7}
2	2.11×10^{-9}	5.75×10^{-13}	6.24×10^{-7}	1.67×10^{-7}	7.93×10^{-7}
3	6.57×10^{-9}	2.14×10^{-12}	4.38×10^{-7}	7.21×10^{-7}	1.17×10^{-6}
4	7.82×10^{-9}	2.06×10^{-12}	7.34×10^{-7}	3.83×10^{-7}	1.12×10^{-6}

Table 13-13 Failure frequency per section per year for the Danish area along the combination of the proposed NSP2 route with V2 /467/.

Section	Dropped objects	Dropped anchors	Dragged anchors	Sinking ships	Total
	(failures per section per year)				
1	5.56×10^{-9}	1.25×10^{-12}	4.41×10^{-7}	2.88×10^{-7}	7.35×10^{-7}
2	2.02×10^{-9}	5.47×10^{-13}	4.14×10^{-7}	1.79×10^{-7}	5.95×10^{-7}
3	1.54×10^{-9}	9.30×10^{-13}	3.29×10^{-8}	2.29×10^{-7}	2.64×10^{-7}
4	3.66×10^{-9}	1.14×10^{-13}	4.82×10^{-7}	4.32×10^{-7}	9.18×10^{-7}
5	7.82×10^{-9}	2.05×10^{-12}	7.38×10^{-7}	3.82×10^{-7}	1.13×10^{-6}

It is noted that not all pipeline failures lead to a gas release; i.e. gas release frequencies are only a subset of the pipeline failure frequencies.

Three different gas release scenarios are considered as described in /467/: gas release from pinhole (20 mm), hole (80 mm), and full-bore rupture (>80 mm). The gas release frequencies due to failure of the pipeline are shown per hole type in Table 13-14 for the combination of the proposed NSP2 route with V1 and in Table 13-15 for the combination of the proposed NSP2 route with V2.

Table 13-14 Gas release frequency per year per section for pinhole, hole and full-bore rupture scenarios for the Danish area along the combination of the proposed NSP2 route with V1 /467/.

Section	Pinhole	Hole	Rupture	Total
	(occurrence per section per year)			
1	1.59×10^{-8}	1.59×10^{-8}	4.64×10^{-7}	4.96×10^{-7}
2	8.36×10^{-9}	8.36×10^{-9}	3.38×10^{-7}	3.54×10^{-7}
3	3.61×10^{-8}	3.61×10^{-8}	7.81×10^{-7}	8.53×10^{-7}
4	1.91×10^{-8}	1.91×10^{-8}	5.64×10^{-7}	6.03×10^{-7}

Table 13-15 Gas release frequency per year per section for pinhole, hole and full-bore rupture scenarios for the Danish area along the combination of the proposed NSP2 route with V2 /467/.

Section	Pinhole	Hole	Rupture	Total
	(occurrence per section per year)			
1	1.44×10^{-8}	1.44×10^{-8}	3.92×10^{-7}	4.21×10^{-7}
2	8.94×10^{-9}	8.94×10^{-9}	2.85×10^{-7}	3.03×10^{-7}
3	1.15×10^{-8}	1.15×10^{-8}	2.16×10^{-7}	2.39×10^{-7}
4	2.16×10^{-8}	2.16×10^{-8}	5.33×10^{-7}	5.77×10^{-7}
5	1.91×10^{-8}	1.91×10^{-8}	5.65×10^{-7}	6.03×10^{-7}

13.3.1.3 Consequence analysis and gas release modelling

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, see /467/. 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; i.e. pinhole, hole and rupture, 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.

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 programme POL-PLUME. 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.

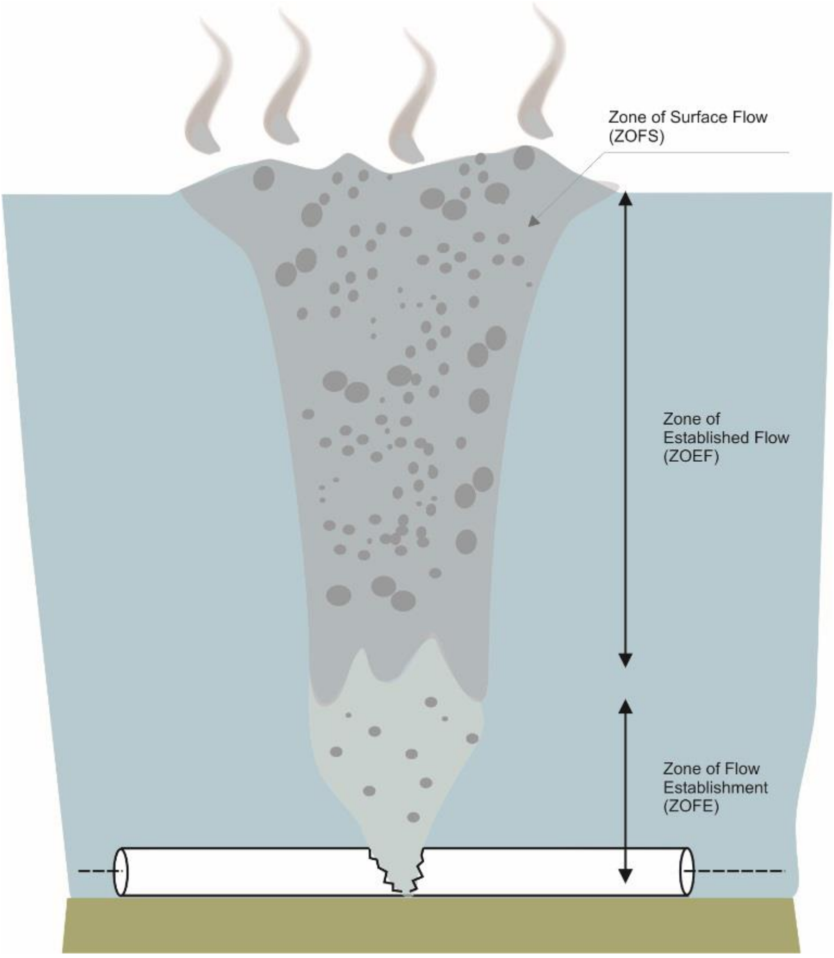


Figure 13-9 Schematic drawing of the release of gas from an offshore pipeline.

The radii of the zone of surface flow (central boil region) and the gas fractions for the three scenarios are summarised in Table 13-16. The results show that the gas plume at the sea surface can be up to 15.1 m in radius.

Table 13-16 Results of underwater gas dispersion calculations /467/.

Leakage type	Water depth (m)	Radius at surface (m)	Gas fraction (%)
Pinhole	54	5.9	8
Hole		6.7	100
Rupture		15.1	100

13.3.2 Environmental risks

The environmental risks during the operational phase are related to damage to the pipeline and the potential for gas release and ignition which may be caused by interactions with vessels in the Baltic Sea. The potential interactions include dropped objects such as containers from cargo vessels, dropped or dragged anchors, sinking ships and grounding ships (close to the landfall areas and not relevant in the Danish sector).

13.3.2.1 Risk assessment and risk acceptance

The risk acceptance criteria for environment are implemented in the form of a risk matrix as shown in Figure 13-10 for the combination of the proposed NSP2 route with V1 and in Figure 13-11 for the combination of the proposed NSP2 route with V2. A semi-quantitative approach has been adopted by means of the risk matrix methodology to predict the risk level for the environment.

Consequence		Probability (increasing probability)			
Description	**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	1 Hole, 1 Rupture 2 Hole, 2 Rupture 3 Hole, 3 Rupture 4 Hole, 4 Rupture			
4 Minor	Restoration time < 1 month. Restoration cost < USD 1 K	1 Pinhole 2 Pinhole 3 Pinhole 4 Pinhole			
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 13-10 Risk matrix for environmental risk /467/ with results from Table 13-14, for the combination of the proposed NSP2 route with V1. Numbers 1 to 5 refer to the five sensitive sections (see Table 13-10).

Consequence		Probability (increasing probability)			
Description	**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	1 Hole, 1 Rupture 2 Hole, 2 Rupture 3 Hole, 3 Rupture 4 Hole, 4 Rupture 5 Hole, 5 Rupture			
4 Minor	Restoration time < 1 month. Restoration cost < USD 1 K	1 Pinhole 2 Pinhole 3 Pinhole 4 Pinhole 5 Pinhole			
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 13-11 Risk matrix for environmental risk /467/ with results from Table 13-15, for the combination of the proposed NSP2 route with V2. Numbers 1 to 4 refer to the four sensitive sections (see Table 13-11).

Concerning environmental consequences, the severity of identified release scenarios is evaluated as minor to moderate, see further /467/ and section 13.3.2.2. In combination with the estimated release frequencies, the risk is evaluated as low and acceptable for all sensitive pipeline sections, see further /467/.

Furthermore, the risk to assets has been evaluated according to the DNV-GL acceptance criteria. The target failure rate of 10^{-5} failures per km per year is met for all km intervals along the route. The DNV-GL acceptance criteria per sensitive section (10^{-4} failures per section per year) is fulfilled for all sensitive sections (2025 ship traffic forecast).

13.3.2.2 Potential impacts on the environment

There is a risk of a gas leakage in case of pipeline damage from third-party activities. The risk is limited to the interaction resulting from the existing ship traffic in the Baltic Sea where some vulnerable sections have been identified.

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 marine organisms (such as fish and marine mammals), resulting in potential acute or chronic impacts depending on 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 animals directly exposed to the flash fire will be exposed to impacts which could be fatal. In the risk assessment it is conservatively assumed that anyone caught in the flash fire would probably be killed.

13.3.2.3 Conclusion

The risk to environment 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 damage, but the assessment shows that the risk for the environment is "low" and acceptable for all scenarios.

