BALTIC PIPE OFFSHORE PIPELINE- PERMITTING AND DESIGN

ENVIRONMENTAL IMPACT ASSESSMENT - BALTIC SEA - DENMARK

FEBRUARY 2019

BALTIC PIPE PROJECT | GAZ system

Co-financed by the Connecting Europe Facility of the European Union

RAMBOLL SMDI MEWO MARITIME INSTITUTE IN GDAŃSK PGNiG | GAZOPROJEKT

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SUMMARY

Environmental impact assessment

Construction and installation of the Baltic Pipe may lead to both environmental and socio-economic impacts, which are assessed in detail in an Environmental Impact Assessment (EIA) report covering all relevant environmental end socio-economic receptors, i.e. components of the environment and human activities (see Table 1). An EIA has been prepared and submitted to the Danish authorities (Ramboll, 2019).

Table 1 Receptors relevant for the EIA for the Baltic Pipe project (offshore part, Baltic Sea).

Physical-chemical environment	Biological environment	Socio-economic environment
• Bathymetry • Hydrography and water quality • Surface sediments and contaminants • Climate and air quality • Underwater noise	• Plankton • Benthic habitats, flora and fauna • Fish • Marine mammals • Seabirds and migrating birds • Migrating bats • Annex IV species • Biodiversity • Protected areas • Natura 2000	• Shipping and shipping lanes • Commercial fisheries • Archaeology and cultural heritage • Cables, pipelines and wind farms • Raw material extraction sites and dumping sites • Military practice areas • Environmental monitoring stations

Baseline

The baseline is a description of the existing environmental conditions in the project area, which in this case the southern Baltic Sea. In this summary of the EIA, special focus is given to the Danish part of the project area offshore. The baseline forms the foundation for the assessments of the project impacts.

A scoping procedure has identified the relevant environmental receptors for the project in the Danish part of the project area. As a result of this procedure, a scoping report has been prepared and submitted to the Danish authorities (Danish Energy Agency), and subjects from the complementary consultation round have been included in the EIA to ensure that all relevant and important environmental and socio-economic aspects are covered. The scoping process has also identified whether some receptors should be given special attention in the EIA.

The baseline has been prepared using desktop studies of scientific literature, technical reports of available data covering the project area and field surveys where results add new information and/or can confirm already existing information.

The Baltic Pipe project is situated in the southern part of the Baltic Sea, mainly in the Arkona Basin (Figure 9-1). The detailed baseline description is provided in the Danish EIA.

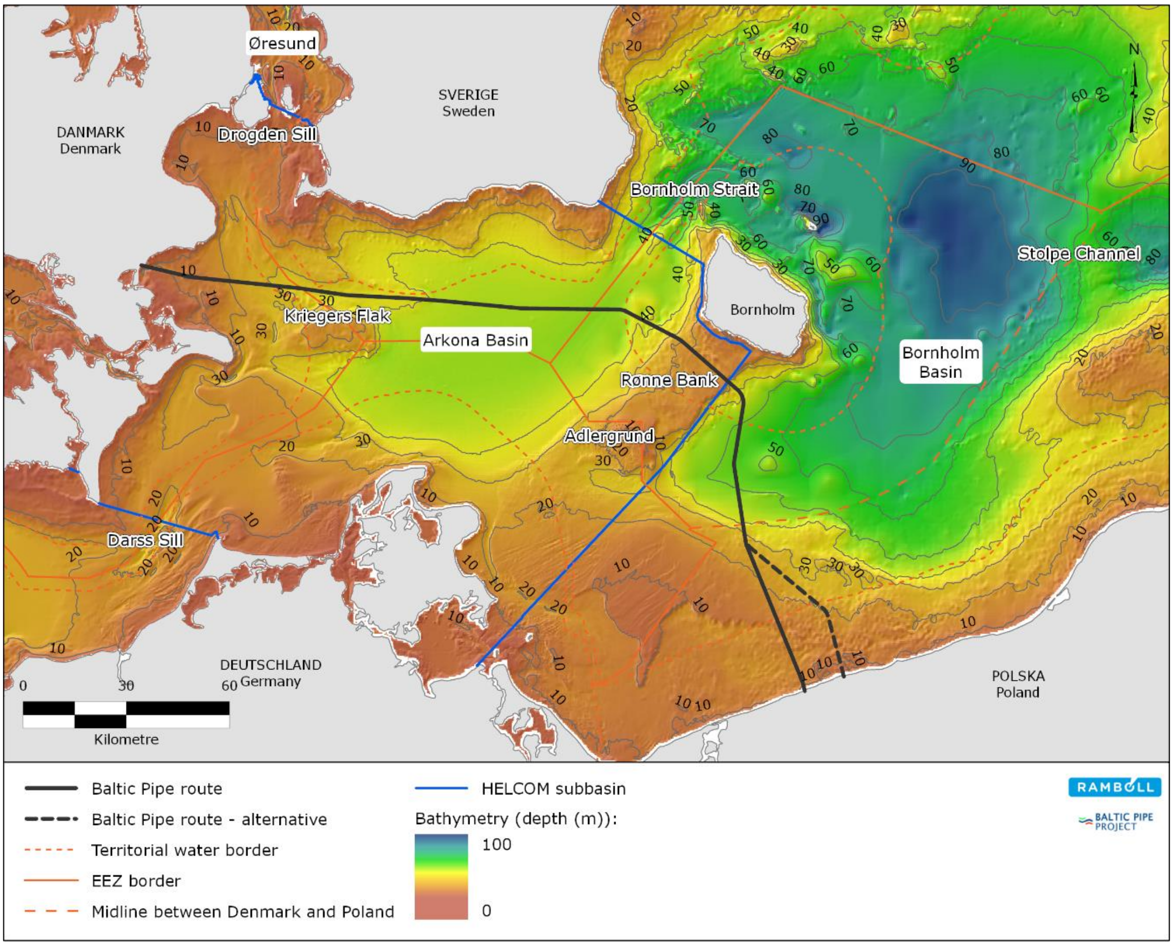

Figure 1 Bathymetry and main basins along the pipeline route.

Potential impacts

Based on the project description, the relevant potential sources of impacts have been identified. Table 2 presents an overview of the potential project impacts together with the receptors that may be affected.

Table 2 Characteristics of potential impacts during the construction phase (Ramboll, 2018).

Potential impact	Impact characteristics	Receptor interaction
Construction phase		
Physical disturbance of seabed	When carrying out seabed interventions work during construction, the seabed will be impacted. Trenching (offshore construction): Lowering of the pipeline into the seabed by establishing a trench in the seabed by mechanical means. This can either be done pre-lay by use of e.g. backhoe dredgers on barges (approximately 0-15 m water depth), or post-lay using e.g. ploughs (more than approximately 15 m water depth). Pipeline length in Danish waters and disputed area: 137.6 km; trench length: 63.5 km; trench width: 10-30 m, depending on trenching method/ depth and sediment type. Spoil heaps from the trenched sediment will be placed along the trench. Rock installation: Rock installation is a means of protecting the pipeline and will be used when crossing existing marine infrastructure (pipelines, telecom and power cables) and potentially also in shipping lanes. The rocks will be placed at the seabed, e.g. using a dynamic positioning (DP) vessel equipped with a flexible fall pipe, which will ensure that the rocks are placed precisely. The physical disturbance of the seabed during construction will be limited to the specific areas where rock installations will take. Impacts from construction vessels: The DP vessel area of influence on the seabed will correspond to the width of the ship used, i.e. approximately 40 m. The anchors and anchor chains area of influence on the seabed will be approximately 1,500 m around the pipeline. The impact will hence be localised around the intervention works areas.	Bathymetry; Surface sediments and contaminants; Benthic habitats, flora and fauna; Fish; Biodiversity; Protected areas; Commercial fisheries; Cables, pipelines and wind farms
Suspended sediment (increased sediment concentration (SSC))	Sediment spill, i.e. suspension of sediment into the water column, primarily originates from the seabed, where the seabed interventions take place. However, a small content of fine sediments in the rock material used for rock installation may also contribute. Sediments are dispersed in the water column and transported with the currents before they re-settle to the seabed. The sediment spill has been modelled (Ramboll, 2019) and the results show that the increase in SSC will be very limited and the duration of SSC exceeding 10 mg/l in the close border areas will be less than 1 hour (Figure 2).	Hydrography and water quality; Benthic habitats, flora and fauna; Fish; Marine mammals; Seabirds and migrating birds; Biodiversity; Protected areas; Tourism and recreational areas; Environmental monitoring stations
Sedimentation	Following dispersion in the water column, the spilled sediments will gradually settle to the seabed at a rate depending on the characteristics of the sediments, the hydrographic conditions, and the water depth. Sedimentation has been modelled for the layer of spilled sediments (g/m^3), and the results show a very limited impact (Figure 3).	Bathymetry; Surface sediments and contaminants; Benthic habitats, flora and fauna; Fish; Biodiversity; Protected areas
Contaminants and nutrients (release of contaminants and nutrients associated with the sediment)	The sediments that are spilled and dispersed in the seawater may potentially include heavy metals and organic contaminants. This is particularly the case with fine-grained sediments and particulate organic matter (POM). A proportion of the particle-associated contaminants may be released to the water column. The majority of the contaminants are, however, expected to remain associated with the particles and will therefore settle back to the seabed. Analyses performed as part of the Danish EIA (Ramboll, 2018a) conclude that the water quality can only be affected very locally and temporarily by an increase in the	Hydrography and water quality; Surface sediments and contaminants; Benthic habitats, flora and fauna; Fish; Seabirds and migrating birds; Biodiversity; Protected areas