Furthermore, the assessment shows that according to the DNV-GL acceptance criteria for assets, the target failure rate per sensitive section (10^{-4} failures per section per year) is fulfilled for all sensitive sections (2025 forecast).

It is concluded in the risk assessment that no pipeline protection is deemed necessary. 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.

13.3.3 Risks to the public

There is a risk of a gas leakage in case of pipeline damage from third-party activities. The risk is limited to the interaction resulting from the existing ship traffic in the Baltic Sea where some vulnerable sections have been identified; i.e., sections with high traffic intensity. Flash fire is considered to represent the only possible scenario caused by the pipeline in the operational phase which may lead to third-party fatalities offshore.

13.3.3.1 Risk assessment and risk acceptance

Flash fires may occur if a 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 effects of the 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 (LFL), are shown in Table 13-17.

Table 13-17 Extent of hazardous gas cloud /467/.

Release size	Distance of flammable limits at 10 m height above the sea	
	LFL (m)	½LFL (m)
Pinhole	Not reached	Not reached
Hole	60.6	88
Rupture	58	76

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) are 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.

The hazardous area is assumed to be the cloud envelope at LFL/2 gas concentration.

Two contributions have been evaluated in order to assess the ignition probability:

• 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 means of an event tree analysis, taking into account the probability of ignition. The event tree is illustrated in Figure 13-12.

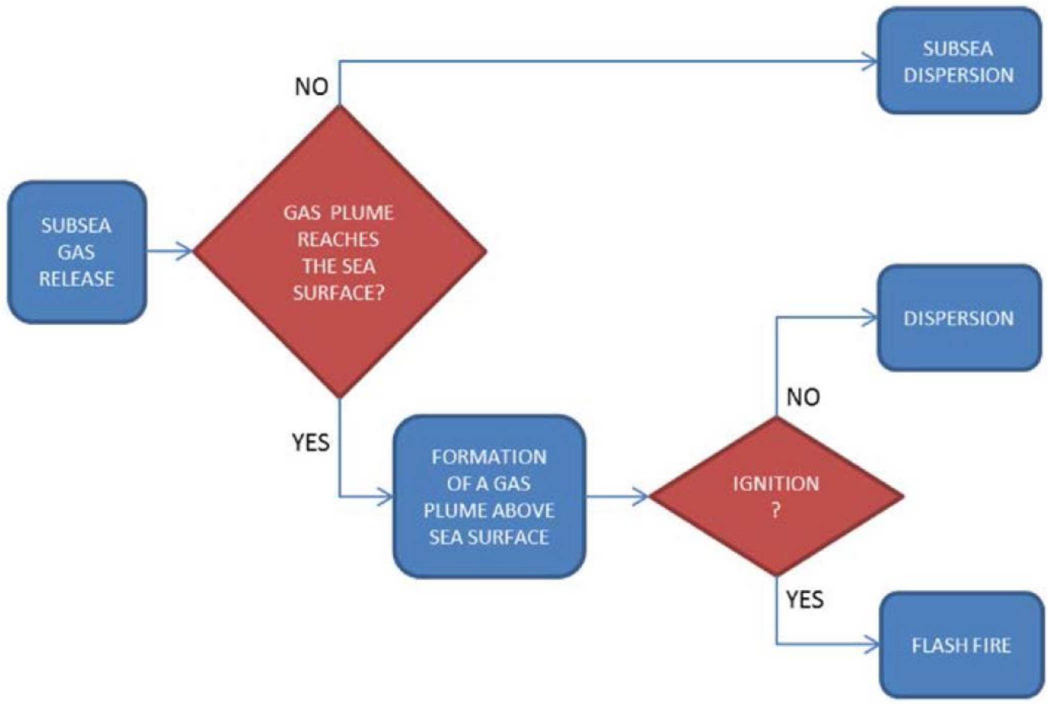


Figure 13-12 Event tree for subsea release.

In the estimation of the ignition probabilities, see Table 13-18, the cloud persistence time has been assumed in analogy to NSP taking into account leak detection time and local ship traffic.

Table 13-18 Conditional ignition probability and cloud persistence time /467/.

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 and 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.

The risk assessment is intended to assess 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 sensitive section is shown in Figure 13-13 (for the combination of the proposed NSP2 route with V1) and Figure 13-14 (for the combination of the proposed NSP2 route with V2) compared with the risk acceptance criteria. For all sections, the risk falls in the broadly acceptable region and therefore no further actions are required.

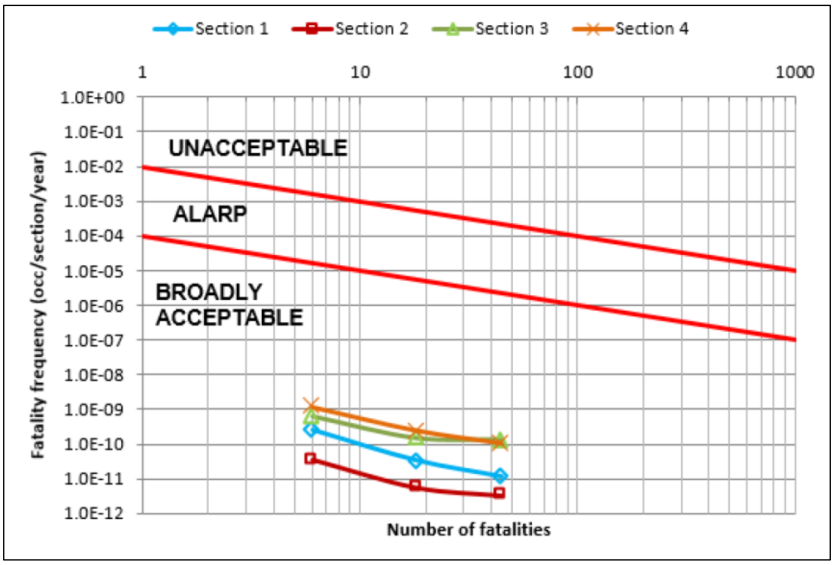


Figure 13-13 F-N diagram and F-N curve for each sensitive section along the combination of the proposed NSP2 route with V1. Numbers 1 to 4 refer to the four sensitive sections (see Table 13-10).

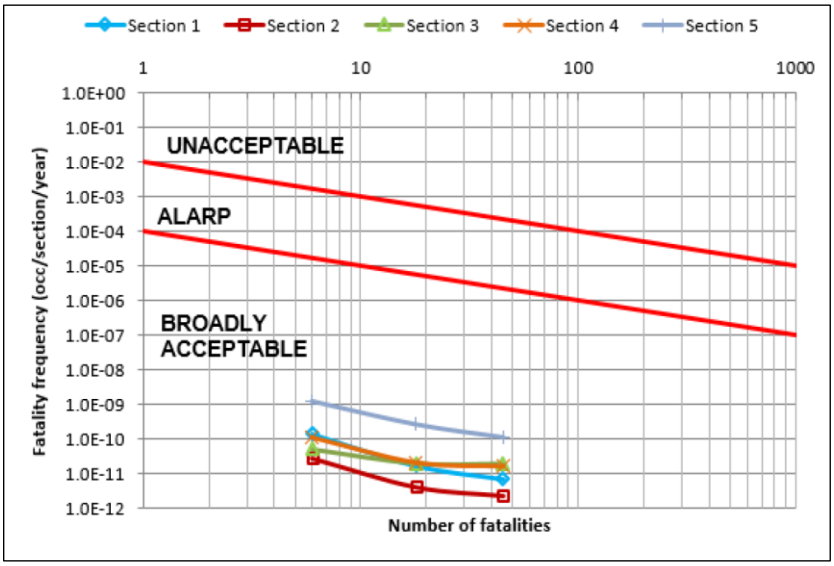


Figure 13-14 F-N diagram and F-N curve for each sensitive section along the combination of the proposed NSP2 route with V2. Numbers 1 to 5 refer to the five sensitive sections (see Table 13-11).

13.3.3.2 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 and 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.

13.3.4 Maintenance and repair works – operational phase

No repair works are planned during the operational phase 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 the pipeline become unsupported, i.e. freespans emerge. In general, such freespans rapidly disappear, but in case they persist for a longer time (as would be revealed during the regular pipeline inspection surveys), such freespans, should they reach a critical length, may require support, e.g. established by rock placement, to safeguard the integrity of the pipelines.

The environmental impacts from rock placement that may be required for freespan 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, sediment quality, hydrography and water quality). The environmental impacts of such repair works will therefore be less than those assessed 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 NSP2 are not significant.

13.4 Emergency preparedness and response

Although the NSP2 pipelines will be designed and constructed to operate safely throughout their operating life, it is prudent to have plans and procedures in place to respond to foreseeable emergencies. Emergency Preparedness and Response (EPR) is an integral part of the Nord Stream 2 Health, Safety, Environmental and Social Management System (HSES MS).

The EPR plans and procedures will be in place to minimise 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 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 Operational phase

Nord Stream 2 AG will develop and implement an emergency response plan for the operational phase. This will be supported by the following:

- Regular and periodic 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 the operational phase, contractors will handle fuels, lubricants and chemicals that could be accidentally spilled and have the potential to have adverse environmental impacts.

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).

To minimise the probability of occurrence of a spill and to ensure that all contractors associated with project activities have suitable procedures in place to respond to a spill, Nord Stream 2 AG 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, 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 Contingency Plan (OSCP) has been produced by Nord Stream 2 AG as a contingency for Tier 2 and 3 spills. The OSCP includes, but is not limited to, a strategy section describing the scope of the plan, including geographical coverage; a description of the maximum credible and most likely case scenarios; identification of perceived risks; a description of roles and responsibilities of those charged with implementing the plan and the proposed response strategy; and a definition of response arrangements. The OSCP sets out the emergency procedures that will enable assessment of the spill and mobilization of appropriate response resources.

Construction contractors will be required to develop their own Spill Prevention and Response Plans tailored to their activities. Contractors are responsible for responding to Tier 1 oil spills, and will do so 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.

13.4.3 Navigation and vessel safety

Vessel safety, particularly during construction, 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 centralised 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 third-party maritime traffic;
- The relevant authorities in each country will be notified of key construction events;
- 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 and monitoring of construction vessel anchors will be undertaken to minimise the possibility of a dragged anchor.

13.4.4 Consultation activities

Nord Stream 2 AG 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 phases

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 project activities may lead to impacts on the environment or present a risk to humans.

The risks are described below at a high level, along with the potential consequences and mitigation measures. Prior to construction activities, detailed risk assessments will be performed by the pipeline installation contractors.

13.5.1 Risks from conventional munitions

The areas of Danish waters around Bornholm, especially the eastern part, including the Bornholm Basin, present a higher risk of encountering chemical munitions dumped into the sea after World War II. Conversely, Danish waters were neither mined nor used as a known water battlefield during the wars.

Reporting of the munitions screening survey (UXO) covering the NSP2 pipe-lay corridors and the intervention works footprint is being finalised at the time of preparation of this EIA, and the early results identify munitions finds on both route variants. The routing has been adapted to safely accommodate the all found munitions along the NSP2 routes, i.e. a minimum offset distance to the pipelines, with the exception of an identified line of ground mines (explosive charge in the order of 800 kg per mine), which traverses the complete corridor of the NSP2 route V2. At the time of this assessment, the required remedial actions have not been fully developed.

Such actions under consideration include one or a combination of the following:

- Rerouting, potential reroute has been surveyed and is being assessed by engineering.
- Relocation of individual munitions to a permanent storage location on the seabed outside the influence of the pipeline corridor, which is yet to be agreed with the competent Danish authority.

Given the accuracy of the munitions screening survey and the precise installation tolerance of the NSP2 pipeline, it is considered highly unlikely that any interaction with munitions (found or non-detected) will occur during construction or operation of NSP2.

The detailed route optimisation will take account of the presence of conventional munitions on the seabed and where possible, the pipeline will be routed around munitions to avoid the impacts associated with clearing. When consistent with safe practice and in agreement with relevant authorities, conventional munitions that cannot be avoided through pipe-line rerouting, will be either recovered for onshore disposal or relocated away from the pipeline corridor. No in situ munitions clearance by controlled detonation is planned in Danish waters.

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, if necessary, handling of munitions will be agreed with the Danish Navy.

To supplement the munitions screening survey, in the unlikely case an anchored pipe-lay vessel is used for the pipe-lay activities, a detailed anchor corridor survey will be performed prior to construction.

13.5.2 Risks from chemical munitions

Potential impacts from chemical munitions during the construction and operational phases relate to the risk of contact with pipelines or marine equipment that subsequently leads to exposure of personnel on the pipe-lay or support vessel.

When chemical munitions are left undisturbed, they should not represent any risk to the pipelines or the marine environment.

13.5.2.1 Risks to pipelines/vessels

Contact of chemical munitions with the pipelines during pipe-lay activities could result in detonation of the munition, which 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, as the shock-sensitive detonators for the explosives were removed before disposal. Further, the charges of the chemical munitions are not sufficient to cause any significant damage.

A munitions screening survey has been completed along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. The Danish Navy will be informed of any potential chemical munitions/munitions-related objects and requested to evaluate the munitions and propose a method of handling the findings. It is expected, in agreement with the munitions expert, that a safety distance in the order of 20 m between the pipeline and any chemical munitions will be maintained.

To minimise the risks of encountering unexpected chemical munitions along the NSP2 pipeline route, e.g. relocated through fishing activity, a pre-lay survey will be conducted in advance of pipe-lay to identify any anomalies along the pipeline route and anchor corridor (in case an anchored pipe-lay vessel is used for the pipe-lay).

Contact with identified chemical munitions will be avoided by marking the positions of the munitions and associated avoidance area in the navigation database as “areas to avoid”. If an anchored pipe-lay vessel is used, the anchor touchdown points and anchor wire sweep will then be planned to avoid the positions of identified chemical munitions. This procedure is considered to negate the impacts from known chemical munitions.

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, if necessary, handling of munitions will be agreed with the Danish Navy.

No adverse events connected with chemical munitions occurred during the construction of NSP. Post-lay munitions monitoring of NSP indicated that the condition of all identified munition objects was unchanged /464/. Hence, there were no impacts as a result of chemical munitions during the construction of NSP in Danish waters.

Maintenance seabed works may be required during the operational phase, and it is possible that placement of rock material may have to be carried out in certain areas if unacceptable freespans 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 the construction phase, and the same avoidance measures would be implemented.

13.5.2.2 Risks to the public

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 an anchor or any other equipment that was in contact with the seabed is lifted. 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 Danish Navy, and similar measures are anticipated to be applied for NSP2.

During both the construction and operational phases, contact with any dumped chemical munitions will be avoided 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 the provision of equipment in accordance with the HELCOM guidelines for preventative measures and first aid, the development of an equipment decontamination procedure and specific training for vessel crews.

The Danish Navy will be informed about all finds of potential munitions identified near the pipelines.

13.5.3 Conclusion

*In situ m*unitions clearance by controlled detonation and other type of contact is not planned in Danish waters. The risk of munitions is addressed with adequate munitions screening surveys in the pipeline corridor and intervention works footprint during the design phase and localised route optimisation to avoid discrete munitions where identified in the survey corridor.

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 on the environment from munitions in Danish waters.

13.6 Wet buckle – Unplanned event

As with all types of construction projects, there is a remote chance that something may not go as planned during construction. Consequently, for NSP2 construction, Nord Stream 2 AG has developed a contingency strategy for an unplanned wet buckle incident /472/. Such a contingency would be used should the pipeline be damaged during pipe-lay in the unlikely event that e.g. the pipe-lay vessel moves unexpectedly, or if there is a failure of the vessel tensioner systems that simultaneously grip and maintain a controlled level of tension on the newly fabricated section of the pipeline between the pipe-lay vessel and the seabed. Such events could potentially cause a buckle (damage) to the pipeline, which could result in damage leading to water ingress and the partial flooding of the installed pipe string. This type of damage is, in the pipe-lay industry, called a wet buckle.

It shall be noted that the various actions to be undertaken in the case of a wet buckle incident are similar actions that were carried out as planned activities during pre-commissioning of the NSP pipelines /473/.

In the unlikely case of a wet buckle, the primary contingency procedure includes the following steps:

1. The pipe-lay vessel abandons the pipeline on the seabed.
2. Cut and remove the damaged section of the pipeline.
3. A vessel would be deployed to the location of the start-up head (located e.g. in Russia, Finland or Sweden) to flood the pipeline in a controlled manner. With the use of a pig, the water and any foreign materials that may have entered the pipeline at the location of the buckle will be pushed out. The water used in the controlled flooding would be filtered sea-water treated with oxygen scavenger (sodium bisulphite, $NaHSO_3$).
4. Once flooded, a Pipeline Recovery Tool (PRT) is installed into the cut end of the pipe string (where the damaged section has been removed). A dewatering pig is then pushed through the pipeline, from the start-up head towards the PRT, with air to dewater the pipeline.
5. Once the pipeline is dewatered, the pipe-lay vessel would recover the pipe string from the seabed and continue with normal pipe-lay operations.

A remote incident leading to a wet buckle could occur at any location; consequently, the potential discharge of treated water can take place at any position along the NSP2 pipeline route from Lubmin Bay to the Arkona Basin.

Based on the above, the possible potential environmental and socio-economic impacts from a wet buckle can be related to the following:

- Physical disturbance, noise and air emissions;
- Impacts caused by the discharge of untreated seawater (ingress water);
- Impacts caused by the discharge of treated seawater from cleaning the pipeline.

No wet buckles occurred during the construction of NSP, and no wet buckles are expected to occur during the construction of NSP2. It is important to stress that the potential environmental impacts of a wet buckle occurrence are impacts of an accidental event, not impacts from a planned activity.

The significance of the impact should a wet buckle incident occur has been assessed to be negligible to minor. This is based on the fact that any potential impact will be local and short-term /474/.

The main environmental risk caused by a potential wet buckle incident will be the discharge of seawater treated with the oxygen scavenger sodium bisulphite, $NaHSO_3$. The potential environmental impact is primarily related to the fact that the discharged water will be oxygen-free.

If a wet buckle incident takes place in shallower areas of the Baltic Sea (e.g. in the eastern part of the Gulf of Finland, east and south of Hoburgs Bank and Norra Midsjöbanken in the Swedish EEZ, and south and west of Bornholm in Danish/German waters), local and temporary impacts can take place. The potential discharge of treated seawater in these areas may impact marine fauna at distances of less than 100 m to a few hundred metres from the discharge points. Discharge of untreated seawater in these areas might also have a minor impact due to its potentially lower oxygen concentration than the surrounding seawater, but to a lesser degree than the discharge of treated seawater /474/.

The environmental impacts from a wet buckle inside Danish waters has been assessed to be very local, of a short duration and result in minor to insignificant impacts /474/.

14 TRANSBOUNDARY IMPACTS

NSP2 will cross the TW of Russia and Germany and will run within the EEZs of Finland, Sweden, Denmark and Germany. Potential transboundary impacts are discussed within this section in accordance with the requirements in the Convention on Environmental Impact Assessment in a Transboundary Context (henceforth referred to as the Espoo Convention).