Potential impact	Impact characteristics	Receptor interaction
	concentrations of contaminants and nutrients caused by the construction works.	
Underwater noise	The Baltic Pipe construction activities will cause emissions of underwater noise of varying frequencies and intensities, which may impact marine mammals and fish. The underwater noise generated from the vast majority of the construction activities are not distinguishable from the ambient noise levels in the Baltic Sea, which is characterized by large volumes of ship traffic and therefore a relatively high background underwater noise level. Hence, only noise from munitions clearance is included in the underwater noise propagation modelling and the impact assessment on marine life. Based on the route design strategy, munitions clearance is treated as an *unplanned event* in the assessments.	Benthic habitats, flora and fauna; Fish; Marine mammals; Biodiversity; Protected areas; Commercial fisheries
Physical disturbance above water (e.g. from presence of vessels, noise and light)	Physical disturbance above water mainly relates to the presence and activity of construction vessels, including supply vessels carrying pipes and food.	Marine mammals; Seabirds and migrating birds; Biodiversity; Protected areas; Commercial fisheries; Raw material extraction sites; Military practise areas; Population and human health; Tourism and recreational areas
Safety zones (around construction vessels)	During construction, safety zones will be established around the construction vessels to ensure navigational safety. Experience from other pipeline construction projects suggests the establishment of a construction exclusion zone around the pipe-lay vessel, with a radius of 1,500 m centred around the pipe-lay vessel. Likewise, safety zones with a radius of 500 m will be defined around other vessels carrying out surveys, seabed intervention works, etc. However, supply vessels are not expected to require the imposition of safety zones. The extent of the safety zones will be agreed with the relevant national maritime authorities.	Shipping and shipping lanes; Commercial fisheries; Tourism and recreational areas; Raw material extraction sites; Military practice areas; Environmental monitoring stations
Emission to air (emission of air pollutants and greenhouse gasses (GHGs))	The combustion of fossil fuels by the vessels used during construction of the Baltic Pipe project will result in the emission of several components. Based on experience from other comparable projects, the following are considered the four main air emissions: CO_2 (carbon dioxide), NO_X (nitrogen oxides), SO_X (sulphur oxides)), and PM (particulate matter). Furthermore, production of the materials used in the project will generate emissions. These air emissions can potentially impact climate, air quality and human health. Air emission calculations for the Baltic Pipe project have been undertaken in the Danish EIA (Ramboll, 2019).	Climate and air quality; Population and human health
Discharge to sea	Discharges to sea will occur as part of the pre-commissioning activities. Potential impacts will be restricted to nearshore areas.	Hydrography and water quality; Protected areas
Airborne noise	Impacts from airborne noise will be restricted to the onshore part of the project and this subject is hence not dealt with in this EIA summary. Impact from airborne noise from vessels is dealt with under "Disturbance above water".	n.a.
Non-indigenous species	All vessels participating in the Baltic Pipe project will be requested to comply with the BWM Convention and the HELCOM Guide to alien species and ballast water management in the Baltic Sea). Therefore, the risk of introducing NIS by Baltic Pipe project activities is considered very low.	Benthic habitats, flora and fauna; Biodiversity
Operation phase		

Potential impact	Impact characteristics	Receptor interaction
Presence of pipeline	The presence of the pipeline may change the seabed conditions and hydrodynamics, resulting in temporary disturbance or permanent loss of habitats for benthic flora and fauna; another potential impact is the introduction of a new substrate i.e. an artificial reef. The pipeline length in Danish waters is 137.6 km, of which a large proportion is laid directly on the seabed and not trenched or supported by rock installations. Rocks are installed as support for the pipeline and/or to cover and protect the pipeline at cable crossings and potentially in shipping lanes. Rock installations create new substrate at the seabed.	Bathymetry; Hydrography and water quality; Surface sediments and contaminants; Benthic habitats, flora and fauna; Fish; Seabirds and migrating birds; Biodiversity; Protected areas; Shipping and shipping lanes; Commercial fisheries; Military practise areas; Cables, pipelines and wind farms
Safety zones (around maintenance vessels)	For the vessels carrying out survey and maintenance, exclusion zones will be defined around vessels carrying out the work, corresponding to the safety zone for "other" vessels during operation (500 m radius around the vessels). The establishment of safety zones results in all ship traffic being requested to avoid these exclusion zones, thus potentially having an impact on both commercial and leisure shipping as well as fishery. The frequency of the survey and maintenance activities are, however, low, i.e. approximately once per year.	Tourism and recreational areas; Commercial fisheries; Raw material extraction sites; Military practice areas; Environmental monitoring stations
Restriction zone (around the pipeline)	Under the Administrative Order on protection of submarine cables and submarine pipelines, cable or pipeline fields are given a 200 m wide restriction zone along and on each side of the infrastructure. Ships may not, without urgent necessity, anchor in the cable and pipeline fields established for such infrastructure (e.g. pipelines for the transport of hydrocarbons, etc.), which cover the associated restriction zones. In the restriction zones, suction dredging, fishing for stones as well as any use of tools or other gear that is dragged on the seabed is prohibited.	Shipping and shipping lanes; Commercial fisheries; Raw material extraction sites; Military practice areas
Heat from pipeline	In the situation with gas flow from Denmark to Poland, the temperature of the gas at the Danish landfall will be approximately 50^{0}C. Therefore, there will be a net transport of heat through the pipeline walls to the surrounding seawater and seabed sediments. Calculations as well as monitoring results from another pipeline project in the Baltic Sea have, however, shown that the impact of the heat from the pipeline on the surrounding environment is negligible (Ramboll, 2019).	Hydrography and water quality; Surface sediments and contaminants; Benthic habitats, flora and fauna; Fish
Contaminants from anodes	Sacrificial anodes consisting mainly of aluminium will be used as a back-up corrosion protection system in the case of damage to the coating of the pipeline. Beyond the immediate vicinity of the anode (i.e. <5 m), the concentrations of metal ions within the water column due to anode degradation during the operational phase will generally be indistinguishable from background concentrations.	Hydrography and water quality; Surface sediments and contaminants; Benthic habitats, flora and fauna; Fish; Protected areas
Underwater noise from gas flow in pipeline	During the operational phase, the gas flow will generate low levels of noise at low frequencies. In the literature it is acknowledged that underwater noise from subsea pipeline operation or installation may occur, but the impacts are most likely to be much lower than the noise from commercial ships and will therefore be masked. Along the alignment through Danish waters, the pipeline will partly be trenched into the seabed and partly be exposed directly on the seabed. At stretches where the pipeline is	Marine mammals

Potential impact	Impact characteristics	Receptor interaction
	trenched into the seabed, no underwater noise is expected to be emitted from the operating pipeline to the water above.	
Emissions to air	The results of the air emissions calculations for the operation of the offshore part of the project are outlined in the Danish EIA (Ramboll, 2019).	Climate and air quality

Model results from the increase in suspended sediment concentration (SSC) and sedimentation from construction works are presented in Figure 2 and Figure 3.

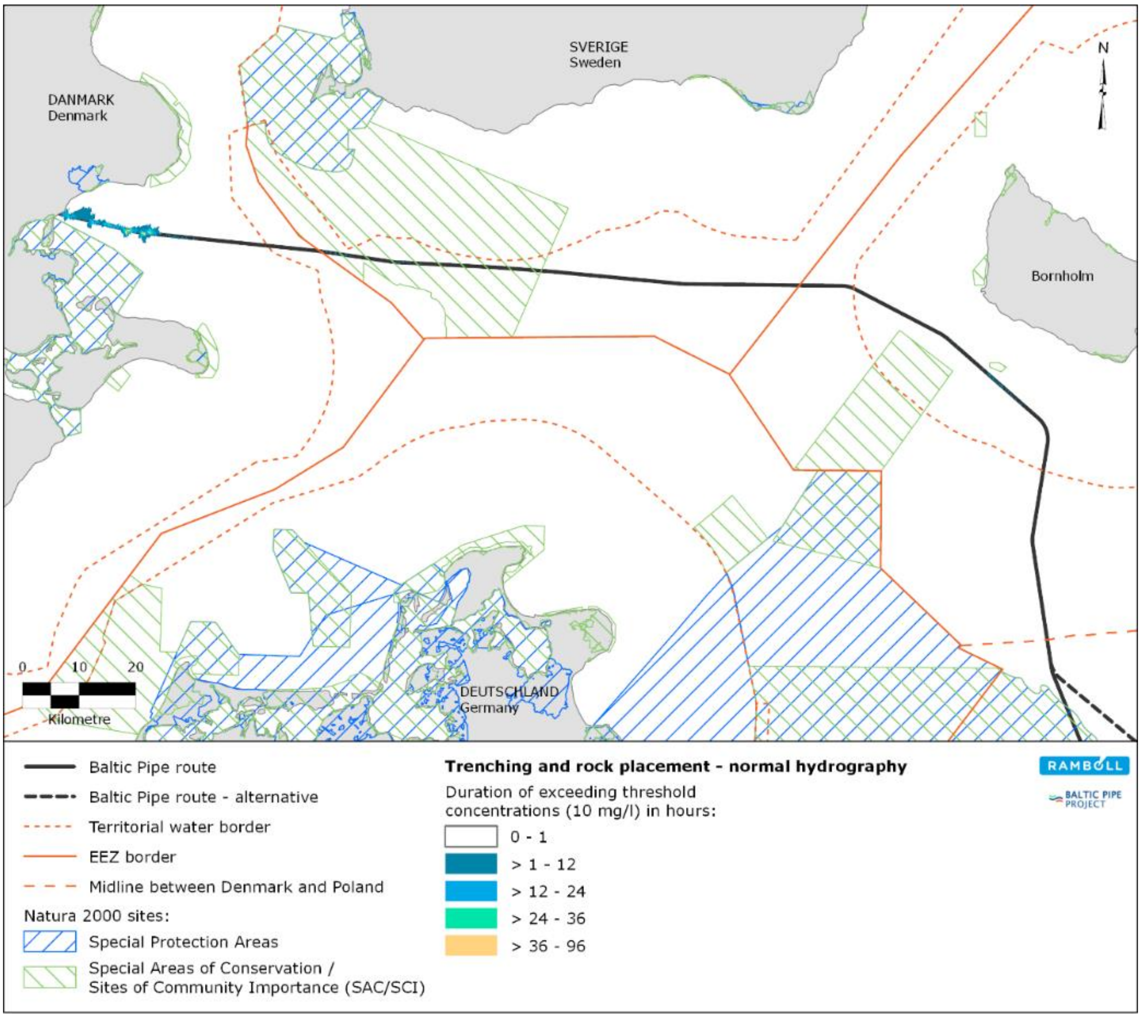

Figure 2 Simulation of the duration of suspended sediment concentration over 10 mg/l (suspended sediment) due to trenching (using back-hoe dredging and post-lay ploughing).