The Espoo Convention requires international cooperation and public participation when a planned activity in one country, referred to as the "Party of Origin" (PoO), may result in significant adverse environmental impacts on another country, referred to as the "Affected Party" (AP).

The potential transboundary impacts have been described in the following sections divided into:

- Transboundary impacts from planned activities within the Danish EEZ on regional or global receptors in the Baltic Sea (see section 14.1);
- Transboundary impacts from planned activities within the Danish EEZ on neighbouring countries (see section 14.2);
- Transboundary impacts from unplanned events within the Danish EEZ (see section 14.3).

14.1 Transboundary impacts from planned activities within the Danish EEZ on regional or global receptors in the Baltic Sea

Some project activities within Danish waters may potentially affect receptors on a regional or global scale. This section assesses potential transboundary impacts with respect to these regional or global receptors in the Baltic Sea.

14.1.1 Hydrography

The marine environment in the Baltic Sea is heavily dependent on the occasional, major inflows of saline water through the Danish straits, as these are essentially the only means of water exchange in the bottom-close 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.

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 studied for NSP and NSP2. The NSP pipelines, the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 do not pass through the Bornholm Strait or the Stolpe Channel, the main gateways for inflowing seawater to the Baltic Proper. 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 /451//484/, and impacts on hydrography were therefore assessed to be negligible.

The mean height of the pipelines above the seabed was assumed to be 1.4 m, as a conservative assumption for the theoretical analysis. Analysis of the embedment of the NSP pipeline in Danish waters showed that five years after installation, the pipeline was embedded at least 50% in most locations.

A hydrographic monitoring programme was carried out in the Bornholm Basin for the existing NSP route 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 NSP /451//484/. The results of this monitoring suggest that the mixing caused by the pipelines in the Bornholm Basin were considerably below any level of effect that could be measured.

Potential impacts from the presence of the pipelines on hydrography during the operational phase are assessed to be local, long-term, and of low intensity, and the overall significance is assessed 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 in Danish waters.

14.1.2 Climate

The marine emissions of CO_2 during construction of NSP2 in Danish waters will temporarily increase the total annual emissions of CO_2 from vessels in Denmark. The total load of CO_2 is predicted to comprise approximately 97,423 t during construction (assuming the combination of the proposed NSP2 route with V2 is implemented), corresponding to approx. 3.8% of the total annual Danish emissions of CO_2 caused by shipping in 2016. The total load of CO_2 during 50 years of operation will amount to 33,667 t (assuming the combination of the proposed NSP2 route with V2 is implemented), which corresponds to 1.3% of the total annual Danish emissions of CO_2 caused by shipping in 2016. Should the combination of the proposed NSP2 route with V1 be implemented, CO_2 emissions are expected to be slightly lower, due to the shorter length of the alignment. Although CO_2 emissions in general have an impact on a global scale, the increased emissions during the construction and operational phases in Denmark are not anticipated to have a quantifiable impact on the global climate, and therefore no significant transboundary impacts are expected.

The marine emissions of NO_X, SO_2 and particulate matter during construction and operation in Danish waters will temporarily reduce the air quality in areas near the vessels. However, the construction and operational activities will take place offshore, meaning that the emissions will be dispersed and diluted to a level that is not quantifiable and no significant transboundary impacts are therefore expected.

14.1.3 Fish

The NSP2 route V1 and the NSP2 route V2 pass through an important area of fishery within the Danish and Swedish EEZs that is closed for fishing between 1 May and 31 October 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.

The water mass where cod spawning may take place, i.e. the reproductive layer, is confined to water depths of approximately 42-68 m. The NSP2 route V1 crosses this area within Danish waters over a distance of approximately 33 km, and at a water depth of 80-90 m. The NSP2 route V2 crosses the cod spawning closure area within Danish waters for a distance of approximately 38 km, and at a water depth of 80-90 m. Suspended sediments caused by construction activities will be limited to the lower 10 m of the water column and will not reach the reproductive volume. Moreover, the size of the area where NSP2 will be constructed is negligible compared to the total size of the area closed for fishery due to spawning of cod.

Therefore, it is assessed that there will be no significant transboundary impacts on Baltic Sea fish caused by the NSP2 project in the cod spawning area in Danish waters.

14.1.4 Natura 2000 sites

As well as being important at the individual level, Natura 2000 sites together form a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types. When considering impacts on such sites, it is thus necessary to ensure that the sites are safeguarded at both the individual and network levels to ensure that the coherence and functioning of the overall network is maintained. Such a network in relation to NSP2 covers the Baltic Sea and is hence transboundary and regional in nature.

The assessment of potential impacts on Danish Natura 2000 sites (the Natura 2000 screening for Natura 2000 site no. N252, Adler Grund and Rønne Banke (reefs and sandbanks)) has demonstrated that there will be no risk of significant or adverse impact on the designated species or habitats, and there will thus be no significant impacts on the integrity of the Natura 2000 sites.

N252 is the only Danish Natura 2000 site within 20 km of the proposed pipeline route. A distance of 20 km from the proposed NSP2 route, the NSP2 route V1 or the NSP2 route V2 was selected based on professional judgement and experience from NSP regarding the potential for impact on Natura 2000 sites from construction and operational activities.

Therefore, the coherence of the Natura 2000 network, including spatial and functional connections, will not be affected.

14.1.5 Marine biodiversity

Potential impacts on marine biodiversity have been assessed and it is concluded that NSP2 will not result in significant impacts on species (at the individual or population level), habitats or the integrity of protected areas during the construction and operational phases. Impacts at individual and population levels are generally assessed to be negligible, except for a minor impact on marine mammals due to underwater noise (during construction) and a minor impact on the benthic environment caused by change of habitat (during operation).

With due consideration of the above, it has been assessed that impacts at either the species or habitat level during construction and operation of NSP2 would not combine to result in impacts which would be sufficient to cause a change in biodiversity or ecosystem functioning.

Therefore, it is assessed that there will be no significant transboundary impacts on Baltic Sea biodiversity caused by the NSP2 project in Danish waters.

14.1.6 Shipping and shipping lanes

In Danish waters, the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 will run east and south of Bornholm, avoiding the heavily trafficked TSS Bornholmsgat. The only area with high ship traffic intensity is where NSP2 crosses the TSS Adlergrund in the Danish and German EEZs, which has approximately 7,000 ship movements per year /279/.

Safety exclusion zones will be implemented around slow-moving construction vessels. Only vessels involved in the construction of NSP2 will be allowed inside the safety zone; therefore, all other vessels not involved in construction activities will be requested to plan their journeys around the safety zone.

The shipping lanes crossed by the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2 in Danish waters provide sufficient space and water depth for ships to plan their journey and safely navigate around possible temporary obstructions. The impact on ship traffic associated with the imposition of a safety zone is assessed to be minor and associated with local and temporary changes to the traffic scheme.

Therefore, it is assessed that there will be no significant transboundary impacts on Baltic Sea ship traffic caused by the NSP2 project in Danish waters.

14.1.7 Fisheries

Commercial fishery in Danish waters comprises both Danish fishing boats and fishing boats of other countries bordering the Baltic Sea.

As mentioned above, safety exclusion zones will be implemented around slow-moving construction vessels. Only vessels involved in the construction of NSP2 will be allowed inside the safety zone; therefore, all other vessels not involved in construction activities (e.g. fishing vessels) will be required to plan their journeys around the safety zone. Due to the local and temporary nature of the impact and given the availability of alternative fishing grounds that can provide the same service, the impacts have been assessed to be negligible.

During operation, the physical presence of pipelines and structures on the seabed has the potential to impact fishing activities either through the imposition of protection zones (loss of opportunity) or through obstruction (additional effort and potential damage or loss of gear). The NSP2 pipelines have been designed to be resistant to impacts from any interaction with fishing gear and Nord Stream 2 AG will apply for a dispensation to remove any fishery restriction zone around the pipelines to allow fishing activities during the operation of the pipeline. Experience from the existing NSP pipelines has demonstrated that fishermen can coexist with the pipeline system, and since installation of the NSP pipelines, no fishery gear has been reported lost or damaged. Therefore, the impact on fishery is assessed to be minor, and there will be no significant transboundary impacts on Baltic Sea fishery caused by the NSP2 project in Danish waters.

14.1.8 Marine strategic planning

There are a number of EU legislative tools designed to protect the marine environment and create a framework for the sustainable use of the marine waters in the Baltic Sea. These include the MSFD and WFD, which are applicable to all EU Member States. The BSAP is also relevant to the area impacted by NSP2. No potentially significant transboundary impacts that have the potential to affect compliance with the EU Directives are predicted. Therefore, NSP2 will not prevent any EU Baltic State from achieving GES for any MSFD descriptor or the WFD. Furthermore, NSP2 will not prevent any country from reaching the targets set out in the BSAP.

14.2 Transboundary environmental impacts from planned activities within the Danish EEZ on neighbouring countries

This section assesses potential transboundary impacts from construction in Denmark on each neighbouring country in which these impacts may occur. During the operational phase, the only potential transboundary impacts are impacts on regional or global receptors in the Baltic Sea, which are evaluated in section 14.1.

The assessment of the potential for transboundary impacts considers the proximity of the NSP2 route, the NSP2 route V1 and the NSP2 route V2 to the neighbouring countries as well as the nature of the impacts. Where the NSP2 route, NSP2 route V1 and NSP2 route V2 run close to the Swedish, German and Polish EEZs, construction activities may potentially cause transboundary impacts on Sweden, Germany and Poland. These impacts are evaluated in sections 14.2.1, 14.2.2 and 14.2.3, respectively.

14.2.1 Transboundary impacts on Sweden

In the northernmost part of the Danish sector, the NSP2 route V1 and the NSP2 route V2 join together and enter the Swedish EEZ from the Danish EEZ at the same location. The environmental conditions on both sides of the Danish-Swedish EEZ border are quite similar. Specifically, the water depth at the border of the Danish and Swedish EEZs where the routes are planned is approximately 80 m, and the seabed sediment consists of mud, silt and fine clay. Furthermore, no seabed intervention works are planned along either route alternative near the Swedish EEZ. As such, the NSP2 route V1 and the NSP2 route V2 are referred to collectively in the assessment below as the "NSP2 route".

During the construction phase, activities such as pipe-lay, post-lay trenching and spot rock placement will lead to physical disturbance, release of seabed sediments, noise and emissions, which may result in transboundary impacts.

Release of sediments and sedimentation

Local impacts on the seabed and the marine benthos in the Swedish EEZ are expected due to the release of sediments and sedimentation during pipe-lay in Denmark close to the EEZ border between Denmark and Sweden. No seabed interventions are planned in the area close to the Swedish EEZ, and as discussed in section 8.4.2.1, pipe-lay will not result in significant sediment spread. Furthermore, identical impacts originating in the Swedish EEZ are expected in the Danish EEZ during pipe-lay activities in the Swedish EEZ close to the Danish EEZ. The impacts are highly localised at the EEZ border and assessed to be of negligible significance.

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. The distance between the closest section for post-lay trenching/rock placement in Denmark to the Swedish EEZ is more than 100 km, with rock placement planned where the NSP2 pipelines will cross the existing NSP pipelines. Numerical modelling has been performed in order to assess the sediment dispersion from post-lay trenching and rock placement within the Danish EEZ. The modelling results indicate that in connection with post-lay trenching, an area of 12.9 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 4.5 hours. In connection with rock placement, an area of 0.04 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 0.5 hours. The modelling results thus indicate that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary. Subsequent sedimentation is assessed to be local and of low intensity.

The release of sediments can result in release of contaminants associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide. Remobilisation and redistribution of CWA and contaminants during construction activities are assessed to potentially occur in the close vicinity of the proposed pipeline, where the sediment is disturbed. Calculations and modelling have been undertaken for the release of contaminants into the water column through post-lay trenching and rock placement. Levels of contaminants in the water corresponding to concentrations of suspended sediment of 2 mg/l (relevant for rock placement and trenching) and 15 mg/l (relevant for trenching only) were calculated assuming that the concentration of each contaminant in the sediment equals the highest measured concentration in the area. Based on the modelling of sediment dispersion and the distance to Swedish waters (more than 100 km to the closest section where spot rock placement is planned), it is assessed that there will be no significant transboundary impacts (e.g. on water quality or benthos) in Swedish waters due to sediment dispersion and the potential release of contaminants.

Generation of underwater noise
As described in section 8.4.5, rock placement is considered to be the noisiest of construction activities within Danish waters and was therefore the focus of underwater noise modelling. The distance between the closest section for rock placement in Denmark to the Swedish EEZ is more than 100 km, with rock placement planned where the NSP2 pipelines will cross the existing NSP pipelines. Numerical modelling has been performed for underwater noise from the rock placement at this location. The modelling has been undertaken for two scenarios (winter and summer conditions), and it has been concluded that no significant sound levels above ambient level will reach the Swedish EEZ.

Imposition of safety zones around vessels
There are no major shipping routes or TSS in Danish waters near the area where the proposed NSP2 route crosses from the Swedish EEZ to the Danish EEZ. As the majority of ships follow predesignated routes that are static and in accordance with existing TSS, it is therefore assessed that there will be no transboundary impacts on Sweden caused by the imposition of safety zones around vessels.

Protected areas
No parts of the NSP2 pipeline within the Danish EEZ are close to protected environmental areas inside the Swedish EEZ. The shortest distance to a Swedish Natura 2000 site is 30 km. As described above, the distances between the activities in Danish waters and protected areas within the Swedish EEZ are such that no transboundary impacts on protected areas in Sweden have been identified.

Conclusion
In conclusion, it is assessed that there will be no significant transboundary impacts on Sweden from the construction or operation of NSP2.

14.2.2 Transboundary impacts on Germany

In the southernmost part of the Danish sector, the proposed NSP2 route enters the German EEZ from the Danish EEZ. The environmental conditions on both sides of the Danish-German EEZ border are quite similar. Specifically, the water depth at the border of the Danish and German EEZs where the route is planned is approximately 30 m, and the seabed sediment consists mainly of sand. Furthermore, the same seabed intervention works are planned near the German EEZ regardless of which route alternative is selected. As such, the NSP2 route V1 and the NSP2 route V2 are referred to collectively in the assessment below as the "NSP2 route".

During the construction phase, activities such as pipe-lay, post-lay trenching and spot rock placement will lead to physical disturbance, release of sediments, noise and emissions, which may result in transboundary impacts.

Release of sediments and sedimentation
Local impacts on the seabed and the marine benthos in the German EEZ are thus expected due to release of sediments and sedimentation during pipe-lay in Denmark close to the EEZ border between Denmark and Germany. Identical impacts originating in the German EEZ are expected in the Danish EEZ during pipe-lay activities in the German EEZ close to the Danish EEZ. The impacts are highly localised at the EEZ border and assessed to be of negligible significance.

Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. The distance between the closest section for post-lay trenching/rock placement in Denmark to the German EEZ is approximately 9 km, with rock placement planned where the NSP2 pipelines will cross the existing NSP pipelines. Numerical modelling has been performed in order to assess the sediment dispersion from post-lay trenching and rock placement within the Danish EEZ. The modelling results indicate that in connection with post-lay trenching, an area of 12.9 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 4.5 hours. In connection with rock placement, an area of 0.04 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 0.5 hours. The modelling results thus indicate that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary. Subsequent sedimentation is assessed to be local and of low intensity.

The release of sediments can result in release of contaminants associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide. Remobilisation and redistribution of CWA and contaminants during construction activities are assessed to potentially occur in the close vicinity of the proposed pipeline, where the sediment is disturbed. Calculations and modelling have been undertaken for the release of contaminants into the water column through post-lay trenching and rock placement. Levels of contaminants in the water corresponding to concentrations of suspended sediment of 2 mg/l (relevant for rock placement and trenching) and 15 mg/l (relevant for trenching only) were calculated assuming that the concentration of each contaminant in the sediment equals the highest measured concentration in the area. However, it is noted that the concentrations of heavy metals and organic contaminants in the sediments are generally much lower in the area where the route enters the German EEZ than in the deeper parts of the route, and potential transboundary impacts correspondingly smaller. Based on modelling of sediment dispersion and the distance to German waters (approx. 9 km to the closest section where spot rock placement is planned at the NSP crossing), it is assessed that there will be no significant transboundary impacts (e.g. on water quality or benthos) in German waters due to sediment dispersion and the potential release of contaminants.

Generation of underwater noise
As described in section 8.4.5, rock placement is considered to be the noisiest of construction activities within Danish waters and was therefore the focus of underwater noise modelling. The distance between the closest section for rock placement in Denmark to the German EEZ is approximately 9 km, with rock placement planned where the NSP2 pipelines will cross the existing NSP pipelines. Numerical modelling has been performed for underwater noise from the rock placement activities at this location. The modelling has been undertaken for two scenarios (winter and summer conditions), and it has been concluded that no significant sound levels above ambient level will reach the German EEZ. Furthermore, as described in section 8.4.5, the threshold distances for TTS in marine mammals and fish have been assessed to be 80 m and 100 m, respectively. As such, rock placement within Danish waters is not expected to cause TTS-related impacts on marine mammals or fish within the German EEZ.

Imposition of safety zones around vessels
The proposed pipeline route crosses the TSS Adlergrund at the border between the Danish and German EEZs. In this area, safety exclusion zones around the slow-moving construction vessels will extend into the German EEZ during pipe-lay in Denmark close to the EEZ border between Denmark and Germany. This will impose a minor restriction on the east bound traffic in the shipping lane located in the German EEZ. The restriction will extend from the traffic separation zone in the middle of the TSS area and into the one-directional shipping lane, with a total width of 4 km. In any situation, there will be a free width of more than 2 km for safe navigation in the east bound lane. The impact on ship traffic in the German EEZ is therefore assessed to be minor and no significant transboundary impact is therefore expected. Identical impacts originating in the German EEZ are expected in the Danish EEZ during pipe-lay activities in the German EEZ close to the Danish EEZ.

Protected areas
There is a designated German Natura 2000 site where the pipeline route enters the German EEZ. As described above, local impacts on resources and receptors in the German EEZ due to construction activities in the Danish EEZ will be highly localised at the EEZ border and are assessed to be of negligible significance. Furthermore, the distance between the closest section for post-lay trenching/rock placement in Denmark to the German Natura 2000 site is approximately 9 km. As discussed above, any potential impact is assessed to be temporary, local and of low intensity. No significant impacts on German Natura 2000 sites have been identified in associated with activities in the Danish sector.

Conclusion
In conclusion, it is assessed that there will be no significant transboundary impacts on Germany from the construction or operation of NSP2.

14.2.3 Transboundary impacts on Poland

The route does not enter the Polish EEZ, and the shortest distance from the pipeline to the Danish/Polish EEZ border is approximately 7.0 km for the combination of the proposed NSP2 route with V1 and approximately 3.6 km for the combination of the proposed NSP2 route with V2.

During the construction phase, activities such as pipe-lay, post-lay trenching and spot rock placement will lead to physical disturbance, release of seabed sediments, noise and emissions, which may result in transboundary impacts.