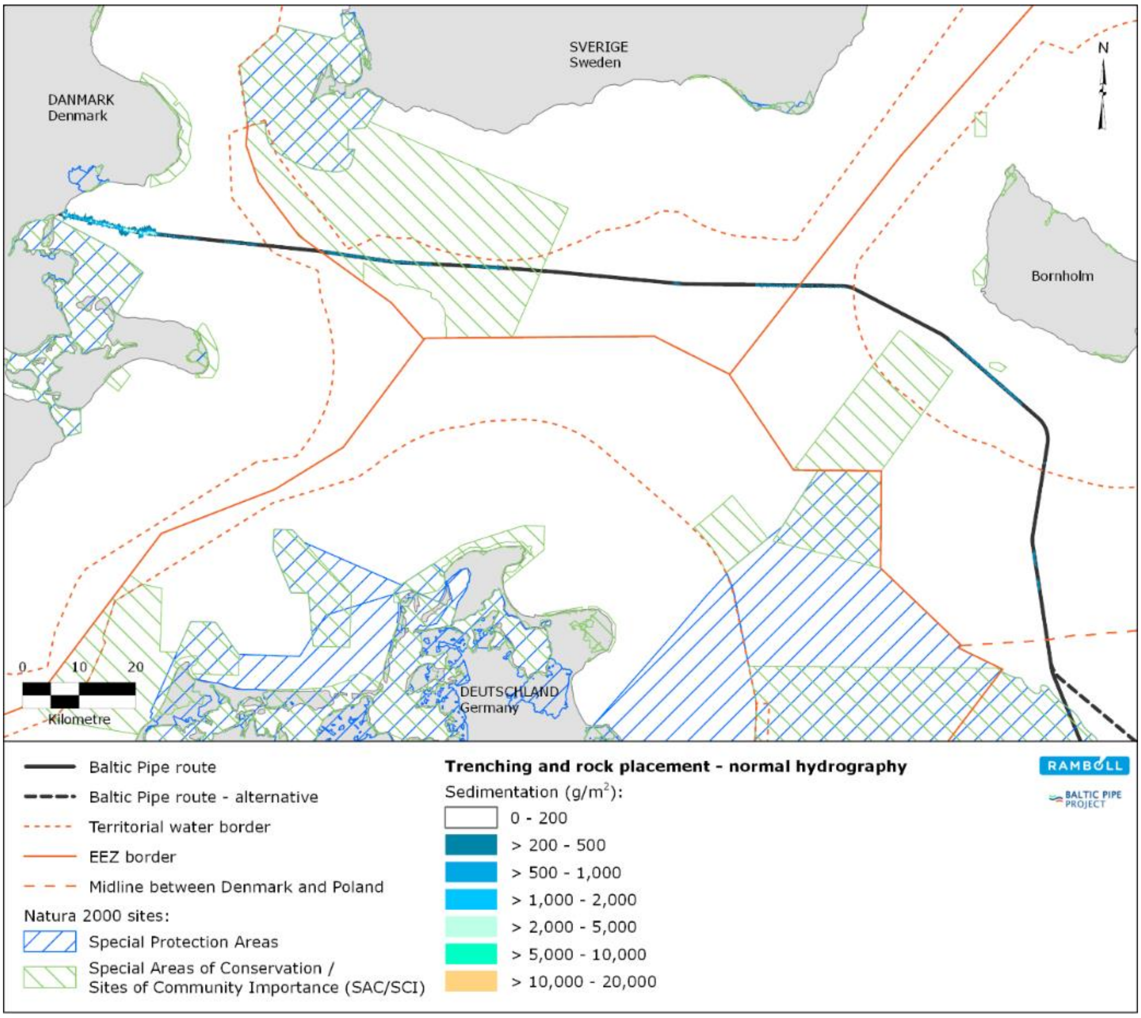

Figure 3 Simulation of the spilled sediment deposits (sedimentation) at the seabed one week after the finalisation of trenching (using back-hoe dredging and post-lay ploughing).

Impacts on the marine environment

A detailed assessment has been carried out with the aim to determine the extent to which the realisation of the Baltic Pipe project will have a significant impact on the marine environment. It is expected that the greatest impact will be associated with the construction phase of the project. Trenching works on the seafloor result in the disturbance of benthic habitats and creation of sediment plumes, and the construction vessels involved cause underwater noise and physical disturbance. In addition, further impacts relate to the construction of the landfall in a vulnerable coastal habitat, where eelgrass meadows are predominant.

Another potential source of impact may emerge in the case that unexploded ordnance is discovered during pre-construction surveys and must be cleared by a controlled detonation. Impulsive underwater noise from detonations can affect marine mammals and fish (see section below on unplanned events).

In the assessment, all possible project impacts have been analysed, and many of them have been screened out, mostly because of their low range, short duration and/or low intensity, which makes significant impact unlikely to occur.

This section summarizes the assessment for those components of the environment (receptors), for which certain impacts could not be ruled out during a screening process.

Benthic habitats, flora and fauna

Benthic habitats will be physically disturbed or damaged where trenching takes place along the pipeline route. After installation of the pipeline, the seafloor will in general be re-established by mechanical backfilling, and natural recolonization will recover the habitats. Natural recovery of marine life on benthic habitats primarily occurs via the settling of drifting larvae (fauna) and gametes (macroalgae) from the water column. The duration of such impact depends on the benthic community structure and may last up to several years. Opportunistic species recover fast, whereas long-lived species recover more slowly.

In the case of the coastal eelgrass meadows, which will be removed within a patch of approx. 5,000 m^2 (0.5 ha) at the exit hole of the landfall tunnel, recovery will take more than 10 years, since eelgrass grows slowly. The area of physical damage has been reduced in the construction design as much as possible, as excavated material will be temporarily deposited on the seafloor in areas at water depths greater than 7 m, where no eelgrass is found. Overall, the area affected is very small compared with the extent of eelgrass stands in the Faxe Bugt, which amount to about 500 ha.

Sediment plumes caused by trenching works will only have a short duration (hours to a few days) and will not have a negative impact further away from the alignment.

In summary, the expected impact affects only very small fractions of the existing seafloor habitats. Most of the physical disturbance is reversible and will be recovered through natural recolonization processes within a few years, although recovery of eelgrass meadows takes more than 10 years. The assessment concludes that the overall impact is not significant.

Fish

Construction of the pipeline is associated with several potential impacts on fish or fish populations, which are summarized in the following.

Construction of the pipeline can affect demersal fish populations, because of the physical disturbance of their habitat. However, the size of the disturbed area is very small compared to the available area, and full recovery of the habitat will take place within a short time after construction.

Suspended sediment from trenching activities may adhere to pelagic eggs, such as cod or sprat eggs, causing them to sink to depths with oxygen deficiency. The planned Baltic Pipe route crosses a cod spawning area in the Arkona Basin. However, since cod spawning occurs in the water column above the halocline, and the SSC increase will primarily take place in the bottom water, there will be very limited, if any, impact on cod eggs or fry. Furthermore, the exceedance of threshold concentrations (5 mg/l) from trenching is generally not located in cod spawning areas such as the Arkona Basin, but rather the nearshore area of Faxe Bugt.

In summary, physical disturbance of fish habitats is limited in extent and affects only small fractions of the existing fish populations. The habitats will recover within a short period of time. There are hardly any effects on juvenile fish stands, i.e. larvae or fry, caused by excess suspended sediment.

The assessment concludes that the overall impact on fish is not significant.

Marine mammals

Three species of marine mammals occur in the Baltic Sea: harbour porpoise, harbour seal and grey seal. The main impact on marine mammals that can arise from the project is disturbance from underwater noise. Underwater noise from construction activities, such as rock installation, trenching, pipe-lay, anchor handling and ship traffic is characterised as continuous noise. Experience from similar projects has shown that noise generated from the construction activities is not distinguishable from the ambient noise levels, as the background levels in the Baltic Sea, where there are already large volumes of ship traffic, are relatively high. The duration will be immediate and will cease after the activity has ended. Impacts from construction activities, hereunder underwater noise, suspended sediment, contaminants and the presence of pipeline on the seabed are assessed to have a negligible and non-significant impact on all three species of marine mammals. The harbour porpoise is the only marine Annex IV species (strictly protected species) found in the Danish offshore section of the Baltic Sea. The assessment concludes that the ecological functionality of the species will not be impaired, nor will the project lead to deliberate killing.

Natura 2000

Natura 2000 screening assessments have been performed in connection with the Danish EIA, documented both as a separate screening document and as supplementary assessments in a separate EIA chapter.

The Baltic Pipe project does not cross any Natura 2000 sites in Danish waters. The conclusions of the screening procedure are that the project will have no significant impacts on any Danish Natura 2000 sites or significant transboundary impacts on adjacent Natura 2000 sites. Furthermore, the assessment concludes that there will be no impact on the coherence of the Natura 2000 network.

Climate and air

Establishment of the Baltic Pipe gas pipeline is associated with emissions of greenhouse gases and pollutants to the atmosphere, originating from machinery and the production of materials. In this section, the contribution of the Baltic Pipe to these emissions is assessed. The assessment, however, focuses on emissions during construction and operation/maintenance only, and does not include the greenhouse gas emissions emerging from the delivered natural gas.

Based on experience from other comparable projects, the following items are considered the four main air emissions: CO_2 (carbon dioxide), NO_X (nitrogen oxides), SO_X (sulphur oxides) and particulate matter (PM). In addition, the production of all components of the Baltic Pipe is associated with emissions to air, in particular CO_2 from steel, concrete, aluminium and coating production.

The CO_2 emissions from the construction phase account for approximately 0.7% of the total annual Danish CO_2 emissions in 2016 and for approximately 1.9% of CO_2 emissions from vessels in the Baltic Sea. As the duration is short-term, it is considered as a minor impact and thus, not significant.

Estimations have been made for the polluting components NO_X, SO_X and PM over the entire construction phase. The estimated air emissions will be emitted in very low doses along the pipeline route during the construction period and will be diluted rapidly because of favourable dispersion conditions and low background concentrations. The degree of impact is therefore low during construction and there is no impact during operation. The scale is mainly local but can also be regional. The assessment concludes that there will be no significant impact on air quality and impacts on human health can be excluded.

Other environmental receptors

The environmental assessment also covers other receptors as listed in Table 1. The results of the assessment indicate that impacts will either be temporary or negligible to minor in extent and therefore not significant. For many receptors, significant impacts could be excluded at the beginning of the assessment process, e.g. impacts on seabirds, migrating birds, migrating bats, plankton and the overall biodiversity. The pipeline alignment in Danish waters does not cross protected areas (HELCOM Marine Protected Areas, Shellfish waters), and significant impact on the nearest sites have been ruled out.

The assessment also builds upon extensive experience from previous projects in the Baltic Sea, in particular the Nord Stream pipeline, for which a wide-ranging monitoring programme has shown mainly no or negligible impacts on the environment.

This indicates that construction and operation of the Baltic Pipe will not cause significant impact on the marine environment as a whole.

Unplanned events – munitions clearance, potential impacts on fish and marine mammals

In connection with the risk assessments as outlined in the EIA report, it has been identified that munitions clearance may pose a risk during the construction phase, although the likelihood is low due to the route optimisation strategy (which prioritises re-routing for avoiding UXOs).

Fish

Impulsive noise emissions exceeding threshold levels that may lead to injury or mortality of fish. In a worst-case scenario, where munitions clearance is unavoidable, mortality can occur within a maximum distance of 0.7 km within Faxe Bugt and 1.3 km near Bornholm. The same maximum distance applies for injuries to fish near Bornholm, whereas the maximum distance within Faxe Bugt is 0.8 km. It is likely that lethal consequences will occur for shoals or schools of fish that are present within these distances in case munitions clearances are carried out.

On a population level, the degree of the impact is small. Munitions clearance will only present a lethal or injury risk to a few individuals in larger populations. This means that the structure and function of the populations will remain unaffected. In addition, as a mitigation measure, a ship-based sonar survey will identify shoaling or schooling fish in the area in order to assess whether the timing of each munition clearance is suitable or if the detonation should be postponed.