Release of sediments and sedimentation
Construction activities, mainly post-lay trenching and rock placement, will result in the release of sediment into the water column. The distance between the closest section for post-lay trenching/rock placement in Denmark to the Danish/Polish EEZ border is approximately 7 km, with rock placement planned where the NSP2 pipelines will cross the existing NSP pipelines. Numerical modelling has been performed in order to assess the sediment dispersion from post-lay trenching and rock placement within the Danish EEZ. The modelling results indicate that in connection with post-lay trenching, an area of 12.9 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 4.5 hours. In connection with rock placement, an area of 0.04 km^2 may be affected by a suspended sediment concentration of >2 mg/l for a period of up to 0.5 hours. The modelling results thus indicate that the majority of the suspended sediment will redeposit locally, and that increased concentrations of suspended sediment will be local and temporary. Subsequent sedimentation is assessed to be local and of low intensity.

The release of sediments can result in release of contaminants associated with the sediment, including metals, organic contaminants, nutrients (N and P), and hydrogen sulphide. Remobilisation and redistribution of CWA and contaminants during construction activities are assessed to potentially occur in the close vicinity of the proposed pipeline, where the sediment is disturbed. Calculations and modelling have been undertaken for the release of contaminants into the water column through post-lay trenching and rock placement. Levels of contaminants in the water corresponding to concentrations of suspended sediment of 2 mg/l (relevant for rock placement and trenching) and 15 mg/l (relevant for trenching only) were calculated assuming that the concentration of each contaminant in the sediment equals the highest measured concentration in the area. Based on modelling of sediment dispersion and the distance to Polish waters (approx. 7 km to the closest section where spot rock placement is planned), it is assessed that there will be no transboundary impacts (e.g. on water quality or benthos) in Polish waters due to sediment dispersion and the potential release of contaminants.

Generation of underwater noise
The distance between the closest section for post-lay trenching/rock placement in Denmark to the Danish/Polish EEZ border is approximately 7 km, with rock placement planned where the NSP2 pipelines will cross the existing NSP pipelines. Numerical modelling has been performed for underwater noise from the rock placement activities at this location. The modelling has been undertaken for two scenarios (winter and summer conditions), and it has been concluded that no significant sound levels above ambient level will reach the Polish EEZ. Furthermore, as described in section 8.4.5, the threshold distances for TTS in marine mammals and fish have been assessed to be 80 m and 100 m, respectively. As such, rock placement within Danish waters is not expected to cause TTS-related impacts on marine mammals or fish within the Polish EEZ.

Imposition of safety zones around vessels
Due to the distance from the proposed pipeline route to the Polish EEZ, it is assessed that there will be no transboundary impacts on Poland caused by the imposition of safety zones around vessels. Furthermore, it is noted that there are no major shipping lanes between Denmark and Poland that will be impacted by the NSP2 route, the NSP2 route V1 or the NSP2 route V2.

Protected areas
No parts of the NSP2 pipeline within the Danish EEZ are close to protected environmental areas inside the Polish EEZ. The shortest distance to a Polish Natura 2000 site is 54 km for the combination of the proposed NSP2 route with V1, or 34 km for the combination of the proposed NSP2 route with V2. As described above, the distances between the activities in Danish waters and protected areas within the Polish EEZ are such that no transboundary impacts on protected areas in Poland have been identified.

Conclusion
In conclusion, it is assessed that there will be no significant transboundary impacts on Poland from the construction or operation of NSP2.

14.3 Transboundary environmental impacts from unplanned events within the Danish EEZ

Potential unplanned events could include, e.g., an oil spill following a ship collision or a gas leakage.

14.3.1 Risk and transboundary impacts from oil spill

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 could 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 major 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.

It is noted that Nord Stream 2 AG has produced an Oil Spill Contingency Plan (OSCP), which is a contingency for Tier 2 and Tier 3 spills. The OSCP sets out emergency procedures to enable assessment of the spill and mobilization of appropriate response procedures. Contractors are responsible for responding to Tier 1 oil spills, and to this end all contractors are required to have an approved Shipboard Oil Pollution Emergency Plan (SOPEP) and equipment on board.

14.3.2 Risk and transboundary impacts from gas release

The probability of a gas release is extremely low. Based on an assessment of different scenarios for gas release, it is assessed that a gas release may be a safety issue for ship traffic, but will not pose a threat to the safety of people on Bornholm or on 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, i.e. inside or outside Danish waters, there may be transboundary impacts. The impacts on the marine environment would be local and of a relatively short duration, while the impacts on ship traffic (i.e. changing shipping routes) would be of a longer duration, owing to safety exclusion zones around repair locations that will be of the same extent as exclusion zones during the construction phase.

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 that is present across all countries and contributes to climate change.

14.4 Conclusion

In general, it is assessed that there will be no significant transboundary impacts from the NSP2 project activities within Danish waters on neighbouring countries. This conclusion is in line with the monitoring results during construction and the first years of the operation of the existing NSP pipelines in Danish waters.

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 are of the same nature, but of a significantly smaller magnitude than those resulting from similar construction activities within the German and Swedish EEZs, respectively. No significant transboundary impacts on Poland have been identified.

It is further assessed that NSP2 project activities in Danish waters will not lead to any significant transboundary impacts on a regional or global level.

The construction and operation of the NSP2 pipelines within the Danish EEZ will have no significant impact on protected areas, including internationally protected areas (i.e. Natura 2000 sites, Ramsar sites). Therefore, the coherence of the Natura 2000 network, including spatial and functional connections, will not be affected.

15 MITIGATION MEASURES

15.1 General

Nord Stream 2 AG is committed to designing, planning and implementing the pipeline project with the least impact on the environment as is reasonably practicable. The health, safety, environmental and social management system (HSES MS) 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 technically 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 CHOs and near areas known to be contaminated with chemical warfare agents. Avoidance reduces the need for further 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, minimised 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

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 away 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 water 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 untreated sewage will take place from stationary 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. 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. Ballast tanks will also be cleaned as required 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.

In order to reduce invasive species from spreading into the Baltic Sea, Nord Stream 2 AG and its contractors will follow the 2004 IMO Ballast Water Management Convention. The Convention entered into force on the 8th of September 2017.

15.4 Shipping and shipping lanes

For the construction phase, Nord Stream 2 AG will apply to the DMA for the implementation of a safety exclusion zone around each work vessel. The default exclusion zone around the pipe-lay vessel is a zone with a radius of 1 nm; i.e. about 1.85 km, and the default exclusion zone around other vessels with restricted manoeuvrability is 500 m. Details including shape, size and marking of the exclusion zones are to be agreed with the authorities. The imposition of the exclusion zones will be temporary at any given location as the construction activities progress.

Nord Stream 2 AG, 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.

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.

Where relevant, installation contractors will prepare specific procedures for crossing shipping lanes and areas of high traffic density. Nord Stream 2 AG also intends to provide native speakers on the pipe-lay vessel in order to allow communication with local vessels such as fishing vessels and coasters.

For communication, a temporary, local notification system can be established in order to increase the alertness of approaching ships. This system can be set up with a local vessel that calls to other vessels. Such a temporary system was established during the construction of NSP, where a person local to the area was used to ensure efficient communication with other vessels. A similar measure is planned for the construction of NSP2.

15.5 Commercial fishery

Nord Stream 2 AG will apply to the DMA for the implementation of a safety zone in the order of 3 km (approximately 1.5 nm) for the anchored pipe-lay vessel, 2 km (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.

Nord Stream 2 AG, 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.

Nord Stream 2 AG will apply for a dispensation to remove the fishery restriction zone around the pipelines to allow fishing activities during the operation of the pipeline.

15.6 Cultural heritage

Objects of potential cultural importance have been identified and, where required, will be subject to further gradiometric and visual inspection at a later stage of the project. The need for further inspection will be agreed on in consultation with the relevant Danish authorities. Assessment of the general data quality and the cultural significance of discovered wreck sites will be undertaken by a recognised marine archaeology agency of Denmark upon receipt of survey results. Should any new assets be identified, these would be managed through local rerouting of the NSP2 pipelines.

In the event that an anchored pipe-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 CHOs. 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.

A recognised marine archaeology agency will additionally 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 Danish Agency for Culture and Palaces.

In the pipeline routing process for NSP2, an initial avoidance buffer of up to 200 m (to be determined in consultation with individual regulations) will be placed around all CHOs within the near-shore 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 on 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 rerouting 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.

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.

Where required an exclusion zone around CHOs will be established (the final radius of the zone will be determined in consultation with individual regulations).

15.7 Conventional and chemical munitions

15.7.1 Conventional munitions

Route planning will take the presence of conventional UXO on the seabed into account and where possible, the pipeline will be routed around UXO to avoid the impacts associated with clearing. If consistent with safe practice 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 Danish Navy.

15.7.2 Chemical munitions

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.

A munitions screening survey has been completed along the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2. The Danish Navy will be informed of any potential chemical munitions/munitions-related objects and requested to evaluate the munitions and propose a method of handling the findings. It is expected that the munitions experts will recommend leaving chemical munitions where found and maintain a minimum safety distance (anticipated to be 20 m).

To minimise the risks of encountering unexpected chemical munitions on the NSP2 pipeline route, a pre-lay survey will be conducted in advance of pipe-lay to identify any anomalies along the pipeline route and anchor corridor (in case an anchored pipe-lay vessel is used for the pipe-lay).

During pipe-lay 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 and associated avoidance area in the navigation database as "areas to avoid". If an anchored pipe-lay vessel is used, the anchor touchdown points and anchor wire sweep will then be planned to avoid the positions of the identified chemical munitions.

Nord Stream 2 AG plans to perform post-lay trenching in some sections of the pipeline in Danish waters. A post-lay pipeline plough will lower the pipelines through the ploughed sections such that the top of the pipelines are flush with the natural seabed. Due to the nature of post-lay trenching operations, seabed soils will be present on the pipeline plough when it is recovered on board the plough support vessel. Accordingly, it is proposed that an expert lead from the Danish Navy be mobilised to the plough support vessel for the duration of the post-lay plough operations in order to check for any chemical munitions that may have come into contact with the trenched pipeline section.