The application of mitigation measures will reduce the size of the impact, as fewer individuals will be affected by munitions clearance. Lethal effects and injury to fish caused by impulsive noise from munitions clearance will not have a significant effect on fish populations. The assessment concludes that the overall impact on fish is not significant.

Marine mammals

Impulsive noise emissions exceeding threshold levels may lead to injury or mortality of marine mammals. In a worst-case scenario, where munitions clearance is unavoidable, permanent threshold shift (PTS) can occur within a maximum distance of 2.8 km within Faxe Bugt and 5.2 km near Bornholm. The same worst-case scenario applied for temporary threshold shift (TTS) show maximum distances of 8.3 km within Faxe Bugt and 17.5 km near Bornholm. Based on this scenario, it cannot be ruled out that a few individuals may be affected by munitions clearance.

To mitigate the impact, several measures will be implemented:

- Visual monitoring: Visual monitoring by a marine mammal observer is undertaken from the source vessel. If marine mammals are present prior to planned munition clearance, the detonation will be postponed.
- Application of seal scarers: Seal scarers are acoustic devices, which can be used to deter seals and harbour porpoises from e.g. construction activities, fishing gear etc. A setup of monitoring and deterrent devices like the one used on NSP2 will be used.
- Timing of munitions clearance: Two populations of harbour porpoise can be found in the Baltic Sea; the Baltic Sea (or Baltic Proper) population and the Belt Sea population. The Baltic Sea population is an endangered population with only very few individuals (500 individuals). However, this population is only likely to occur during the winter period (November–April) in

the Arkona Basin. By excluding the winter season from munitions clearance activities, impact on the endangered Baltic Sea population can be avoided.

In summary, it is perceived that a combination of these three proposed mitigation measures will significantly reduce the impact on harbour porpoises and seals. The most effective way of protecting the endangered Baltic Sea population will be to plan munitions clearance only during the summer period (May-October).

The number of individual animals affected can be reduced significantly through the use of seal scarers and visual monitoring. The assessment concludes that there will be no significant impact on marine mammal populations. It should be emphasised that the use of marine mammals observer, passive acoustic monitoring and seal scarers must be implemented to protect marine mammals present in the area.

Impacts on the socio-economic environment

A detailed assessment has been carried out with the aim to determine to what extent the realisation of the Baltic Pipe project will have a significant impact on the marine socio-economic environment.

Contrary to the biological environment, which is mainly affected by construction activities, the socio-economic environment is additionally potentially affected by the long-term effects of the presence of the pipeline and the restriction zones around it, which may impose restrictions to spatially overlapping utilization or exploitation, e.g. commercial fisheries and military practice areas.

Commercial fisheries

During construction, safety zones of 1,000 to 1,500 m will be established around the pipe-lay vessel and accompanying vessels. Safety zones will follow the vessels as they move continuously with a speed of 3-4 km per day at water depths of over 20 m, which is where the most high-intensity fishing is carried out. Therefore, the impact on commercial fisheries from safety zones will be spatially restricted and temporary.

A restriction zone with a radius of 200 m for the use of demersal fishing gear will be set around the pipeline once it is fully operational. As for demersal trawlers, the impact is expected to be small, as it will occupy less than 1% of the total fishable area in the Arkona and Bornholm Basins. There will be no restrictions for pelagic trawlers.

The presence of the pipeline can affect demersal trawlers, as their gear can become hooked upon contact with the pipeline. However, hooking is a rarely occurring accidental situation where the trawl equipment becomes stuck under a free-spanning area of the pipeline. The seabed is relatively flat where the pipeline will be laid, and in areas where free spans are present and high trawl intensity exists, trawl infill, i.e. rocks, will be used to fill potential spans. Demersal trawlers are advised to avoid fishing across the pipeline, i.e. there will be a need for the adaptation of trawl patterns. Since the pipeline occupies less than 1% of the total fishable area, the impact is assessed to be rather small.

The assessment concludes that the overall impact on commercial fisheries is not significant. However, economic effects will be compensated.

Military practice areas

The above-mentioned establishment of temporary safety zones of 1,000 to 1,500 m around the pipe-lay vessel and accompanying vessels is a source of potential impact for nearby military practice areas during construction. No non-project related vessels will be permitted to enter the safety zones. Since the pipeline will run only 550 m from the northern border of the military practice area Bravo 5 in the eastern Arkona Basin for a distance of 8 km, some temporary impact from the safety zones can be expected. Furthermore, the pipeline route runs approximately 1.4 km away from one of the corners of the firing danger area "EK D 395 Raghammer Odde" near Bornholm, and a 1,500 m safety zone would therefore overlap with this corner of the military area, potentially causing an impact. The planned activities will be coordinated and communicated with the relevant authorities to ensure minimum disruption of military practice activities.

Restrictions in the use of the submarine exercise areas will be limited to 3-4 days of construction activities. If a safety zone of 1,500 m is required for the construction vessel, then the firing danger area "EK D 395 Raghammer Odde" will be affected for a distance of 300 m along the pipeline route, and the impact will be restricted to a few hours. The assessment therefore concludes that the overall impact is not significant.

Other socio-economic receptors

The socio-economic impact assessment also covers the remaining receptors listed in Table 1. The results indicate that impacts are either temporary in duration or negligible to minor in scale, and therefore not significant. This means that the Baltic Pipe will not cause significant restrictions on important maritime activities such as international navigation, installation of infrastructure i.e. cables and pipelines and raw material extraction. Similarly, it is not expected that the project will affect potential archaeological sites of interest, nor will it have an influence on monitoring stations and research areas. With regard to potential munitions, which may be detected during pre-construction surveys, procedures are in place for handling these in coordination with the competent authorities.

Conclusion

In Table 3, the overall impact significance for all assessed receptors and subjects are presented. Significant cumulative impacts are not foreseen in connection with the construction and operation of the pipeline.

Table 3 Overall summary of impact significance for environmental receptors for *planned* events.

Receptor	Overall significance of impact
Physical-chemical environment	
Bathymetry	None
Hydrography and water quality	None
Surface sediments and contaminants	None
Climate and air quality	None
Underwater noise	*Assessed based on impacted biological receptors*
Biological environment	
Plankton	None
Benthic habitats, flora and fauna	None
Fish	None
Marine mammals	None
Seabirds and migrating birds	None
Migrating bats	None
Annex IV species	None
Biodiversity	None
Protected areas	None
Natura 2000	None
Socio-economic environment	
Shipping and shipping lanes	None
Commercial fisheries	None
Archaeology and cultural heritage	None
Cables, pipelines and wind farms	None
Raw material extraction sites	None

Receptor	Overall significance of impact
Military practice areas	None
Environmental monitoring stations and research areas	None
Other	
Marine Strategy Framework Directive (MSFD)	None
Water Framework Directive (WFD)	None
Baltic Sea Action Plan (BSAP)	None

Mitigation measures and compensation
The EIA report includes an overview of all mitigation measures that are being implemented to reduce the impact on human beings and the marine environment. Mitigation measures are either integrated into the design of the pipeline or implemented as regulatory or common practice mitigation measures. The most important are presented below:

- **Landfall tunnelling**: Tunnelling has been determined as the preferred construction method at the landfall, rather than excavation. The height of the cliff at Faxe Syd is 15-17 m, and excavation would leave a large mark in the landscape that is not easily reinstated. Furthermore, excavation volumes would be excessive, causing a significant disturbance to the cliff and, moreover, sediment dispersion from the shallow-water excavation works. By using tunnelling, the cliff is preserved as a natural habitat, and potential breeding sites for sand martins remain undisturbed.
- **Disposal area for trenched material at 7 m sea level**: Trenched material from the exit point of the tunnel boring machine and trenched material from the associated transition zone at approximately 4 m water depth will be transported to a temporary disposal area on the seabed at a water depth of a minimum of 7 m in order to minimize the potential impact on eelgrass.
- **Restoration of seabed**: In general, for areas disturbed by dredging, trenching or ploughing, the seabed will be restored to its pre-impact condition through mechanical backfilling.
- **Mitigation of underwater noise from munitions clearance**: If munitions clearance needs to take place, the following measures will be taken for the protection of fish and marine mammals:
  - sonar surveys on shoaling or schooling fish allow for the timing of the detonation when fish are absent;
  - visual and passive acoustic observation of marine mammals allows for the timing of the detonation when marine mammals are absent;
  - the application of seal scarers deters seals and harbour porpoise prior to detonation;
  - restriction of munitions clearance to the summer months avoids potential impact on the endangered Baltic Sea population of harbour porpoises, if reasonable possible.
- **Light reduction**: Electric lighting on ships poses a collision risk for nocturnal migrants because it may attract birds and/or bats. Decreasing illumination and restricting the spectrum of light is an approach to reducing impacts on biological resources while still maintaining safe operations.
- **Compliance with international norms and standards**: All construction procedures and machinery will be required to comply with national and international legislation in force, including:
  - The Ballast Water Management (BWM) Convention: Prevention of the spread of harmful aquatic organisms from one region to another (non-indigenous species).
  - SO_X and NO_X emission control areas: The International Maritime Organization has designated the Baltic Sea as a Sulphur Emission Control Area (SECA) since 2015 under Regulation 14 of MARPOL Convention Annex VI to limit the emission of SO_X, and from 2021, the Baltic Sea will be designated as a NO_X Emission Control Area (NECA) under Regulation 13 of MARPOL Convention Annex VI to limit the emission of NO_X.
  - Euronorm stage IIIA: To limit the emissions to air, construction equipment covered by the European emission standards (known in Denmark as Euronorms) for engines in

    non-road machinery, e.g. dredgers and dozers, should as a minimum live up to stage IIIA.
  - The Museums Act: The Museum Act section 27 applies at all times, which means that construction activities should be stopped if archaeological objects appear during construction.
- **Economic compensation of fishermen**: Compensation will be offered to fishermen to reduce the economic impact on those fishing in areas that will be temporarily closed due to the safety zones imposed around the construction vessels.

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ABBREVIATIONS LIST

AIS - Automatic identification system
ALARP – As Low As Reasonably Practicable
API – American Petroleum Institute
BAC – Background Assessment Concentration
BWM – Ballast Water Management Convention
CEE – Central Eastern Europe
CP – Cathodic Protection
CPT – Cone Penetration Test
CPUE – Catch per unit effort
CRA – Construction Risk Analysis
CWA – Chemical Warfare Agents
DCE - Danish Centre For Environment and Energy
DEA – Danish Energy Agency
DP – Dynamical Positioning
DPD – Detection Positive Days
DPS – Dynamical Positioning System
DW – Dry Weight
EAC – Environmental Assessment Criteria
EEZ – Exclusive Economic Zone
EIA – Environmental Impact Assessment
EPB – Earth Pressure Balance
EQS – Environmental Quality Standard
ERL – Effect Range Low
EU – European Union
FAR – Fatal Accident Rate
FCG – Flooding, cleaning and gauging
FPV – Fall Pipe Vessel
FTU – Formazine Turbidity Unit
GES – Good Environmental Status
GHG – Greenhouse Gas
GT – Gross Tonnage
GWP – Global Warming Potential
HAZID – Hazard Identification
HELCOM – Helsinki Commission, Baltic Marine Environment Protection Commission
ICES – International Council for the Exploration of the Sea
ID – Inner Diameter
IGV – International Guidance Values
IMO – International Maritime Organization
IROPI – Imperative Reasons of Overriding Public Interest
IUCN – International Union for Conservation of Nature
K.C. – Kampfstoff Cylindrisch
KP – Kilometre Point
KPI – Kilometre Point Interval
LAL – Lower Action Level
LC – Least Concern
LOI – Loss On Ignition
MAI – Maximum Allowable Input
MARPOL – International Convention for the Prevention of Pollution from Ships
MBI – Major Baltic Inflow

MDS - Multidimensional Scaling
MEG – Mono Ethylene Glycol
MODIS - Moderate Resolution Imaging Spectroradiometer
MPA – Marine Protected Area
MSFD – Marine Strategy Framework Directive
NEQS – National Environmental Standards
NIS – Non-indigenous species
NSP – Nord Stream Project
NSP2 – Nord Stream Project 2
OSPAR – Convention for the Protection of the Marine Environment of the North East Atlantic
PAH – Polyaromatic hydrocarbon
PCB – Polychlorinated biphenyls
PCI – Projects of Common Interest
PLONOR – Pose Little or No Risk to the Environment
PM – Particulate matter
POM – Particulate organic matter
PSU – Practical salinity unit
PTS – Permanent threshold shift
QRA – Quantitative Risk Assessment
RAC – Risk Assessment Criteria
ROV – Remotely Operated Vehicle
SAC – Special Areas of Conservation
SCI – Sites of Community Interest
SD – Subdivision
SEL – Sound Exposure Level
SPA – Special Protection Areas
SPL – Sound Pressure Level
SSC – Suspended sediment concentration
TBM – Tunnel boring machine
THC – Total Hydrocarbon
TNT - Trinitrotoluene
TOC – Total Organic Carbon
TOP – Top of pipe
TSS - Traffic separation scheme
TTS – Temporary threshold shift
TW – Territorial waters
UNCLOS – United Nations Convention on the Law of the Sea
UXO – Unexploded Ordnance
VMS – Vessel Monitoring Systems
VU – Vulnerable
WFD – Water Framework Directive
WWI – World War I
WWII – World War II

1. INTRODUCTION

The Baltic Pipe project is planned as a collaboration between GAZ-SYSTEM S.A., the Polish gas transmission company, and Energinet, a Danish operator of transmission systems for natural gas and electricity.

The Baltic Pipe is hence a strategic gas infrastructure project, with the goal of creating a new gas supply corridor on the European market. The project will ultimately make it possible to transport gas from fields in Norway to the Danish and Polish markets, as well as to customers in neighbouring countries. If required, the Baltic Pipe will also enable the supply of gas reversely from Poland to the Danish and Swedish markets. The offshore pipeline between Denmark and Poland is an important part of the overall Baltic Pipe project.

The Baltic Pipe project consists of five key components (see Figure 1-1):

1) A new gas pipeline in the North Sea (length 120 km) from the Norwegian offshore gas fields to the Danish coast. In the North Sea, the pipeline ties in the existing Europipe II pipeline connecting Norway and Germany.
2) A new, onshore gas pipeline is planned, which extends over approx. 220 km across Jylland, Fyn, and Southeast Sjælland in Denmark.
3) A new compressor station (CS Zealand) at the Danish shore in Sjælland.
4) *An offshore pipeline linking Denmark and Poland for bi-directional gas transmission, which is the subject of this report.*
5) The necessary expansion of the Polish gas system to receive gas from Denmark.

Figure 1-1 Schematic of the five major components of the Baltic Pipe project.

1.1 PCI project

The main objectives of the Baltic Pipe project are to further strengthen supply diversification, market integration, price convergence and security of supply in primarily Poland and Denmark and secondarily in Sweden, Central and Eastern Europe (CEE) and the Baltic region.

For these reasons, the Baltic Pipe project was included in the first list of Projects of Common Interest (PCI), drawn up by the European Commission in 2013, and in the subsequent list adopted by the European Commission on 18 November 2015, thus underlining its regional importance. Baltic Pipe is project No. 8.3 in the Union list of projects of common interest (Annex VII, (8), 8.3).

Because of its PCI status, the project may benefit from accelerated planning and permit granting, a single national authority for obtaining permits, improved regulatory conditions, lower administrative costs due to streamlined environmental assessment processes, increased public participation via consultations, and increased visibility to investors.

1.2 General technical specification

The Baltic Pipe offshore pipeline will be constructed of carbon steel pipes with an outer diameter of approximately 1 m (36”). It will have a transmission capacity of up to 10 billion m^3 per year to Poland and up to 3 billion m^3 per year to Denmark and Sweden. The operational design lifetime of the pipeline is 50 years.

The gas pipeline is planned to be ready for operation in 2022.

1.3 This report

This report forms the Environmental Impact Assessment (EIA) report covering the Baltic Pipe route within Danish territorial waters (TW) and Exclusive Economic Zone (EEZ) (see Figure 1-2).

The competent Danish authority for the EIA and the construction permit for this project is the Danish Energy Agency (DEA).

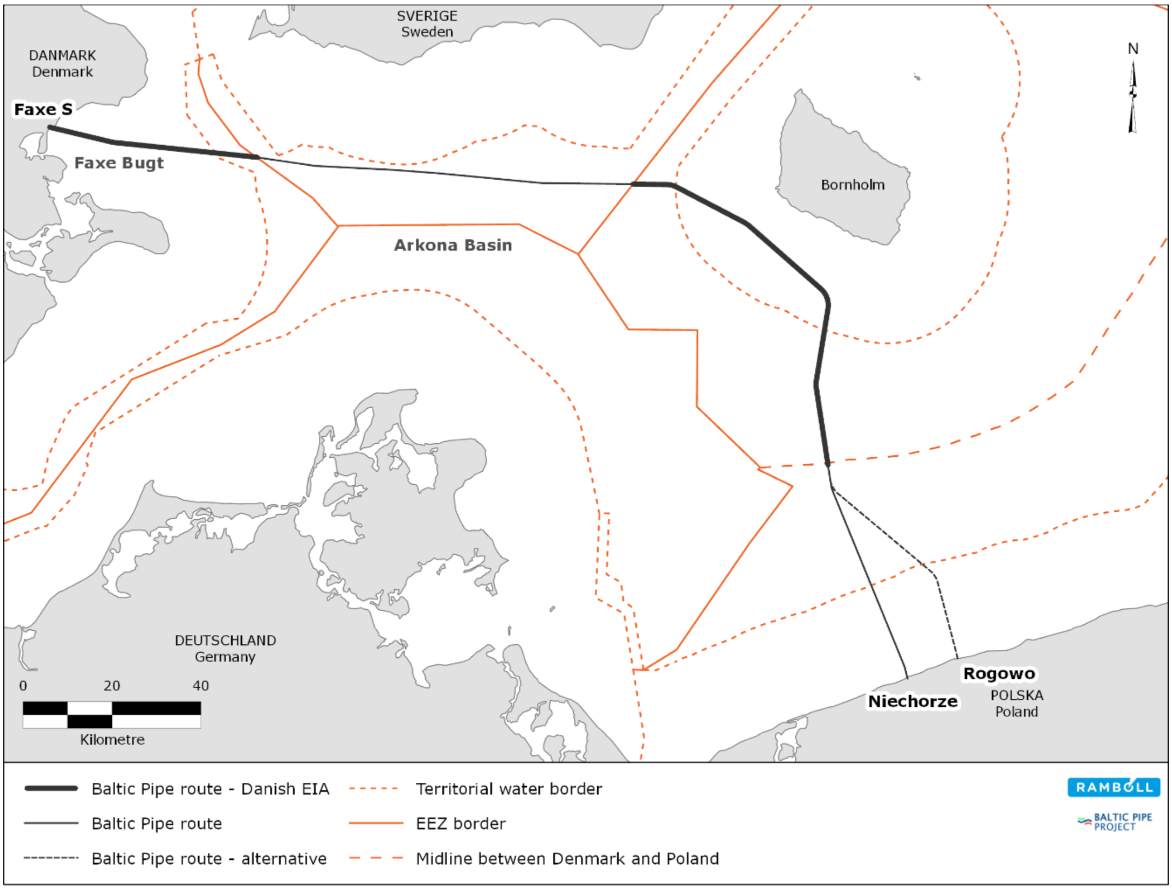


Figure 1-2 Baltic Pipe route from Denmark to Poland.

In addition to the Danish EIA, separate EIAs for the parts of the project in Sweden and Poland, as well as an Espoo report are being prepared.

The report, "Environmental Impact Assessment – Baltic Sea – Denmark", is a part of a combined EIA covering all the components of the Danish part of the Baltic Sea project. The structure of the overall EIA report is presented in Figure 1-3.

It should be mentioned that the *onshore* baseline and assessments will be included in the Onshore EIA prepared by Energinet (Figure 1-3), but are presented in this report as well to describe the baseline and impacts for the transition zone between the onshore and offshore sections in the Baltic Sea.

Figure 1-3 Structure of the Danish EIA, where this report is one of the five sub-components.

1.3.1 Compliance with legislative requirement

The present EIA report is structured as outlined in Table 1-1. To inform of compliance with legal requirements, references to the applicable requirements in Danish legislation are given (the EIA law[1], Chapter 7).

Table 1-1 Structure of report and reference to the Danish EIA legislation.

Chapter	Chapter title	Reference to Danish EIA legislation[1]
Chapter 0	Non-technical summary *Common chapter with Energinet*	Section 20(2)(5) Annex 7(9)
Chapter 1	Introduction	-
Chapter 2	Project developers	-
Chapter 3	Project description	Section 20(2)(1) Annex 7(1)(a), (b) and (c) Annex 7(5)(a)
Chapter 4	Risk assessment	Annex 7(8)
Chapter 5	Potential impacts	Section 20(2)(2) Annex 7(1)(d)
Chapter 6	Alternatives	Section 20(2)(4) Annex 7(2) and (3)
Chapter 7	Legal framework	-
Chapter 8	Methodology	Annex 7(6)
Chapter 9	Environmental baseline and assessment, covering the three overall environments onshore and offshore: physical-chemical, biological, and socio-economic environment	Section 20(2)(3) Section 20(4) Annex 7(3), (4), (5) and (7)
Chapter 10	Marine Strategy Framework Directive & Water Framework Directive	Section 20(2)(3) Section 20(4) Annex 7(3), (4), (5) and (7)
Chapter 11	Cumulative impacts	Annex 7(5)
Chapter 12	Transboundary impacts	Annex 7(5)
Chapter 13	Mitigation measures	Section 20(2)(3) Annex 7(7)
Chapter 14	Monitoring programme	Annex 7(7)
Chapter 15	Gaps and uncertainties	Annex 7(6)
Chapter 16	References	Annex 7(10)

[1] Consolidated Act no. 1225 of 25/10/2018on environmental assessment of plans and programmes and specific projects (EIA) *(bekendtgørelse af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM))*.