During both the construction and operational phases, contact with any dumped chemical munitions will be avoided 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 the provision of equipment in accordance with the HELCOM guidelines for preventative measures and first aid, the development of an equipment decontamination procedure and specific training for vessel crews.

The Danish Navy will be informed about all finds of potential munitions identified near the pipelines.

15.8 Existing and planned installations

Where the pipeline crosses existing infrastructure such as cables and pipelines, Nord Stream 2 AG will agree designs for safe crossing with the owners 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

Nord Stream 2 AG 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.

15.10 Environmental monitoring stations

In order to exclude any potential impact on historical and future data acquired by long-term monitoring stations, Nord Stream 2 AG will consult with the relevant authority and/or organisation operating the station to minimise interference.

15.11 Risk assessment

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

Nord Stream 2 AG will ensure that its contractors manage wastes to acceptable international standards. Contractor waste management plan(s) and supporting procedures will be developed and implemented for each vessel and Nord Stream 2 AG will track waste volumes and types in a waste inventory.

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 Contingency Plan (OSCP) has been produced by Nord Stream 2 AG as a contingency for Tier 2 and 3 spills. The OSCP includes, but is not limited to, a strategy section describing the scope of the plan, including geographical coverage; a description of the maximum credible and most likely case scenarios; identification of perceived risks; a description of roles and responsibilities of those charged with implementing the plan and the proposed response strategy; and a definition of response arrangements. The OSCP sets out the emergency procedures that will enable assessment of the spill and mobilization of appropriate response resources.

Construction contractors will be required to develop their own Spill Prevention and Response Plans tailored to their activities. Contractors are responsible for responding to Tier 1 oil spills, and will do so 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.

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 Danish EEZ 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 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 NSP pipelines, an environmental monitoring programme covering activities within Danish waters 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 construc-tion	During construc-tion	During operation
Environmental parameters						
Fish along the pipeline	/475/	2010	2014	X		X
Benthic fauna	/476/	2010	2013	X		X
Epifauna (reef effect)	/475/	2011	2014			X
Water quality	/477/	2011	2012		X	
Chemical warfare agents in sediment	/476/	2008	2012	X		X
Hydrographical conditions in the Bornholm Basin	/478/	2010	2011	X		X
Socio-economic monitoring parame-ters						
Cultural heritage	/479/	2010	2014	X	X	X
Chemical munitions	/479/	2010	2012	X	X	X
Maritime traffic	/480/	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 /481/;
- Monitoring activities and results for 2011 /314/;
- Monitoring activities and results for 2012 /315/;
- Monitoring activities and results for 2013 /482/;
- Monitoring activities and results for 2014 /483/.

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, quantitative changes in the fish community in the immediate vicinity of NSP and to compare the findings with the fish community of the surrounding seabed area. The aim of the monitoring programme was to investigate whether the pipelines led 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 included: 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 the changes in the benthic communities in the vicinity of the pipeline or areas where seabed intervention works (trenching) were carried out, before, during and after construction of NSP.

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-salinity area of the Baltic Sea. The abundance and biomass of the benthic fauna were 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 was concluded that 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 four of the 10 locations. The final survey, carried out in 2014, revealed the establishment of mussels at eight out of 10 locations. In addition, single bryozoans were observed at five locations; opossum shrimp were observed at two stations and the crustacean *S. entomon* was observed at one station.

The monitoring of epifauna along NSP has revealed the establishment of sessile epifauna consisting of mainly blue mussels. However, clear evidence of a reef effect for the demersal fish assemblage was not found. 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 coming 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 /314/ and 2012 /315/.

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 20 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 /315/.

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 /484/. In that report, it was concluded that the two pipelines may 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 from January 2010 until January 2011 /451/.

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 /484/. 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 the pipe-lay 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 /483/.

16.1.8 Monitoring of chemical munitions

The purpose of munitions monitoring in Denmark was to document that identified chemical munitions objects in Danish waters 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. The Danish Navy assessed these objects, and it was agreed with the Danish Navy 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 the pipe-lay vessels to ensure that traces of chemical munitions were not brought on board the construction vessels.

Post-lay munitions monitoring for Line 1 was conducted in January 2011, and 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 /315/.

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, temporary 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 of monitoring carried out for NSP, it is concluded that the impacts on the marine environment had a minor to insignificant effect that was limited to the immediate vicinity of the pipelines. Nevertheless, proposed parameters for monitoring in connection with NSP2 are listed in Table 16-2. These parameters are suggested in order to:

- Verify the environmental impacts described and evaluated in the EIA report;
- Meet the expected high interest by various stakeholders and the public in general.

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.

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
Chemical warfare agents Chemical warfare agents 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 behaviour of construction vessels		X	
NSP2 pipelines footprint Monitoring of the seabed area occupied by the NSP2 pipelines and associated structures and documentation of physical loss for overall habitat types			X
*An expert from the Danish Navy 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 NSP.

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

A recognised marine archaeology agency[17] will perform a screening of the geophysical survey results with the aim of assessing potential CHOs. Based on this evaluation, a visual inspection will be performed and/or exclusion zones will be established around protected wrecks in agreement with the Danish Agency for Culture and Palaces. The pipe-lay contractor will be informed of all agreed restriction zones.

The purpose of the cultural heritage monitoring programme in Danish waters would be to document the condition of wrecks before and after construction – thereby verifying that construction of NSP2 did not affect CHOs.

16.2.3 Munitions on the seabed

The purpose of the monitoring programme for munitions in Danish waters would be to document that munitions objects identified during detailed munitions screening surveys along the pipeline

[17] Under The Agency for Culture and Palaces.

corridor are not disturbed during the construction or operation of NSP2. The scope of monitoring during construction will depend on the type of pipe-lay vessel used.

16.2.4 Chemical warfare agents in seabed sediment

Construction of NSP2 within Danish waters includes rock placement and trenching of the pipelines into the seabed in some sections. 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 into pieces. It has generally been assessed that construction activities on the seabed may have only a very local effect on the spreading of CWA.

During construction activities, munitions experts from the Danish Navy will most likely also be on board the construction vessel to ensure that traces of CWA are not brought on board 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. The focus should be on locations where trenching is to be carried out, as this is the activity which results in the greatest sediment disturbance.

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 trawls have to cross the pipeline at as steep an angle as possible, preferably 90 degrees, in order to reduce the risk of the trawl boards becoming stuck. Alternatively, fishermen can lift up the bottom-trawl gear higher in the water column. Therefore, the pipeline will to some small extent reduce the availability of fishermen to fish wherever they want, as they to some extent will need to adapt their trawl patterns or lift their gear while crossing. The 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 3 km/day, depending on the type of vessel. A temporary safety area will be established around the pipe-lay vessel. In the temporary safety area, unauthorised 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 ship traffic to 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 programme in relation to maritime traffic would be to minimise the risk of collisions or other accidents involving commercial ship traffic and/or vessels performing construction activities for the project. 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 AIS) for identification and locating of vessels.

16.2.7 NSP2 pipelines footprint

Construction of the NSP2 pipelines and associated support structures on the seabed will require the occupation of a portion of the seabed (referred to as the "footprint") and will lead to a loss of natural habitat within this occupied area and physical disturbance of the habitats along the pipeline.

The purpose of the monitoring is to calculate the footprint of the NSP2 pipelines and associated structures and to document the physical loss and physical disturbance for the overall habitat types along the NSP2 route in Danish waters.

Calculations of the seabed area occupied and directly impacted by the NSP pipelines and associated structures (arising e.g. from post-lay trenching and rock placement) along the NSP pipelines inside Danish waters was <5 km^2.

Monitoring will include a combination of ROV, SSS and/or MBES surveys. The definition of the main habitats along the NSP2 route inside Danish waters will be based on the results of the environmental baseline surveys performed in 2018 and 2019 combined with data on surface sediment composition, depth, salinity and oxygen condition. Calculations of the pipeline footprint and the loss of overall habitats will be made based on as-built survey results and the seabed sediment types along the whole NSP2 pipeline section (Line A and Line B) inside Danish waters.

17 HEALTH, SAFETY, ENVIRONMENTAL AND SOCIAL MANAGEMENT SYSTEM

17.1 HSES policy and principles

Nord Stream 2 AG'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 AG staff and contractors.

The implementation of the Policy is through a HSES MS aligned to the international standards ISO 45001:2018 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 AG 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 NSP2. It will be adjusted once the pipeline system is commissioned so as to manage HSES issues for the operational phase.

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.

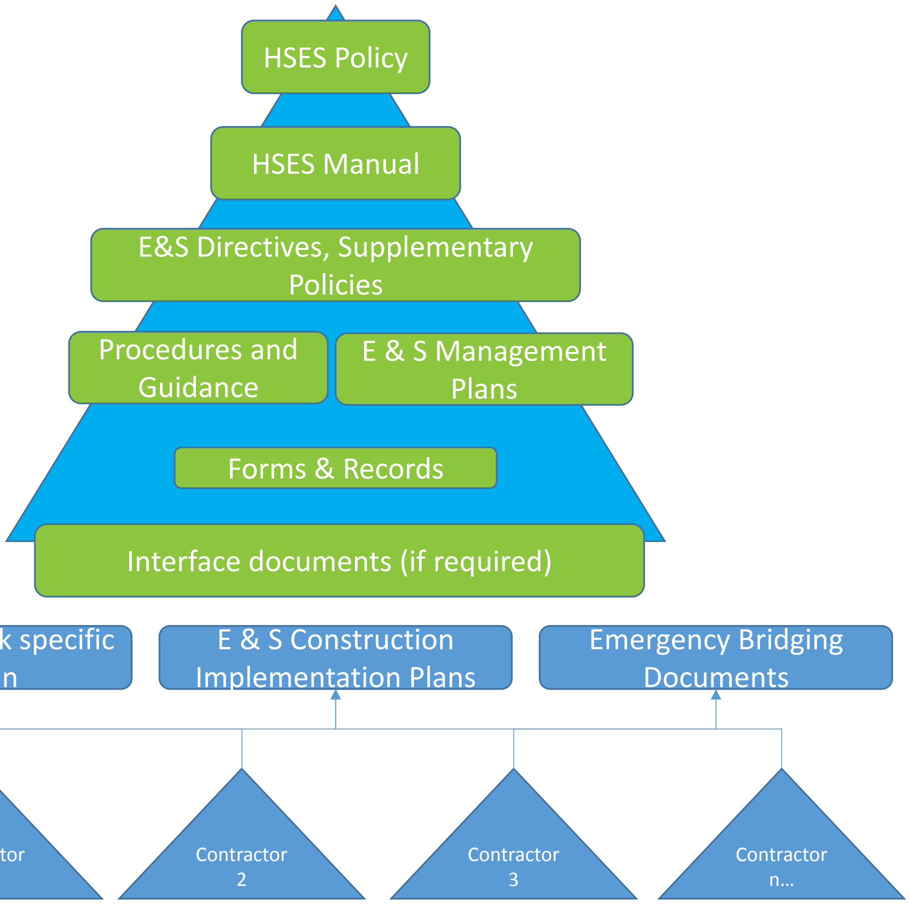


Figure 17-1 Structure of the HSES Management System (planning and construction phases).

Figure 17-2 shows in more detail the hierarchy of E&S Management documents and their relationship to permitting and financing documents.

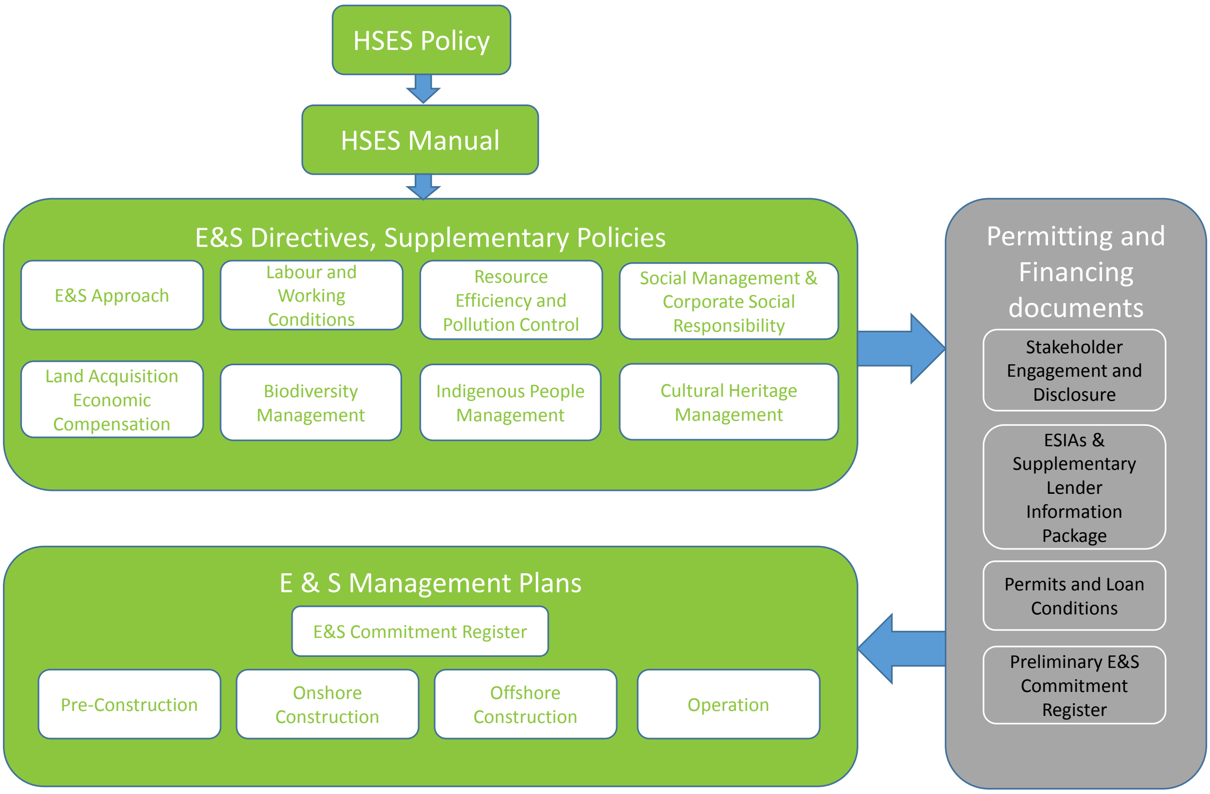


Figure 17-2 Sub-structure of the E&S Management System.

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 subsystem 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 and 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 minimises 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 and 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 and security hazards and environmental and 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, and 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 and 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 Key Performance Indicators (KPIs) and communicated in order for the system to be efficient and effective.

Expectations:

- Nord Stream 2 AG 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 stakeholders 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 with 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 programme;
- 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 and 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 programme, testing and calibration, according to the relevant standards.

17.3.8 Monitoring and 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 Nord Stream 2 AG 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 programme 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 and 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

It is a legal requirement that an EIA contains information on difficulties, for instance technical deficiencies or lack of knowledge, encountered in compiling the required information and the main uncertainties involved.

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. Therefore, it is important to draw attention to the fact that the nature of an EIA is *predictive.*

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 verifying the predicted impacts from the project.

The technical deficiencies and/or lack of knowledge identified will not result in significant changes to the outcome of the assessments performed.

18.2 Technical deficiencies

The terminology "technical deficiencies" should be understood as shortcomings in relation to the description of the project (see 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 NSP2 have been developed in parallel with the evaluation of environmental impacts. At this stage, the project has been 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 essence, the routing and the technical designs have been established.

The routing of the pipeline has been subject to optimisations throughout the design process in order to identify the best solution from both a technical and environmental perspective. Adjustments have been made to obtain pipeline stability while at the same time minimising 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 on-going and will continue during further detailed design stages; however, such 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, anti-friction 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, munitions surveys will be carried out in the anchor corridor if an anchored pipe-lay vessel is to be used. 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 avoid contact with munitions or other objects in the anchor corridor. In the event that additional munitions are found in the anchor corridor, it is expected that they will be left untouched on the seabed. 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 at the time when all permits have been granted. Pipe-laying could either be anchor-based or with a DP vessel. Throughout the EIA a worst case assessment has been employed where appropriate. This 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 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. 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.

18.2.4 Operation

During the operational phase, maintenance of the pipeline will be required in terms of internal and external inspections. The frequency of these inspections is expected to be every one to two years for the first years and then may be adjusted on the basis of experience and requirements.

18.2.5 Decommissioning

As stated previously, 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 are 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 have been evaluated as 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 models are dependent on input, some assumptions have been applied. These assumptions are described in section 8.4.

18.3.2 Environmental baseline surveys

At the time of completion of this report, the results of environmental baseline surveys along the proposed NSP2 route (SE route) in Danish waters and along the NSP2 route V2 were available and therefore incorporated into the baseline descriptions. However, the results of surveys along the NSP2 route V1 were not yet finalised, and were only available in preliminary versions when preparing this EIA. The preliminary results do not, however, give rise to changes in the conclusions of this report. The descriptions and assessments of impacts are based on the results of prior surveys conducted as part of the investigations of alternative routes for the NSP and NSP2 pipeline systems, as described in section 7.1.1. It is noted that the general locations of prior sampling events (i.e., in Danish waters east and south of Bornholm) are similar in character to the area covered by the proposed NSP2 route, the NSP2 route V1 and the NSP2 route V2.

Furthermore, monitoring results can differ based on the selection of monitoring stations, even for those located in close proximity to one another. Therefore, a certain degree of natural variability in 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-rectangles for the period 2010-2014 have been collected from all the counties surrounding the Baltic Sea, with the exception of Russia, for which it was not possible to obtain data.

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 are not publicly available. This represents a data gap which has required further data collection from other sources i.e. HELCOM.

18.3.5 Cultural heritage

Current evaluations of potential cultural heritage finds in the proposed NSP2 corridor are based on the results of prior surveys conducted as part of the NSP2 base case route investigations and the information available on the databases of heritage agencies. This information will be updated with the results of detailed geophysical reconnaissance surveys of the proposed NSP2 route, NSP2 route V1 and NSP2 route V2, and potential further gradiometric and visual inspections at a later stage of the project. Furthermore, assessment of the general data quality and the cultural significance of discovered wreck sites will be undertaken by a recognised marine archaeology agency of Denmark upon receipt of survey results. Should any new assets be identified, these would be managed through local rerouting of the NSP2 pipelines.

18.3.6 Munitions

A munitions screening survey has been completed along the proposed NSP2 route, NSP2 route V1 and NSP2 route V2. The Danish Navy will be informed of any potential chemical munitions/munitions-related objects and requested to evaluate the munitions and propose a method of handling the findings.

18.3.7 Environmental monitoring programme

The environmental management and monitoring programme (see section 16), which includes monitoring before, during and after construction of the pipelines, will be elaborated in consultation 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 AG technical team, national authorities and other parties of interest. The technical deficiencies and/or lack of knowledge identified will not result in significant changes to the outcome of the assessments performed.

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