2. PROJECT DEVELOPERS

The project is being developed as a joint venture between the Danish gas and electricity transmission system operator Energinet and the Polish gas transmission system operator GAZ-SYSTEM S.A.

- Energinet will be responsible for the construction of the onshore project components in Denmark and the offshore components in the North Sea and Little Belt and will own and operate these components.

- GAZ-SYSTEM S.A. will be responsible for the construction of the offshore pipeline between Denmark and Poland and the expansion of the Polish gas transmission system and will own and operate these components.

Energinet and Gaz-System have concluded a Construction Agreement, in which they divided the responsibility for specific main component of the Baltic Pipe. According to the Construction Agreement, Energinet will construct, own and operate Norwegian Tie-In, the expansion of the Danish transmission system and the Compressor Station, while Gaz-System will construct, own and operate the offshore interconnector between the Polish shore and the Danish shore on the island of Zealand, as well as the expansion of the Polish transmission system. Details of the division of ownership and operatorship can be found at: https://www.baltic-pipe.eu/the-project/.

Both companies are committed to maintaining a high level of security of supply and to supporting the development of a diversified and integrated European energy market. Implementation of the Baltic Pipe project will significantly contribute to achieving these key objectives of the European Union.

3. PROJECT DESCRIPTION

In this chapter the various activities and phases related to construction and operation of the Baltic Pipe project are outlined. The project description provides the basis for assessing the environmental impacts of the project within the Danish part of the project, i.e. activities within Danish territorial waters and EEZ as well as at the Danish landfall at Faxe S.

The description presents the field surveys conducted in order to make the basis for the project design, as well as the design parameters relevant for the environmental impact assessment. The dimensions of the pipeline, coatings and anodes for corrosion protection are described.

The construction work is divided within this chapter into landfall construction and offshore construction comprising seabed interventions work and offshore pipe-lay. The landfall construction includes both work on land and nearshore work (seabed interventions, pipeline installation).

After construction, pre-commissioning takes place to prepare the pipeline system for operation. Pre-commissioning includes pressure testing of the pipeline, which involves filling of the pipeline with seawater (possibly treated with an oxygen scavenger chemical to prevent corrosion), pressure testing, and discharge of the treated seawater.

Lastly, commissioning, operation and decommissioning are described.

3.1 Pipeline route

The route for the offshore part of the Baltic Pipe, linking Denmark and Poland, is shown in Figure 3-1. Other route alternatives that has been considered, are described in Section 6.2.

The Baltic Pipe project covered by this EIA is defined to begin at first dry weld of the pipeline at the Danish landfall. The upstream pipeline and facilities in Denmark are covered in a separate report (see Chapter 1). The pipeline section through Swedish EEZ, Polish EEZ and the downstream facilities in Poland are covered under separate permitting processes in the two countries, respectively. The centreline for the surveyed route makes the basis for the EIA.

The landfall is located south of Faxe Ladeplads in Faxe Bugt at an agricultural field. First dry weld is approximately 400 m along the pipeline from the shore of Faxe Bugt (250 m perpendicular to the coastline) (see Section 3.4 for further landfall description).

From Faxe Bugt the pipeline route is entering Swedish EEZ and enters again Danish EEZ/territorial waters around Bornholm. From here it enters the disputed area[2] between Denmark and Poland, before entering Polish EEZ/territorial waters. The Polish landfall is expected to be Niechorze, alternatively Rogowo.

[2] Agreement on a border between Denmark and Poland has been decided, but the agreement needs to be ratified.

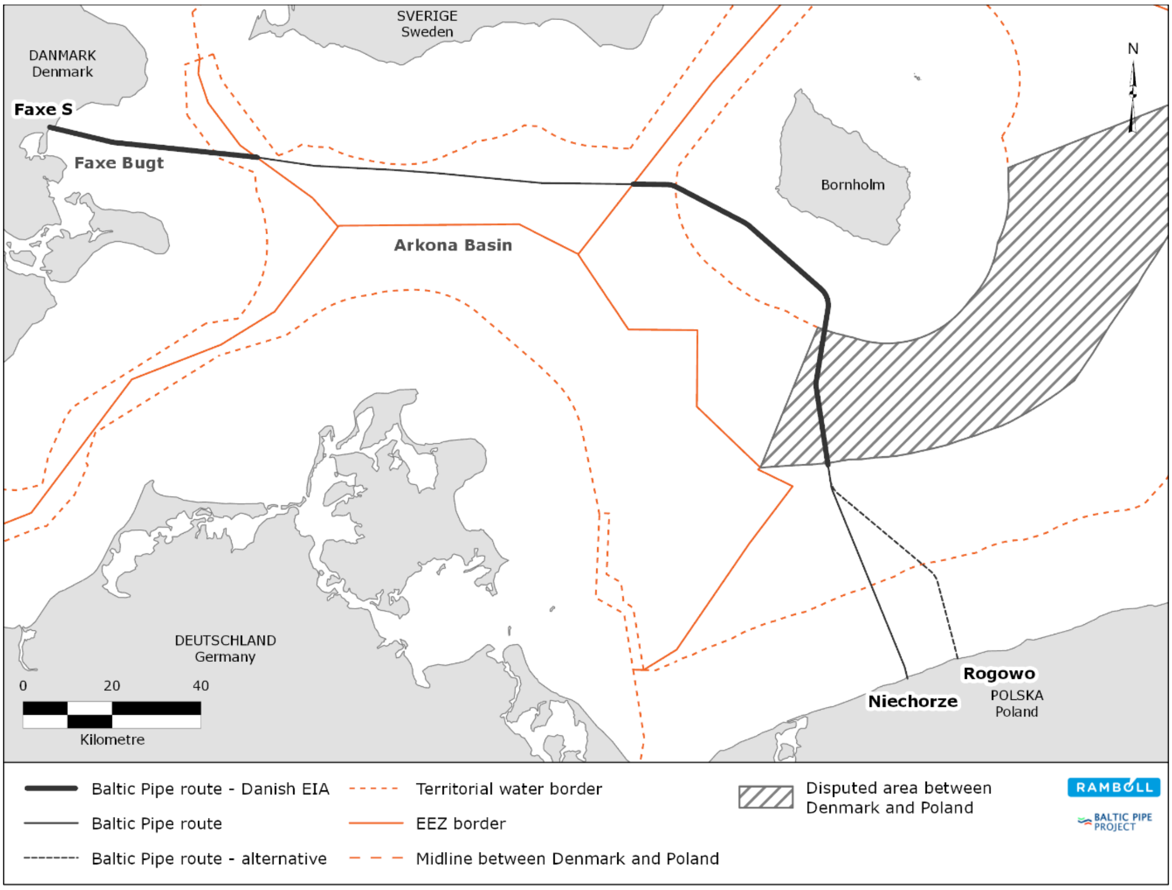


Figure 3-1 Offshore section of the Baltic Pipe route.

The lengths of the various route segments are shown in Table 3-1.

Table 3-1 Route length within the various national jurisdictions. The disputed area is an area between Denmark and Poland where the EEZ border has not been agreed. The disputed area extends from the Danish TW border to the midline between Denmark and Poland.

Route section	Route lengths in different TW and EEZs (km)				
	Danish	Swedish	Disputed area	Polish	Total
Proposed pipeline route	107.3	84.7	30.3	51.3	**273.7**

As mentioned, this EIA covers the Danish TW and EEZ, which includes the disputed area. Thus, the total length of the pipeline in Denmark is 137.6 km.

3.2 Field surveys

Geophysical and geotechnical surveys have been carried out, starting in October 2017. The survey results will provide the basis for the detailed engineering design of the pipeline system and are used together with environmental surveys for the environmental baseline description and when assessing the possible environmental impacts of the pipeline project (see Chapter 9 for the environmental baseline and impact assessment).

Additional geophysical and/or geotechnical surveys might be carried out during the pipeline installation phase. This could include a survey for possible UXO (Unexploded Ordnance) objects and other surveys for ensuring an optimal and safe pipeline installation.

3.2.1 Geophysical surveys

The geophysical investigations include multibeam bathymetry, side scan sonar, magnetometer measurements and high frequency seismic investigation of the uppermost 10 m of the seabed.

Geophysical investigations are carried out in a 500 m wide corridor around the centreline of the pipeline route (250 m at each side). Within Natura 2000 sites, the survey corridor has been expanded to 1,000 m around the centreline. In some areas with special challenges related to crossings and environmental conditions, the survey corridor has been expanded to 2,000 m around the route centreline.

The results of the geophysical surveys are used for optimizing the final route and construction design. This optimisation includes identification of possible UXO objects at the seabed for ensuring that they do not pose a risk to the pipeline (see Section 3.5.1) and identification of possible cultural heritage objects for ensuring that no damage to these takes place.

3.2.2 Geotechnical surveys

The geotechnical investigations include CPT (Cone Penetration Test) measurements and vibrocore sediment sampling along the route alternatives. In the nearshore areas (less than 10 m water depth), CPT and vibrocore sampling are carried out at three positions per kilometre. At depths larger than 10 m, cone penetration tests and vibrocore sampling are carried out at one position for every three kilometres of the route. In the landfall areas (onshore and nearshore), geotechnical drilling down to approximately 30 m below surface level is carried out.

3.3 Pipeline design

The following sections describe the mechanical design activities for the Baltic Pipe and Section 3.3.4 presents the estimated inventory of materials.

3.3.1 Gas composition

The design and construction of the pipeline have been carried out to allow for the gas composition shown in Table 3-2 (gas from Denmark to Poland) and Table 3-3 (gas from Poland to Denmark).

Table 3-2 Gas composition for gas export from Denmark to Poland. Expected gas composition (mole-%) and range in the Baltic Pipe pipeline, with an expected average flow of 8.8 BCM/year.

Component	Symbol	Expected composition	Expected range
Methane	C1	89.65	84 – 97
Nitrogen	N2	0.64	0.3 - 2.6
Carbon dioxide	CO2	1.94	0.1 – 2.5
Ethane	C2	6.31	1.5 - 8.5
Propane	C3	1.04	0.1 – 3.9
iso-Butane	iC4	0.14	0 – 0.4
n-Butane	nC4	0.19	0 - 0.8
iso-Pentane	iC5	0.04	0 – 0.2
n-Pentane	nC5	0.03	0 – 0.1
n-Hexane	C6	0.02	0 – 0.1
Gross calorific value	MJ/Nm3	41.73	40.3 – 45.0
Gross calorific value	kWh/Nm3	11.59	11.2 – 12.5
Normal density	Kg/Nm3	0.807	0.74 – 0.87
Molecular weight	g/mole	18.03	16.6 – 19.3

Table 3-3 Gas composition for gas export from Poland to Denmark. Expected gas composition (mole-%) and typical parameters of gas in the Baltic pipe pipeline, based on examples from the LNG Terminal Świnoujście in Poland, for expected average flow of 3 BCM/year.

Component	Symbol	Natural gas from LNG Terminal (4.9.2017)	Natural gas from LNG terminal (15.9.2017)
Methane	C1	93.30	92.00
Nitrogen	N2	0.17	0.46
Carbon dioxide	CO2	0.00	0.00
Ethane	C2	6.50	5.95
Propane	C3	0.03	1.20
iso-Butane	iC4	0.00	0.12
n-Butane	nC4	0.00	0.25
iso-Pentane	iC5	0.00	0.02
n-Pentane	nC5	0.00	0.00
n-Hexane	C6	0.00	0.00
Min. gross calorific value	MJ/Nm3	41.84	42.39
Wobbe Index	MJ/Nm3	54.47	54.73
Relative density	-	0.59	0.60
Molecular weight	g/mole	16.98	17.44

3.3.2 Wall thickness

The pipeline system will be designed in accordance with the DNVGL offshore standard F101 Submarine Pipeline Systems (DNVGL-ST-F101, 2017), and any other national requirements that the authorities may have or disclose during the liaison process (Rambøll, 2017).

The following assumptions have formed the basis for the design of the wall thickness of the pipeline:

- Pipeline size: 36" (fixed inner diameter of 872.8 mm);
- Estimated annual transfer volume: up to 10 billion m^3/year;
- Expected input pressure to the onshore network in Poland: 46-84 barg;
- Design pressure: 120 barg.

The offshore pipeline will be constructed using high-quality carbon steel, commonly used for the construction of high-pressure pipelines. Pipe joints with a length of 12.2 m will be welded together during a continuous pipe-lay process. Steel pipes with standard thickness will be used.

The selected wall thicknesses are shown in Table 3-2, and have been calculated according to the risks to the pipeline integrity along the pipeline route. With the required wall thickness, no buckle arrestors are required to prevent propagating buckling (Rambøll, 2018d).

Table 3-4 Selected wall thickness for the 36'' diameter Baltic Pipe. The safety zone 2 is the highest safety class, applied onshore at the Danish landfall (and Polish landfall), extending 500 from the shore. The rest of the pipeline is zone 1, i.e. medium safety class (Rambøll, 2017).

Wall thickness criteria	Safety Zone	Unit	Wall thickness [mm]
Selected API wall thickness	Zone 1	mm	20.6
	Zone 2	mm	23.8

3.3.3 Coating

Internal flow coating

The line pipe joints will be coated with internal flow coating to limit flow friction. The coating will consist of 0.1 mm epoxy paint.

External anti-corrosion coating

External anti-corrosion coating will be applied to the pipeline to prevent corrosion. This coating consists of 4.2 mm polyethylene (PE).

Concrete weight coating

The on-bottom stability design complies with the requirements from DNVGL's recommended practice On-bottom stability design of submarine pipelines (DNVGL-RP-F109, 2017).

Concrete weight coating with a thickness ranging between 50 mm and 140 mm will be applied over the pipeline's external anti-corrosion coating to provide on-bottom stability. While the primary purpose of the concrete coating is to provide stability, the coating also provides additional external protection against external load, e.g. trawl gear.

To assess the on-bottom stability of the offshore part of the Baltic Pipe as subject to wave and current loading, calculations have been made of how thick a of concrete weight coating is required, and to identify where seabed interventions are required.

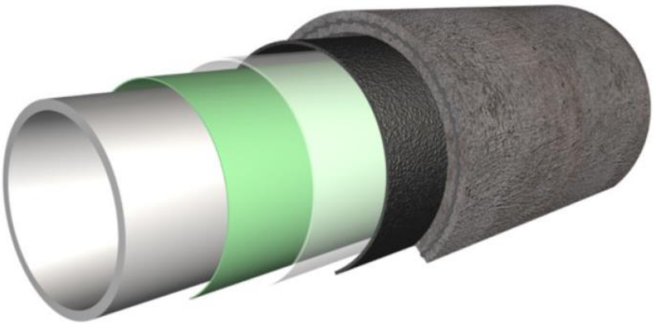


Figure 3-2 External concrete coating on top of the three-layer anticorrosion coating covering the steel line pipes.

While the concrete thickness ranges from between 50 mm and 140 mm, the concrete density is between 2,250 and 3,300 kg/m^3. In this report, the average concrete weight coating is assumed to be 100 mm @ 3,040 kg/m^3.

For some sections of the pipeline, stability cannot be proven by weight coating alone. In these areas, the pipeline will be trenched and/or rock dumped for stability purposes. Ideally it will be trenched, but if trench depths cannot be achieved, rock dumping may be used. In addition, in the very nearshore region, rock backfill may be used within the trench (instead of sand backfill). This is further detailed in Section 3.5.

Field joint coating

To facilitate welding of the 12.2 m long steel pipe joints on the installation vessel, the pipe coating is stopped before the steel pipe ends. The cut-back lengths are estimated at 240 mm for the anticorrosion coating and 340 mm for the concrete coating. After completion of the circumferential weld, the bare steel area is protected by a heat shrink sleeve, and the void between the adjacent concrete coatings is filled with moulded polyurethane (PU), either solid or foam.

3.3.4 Corrosion protection design

The design of corrosion protection has been made to comply with the requirements of DNVGL-ST-F101, 2017, DNVGL-RP-F106, 2017, and DNVGL-RP-F103, 2016. The operating temperature is conservatively assumed to equal the maximum design temperature with respect to the technical design, and the external barrier coating is envisaged as 4.2 mm, 3-layer PE coating in accordance with DNVGL-RP-F106, 2017.

External coating will be applied to the pipeline to prevent corrosion. Further corrosion protection will be achieved by sacrificial anodes of aluminium alloy. The sacrificial anodes are a dedicated and independent protection system to that of the anticorrosion coating. The cathodic protection shall provide sufficient anode mass to protect the pipeline during the entire design life, and sufficient exposed surface to deliver the required protective current in the final end-of-life situation (Rambøll, 2017). For concrete coated pipelines, it shall be ensured that the anodes do not protrude from the coating. Therefore, an anode thickness of 45 mm will be adopted, irrespective of the concrete coating thickness (Rambøll, 2017). The dimensions and properties of the anodes are shown in Table 3-3.

Table 3-5 Anode properties (Rambøll, 2017). The anodes consist of aluminium alloy (Al-Zn-In).

36 inch pipeline					
Anode inner diameter (ID)	Anode thickness	Anode length	Anode weight	Anode current output	
				Buried	Exposed
932 mm	45 mm	240 mm	86.41 kg	0.10 A	0.36 A

The Baltic Pipe offshore pipeline has been designed with an anode mass of 1,180 kg/km. This amount ensures a sufficiently large anode surface; the anode consumption has been calculated to be a maximum of 495 kg/km during the 50-year design life of the pipeline. This corresponds to a maximum anode consumption of 7.9 kg/km/year.

In practice, the release will be much lower as the role of the anodes is to provide back-up protection in case the coating of the pipeline is degraded or damaged; only a small fraction of this amount will be released.

The recommended composition of the anode material is outlined in Table 3-4.

Table 3-6 Recommended compositional limits for anode materials (DNVGL-RP-F103, 2016).

Element	Al-Zn-In anodes	
	Min (%)	Max (%)
Al	-	Remainder
Zn	4.50	5.75
In	0.016	0.030
Cd	-	0.002
Fe	-	0.090
Cu	-	0.003
Si	-	0.12

The geotechnical survey has identified a 15 km section close to the Polish coast (at kilometre point (KP) 255 – 270) where the seabed resistivity is very high, reducing the current output of the anodes. Therefore, the anode spacing has been reduced from six to four pipe joints, increasing the anode mass by 50% to 1,771 kg/km on this 15 km section. This will not affect the annual anode consumption during the 50-year lifetime, but will of course prolong the duration of anode dissolution, if the pipeline is left on the seabed at the end of the design life.

The flooded section of the pipeline inside the tunnel at the landfall (see Section 3.4) will also be protected by the sacrificial anode system, possibly with a reduced spacing to deliver the required current in the confined space. For the grouted section of the tunnel, corrosion protection will be ensured by the alkalinity of the grout, possibly supplemented by an Impressed Current Cathodic Protection (ICCP) system as it is not submerged and encased in grout. This system will have cabling leading back to the valve station where the control / monitoring equipment will be located.

3.3.5 Inventory of materials

Table 3-5 summarises the expected inventory of materials to be used for construction of the offshore pipeline.

Table 3-7 Use of materials for construction of the offshore pipeline (approximate amounts).

Material	Total route and route in Danish waters	
	Total offshore route	Route in Danish waters
Length of pipeline [km]	273.7	137.6
Steel [t]	125,000	63,000
Internal flow coating, 0.1 mm epoxy paint [t]	85	45
External epoxy coating, 4.2 mm, 3 layer PE [t]	2,900	1,500
Field joint coating, Heat shrink sleeve [no.]	22,500	11,500
Concrete weight coating 100 mm, 3,040 kg/m^3 [t]	253,000	127,000
Field joint coating PU [t]	5,900	3,000
Concrete (tunnel elements) [t]	6,000	4,000
Steel, landfalls (tunnel element reinforcement, sheet piles) [t]	1,100	700

3.4 Landfall construction

The landfall in Denmark is located south of Faxe Ladeplads in Faxe Bugt (see Figure 3-1). The landfall is located at an agricultural field with a 15-17 m high cliff along the beach. The first dry weld is approximately 400 m along the pipeline from the shore. Photos of the landfall location are shown in Figure 3-3.

Figure 3-3 Danish landfall location, views from south and from the beach.

The landfall area with the onshore construction site is shown in Figure 3-4.

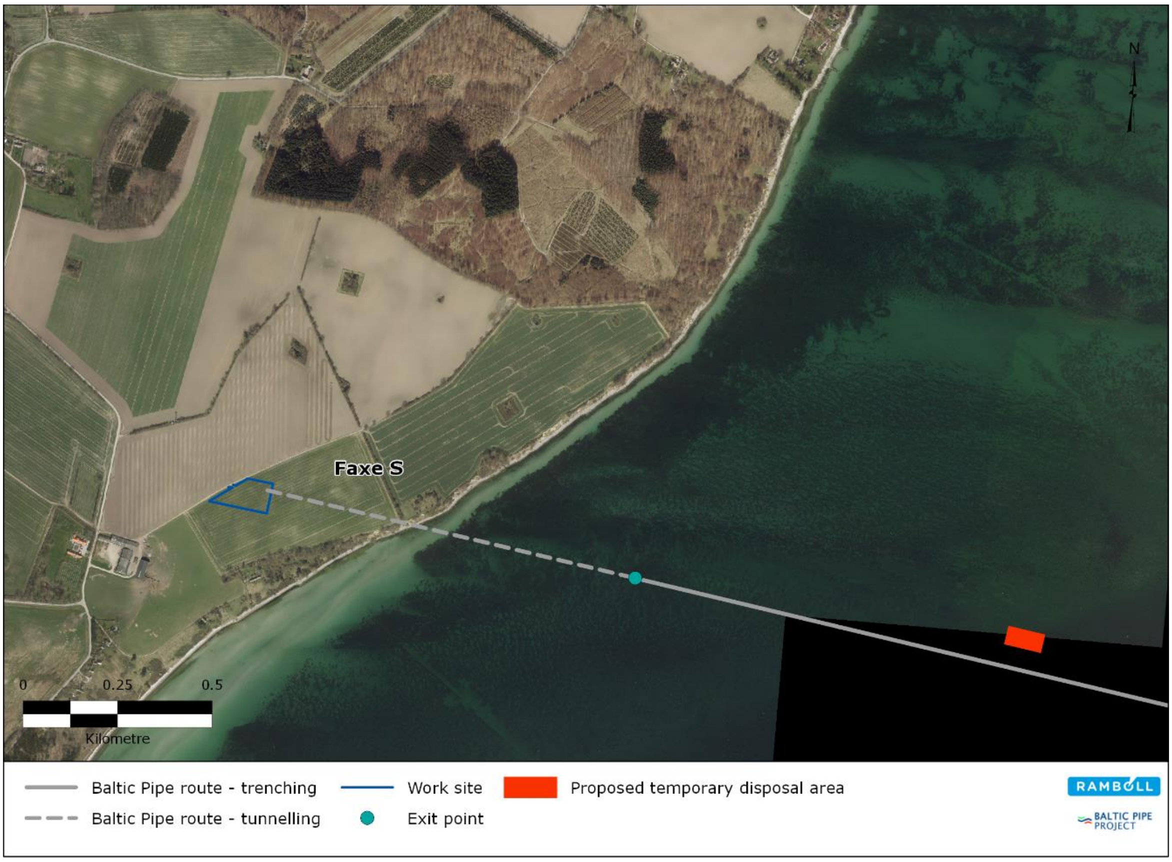


Figure 3-4 The Danish landfall route with onshore work site for tunnelling. The exact size and position of the shown deposit area is subject to change during the detailed design process, but it will be at approximately 7 m water depth, i.e. seawards of the depth limit for eelgrass growth (to avoid covering eelgrass meadows).

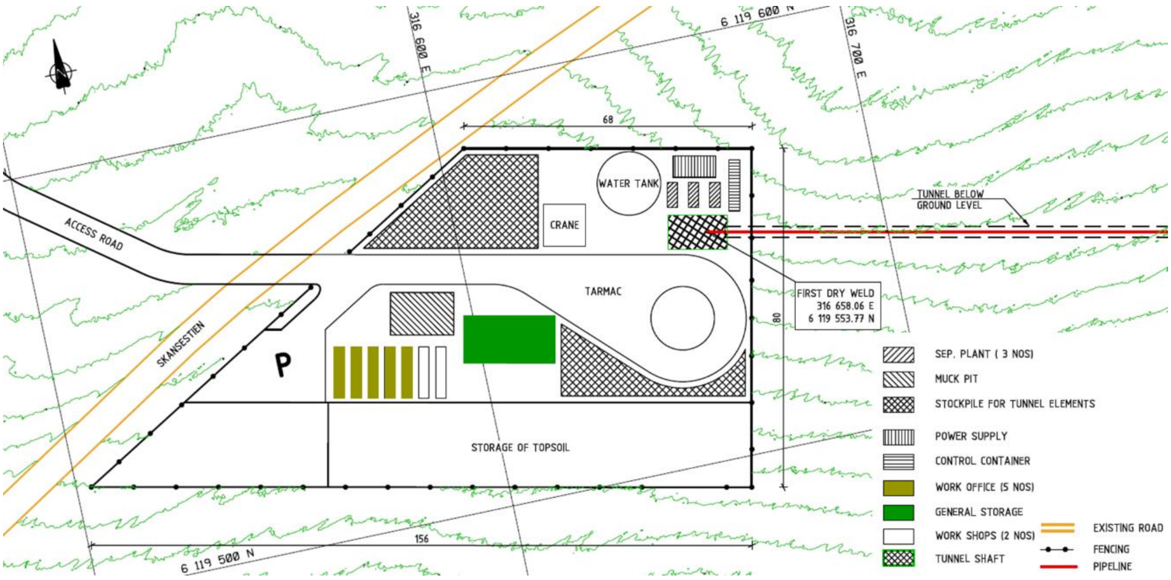


Figure 3-5 The work site area layout for the tunnelling phase. The work site area will be the same for the pull-in phase and the pre-commissioning phase; the layout of equipment etc. within the area will, however, be different. The area of the work site is approximately 9,000 m².

3.4.1 Tunnelling

As mentioned, the height of the cliff at the landfall is 15-17 m, and excavation would leave a large mark in the landscape which is not easily reinstated. Therefore, tunnelling is favoured as the preferred landfall construction method by the investor. Also, excavation of an open trench would lead to excessive excavation volumes, causing a significant disturbance to the cliff and sediment dispersion from the shallow-water excavation works.

Tunnelling is a method where a lined tunnel is installed. The hole is drilled using a conventional tunnel boring machine (TBM) with a full-face rotating drill head. As the TBM advances, concrete jacking pipe elements are pushed in behind it, forming a permanent tunnel lining. The required reaction is provided either by a back anchor or the wall of a construction pit, see Figure 3-6. A messenger line installed inside the tunnel is picked up by the lay barge, stationed at the exit point of the tunnel, connected to the pull wire, and the pipeline is subsequently pulled by an onshore winch (not shown in Figure 3-6).

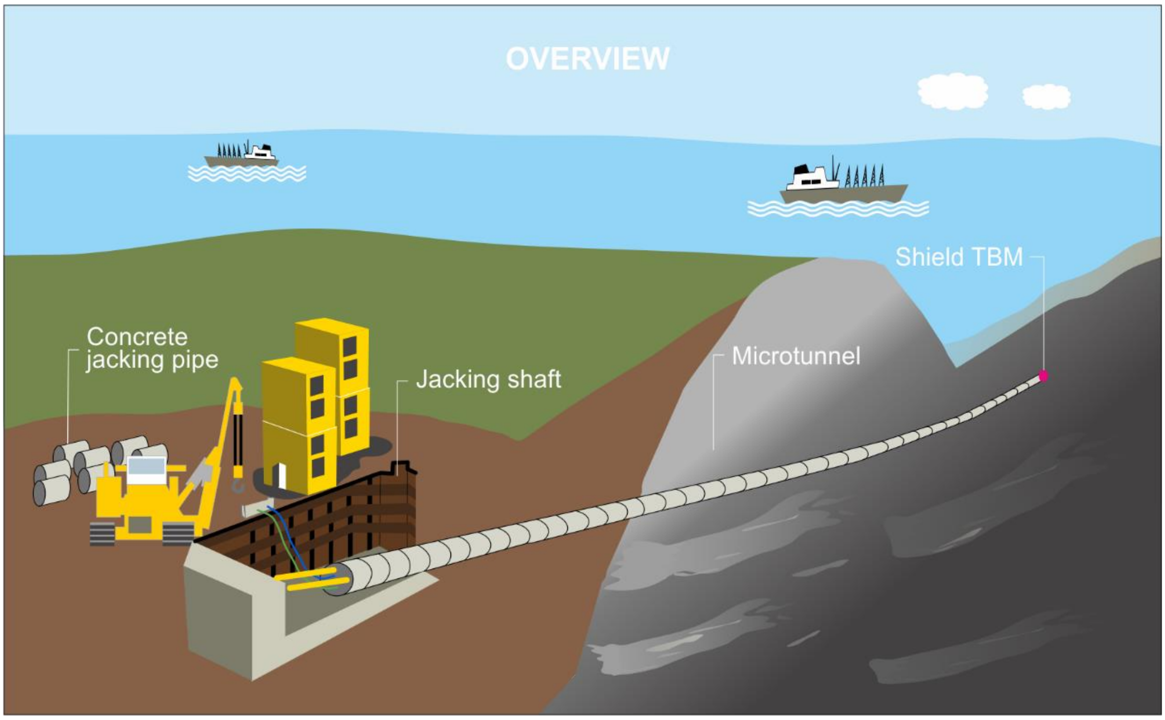


Figure 3-6 Principle of tunnelling.

Figure 3-4 gives an overview of the areas needed as part of the construction activities at the Danish landfall area, using the tunnelling construction method; the dimensions of the worksite is shown in Figure 3-5. The work site and the access road will be cleared of trees and other obstructions to allow access and for positioning of the machinery. The work site includes parking for personnel, personnel facilities, storage of machinery and temporary storage of the excavated top soil etc. At the work site, a launch shaft (l:10 m, w: 5 m d: 10 m) will be established with sheet pile walls to ensure stability. After completion of tunnelling/pipe-jacking activities, the launch shaft will be extended further back (e.g. using sheet piles) to allow for shore-pull and pipeline installation to take place. Subsequently, the work site will be rearranged for pre-commissioning (see Section 3.9). The work site will be re-instated after finalization of construction and pre-commissioning.

Tunnelling is expected to be continued underneath the shoreline, until a water depth of approximately 4 m, where the TBM is recovered from an exit point, which will be dredged/excavated (see Figure 3-7). Furthermore, a transition zone from the exit point to the trench of the pipeline at 2 m below seabed surface will be established. Dredged material from the exit point and transition zone will transported to a temporary disposal area on the seabed at a water depth of minimum 7 m. After pipe-lay, the material from the temporary deposit will be backfilled into the hole. The locations of the pit (the exit point) and the temporary deposit area (at approximately 7 m water depth) are shown in Figure 3-4.

It is envisaged that the 36" pipeline is welded onboard a shallow water lay barge, and pulled-in through the tunnel (Rambøll, 2018a).

As shown in Figure 3-4, the tunnel will be at an angle on the coastline and the tunnelling distance will comprise approximately 400 m onshore and 600 m offshore. Therefore, approximately 1,000 m tunnelling distance in total is anticipated.

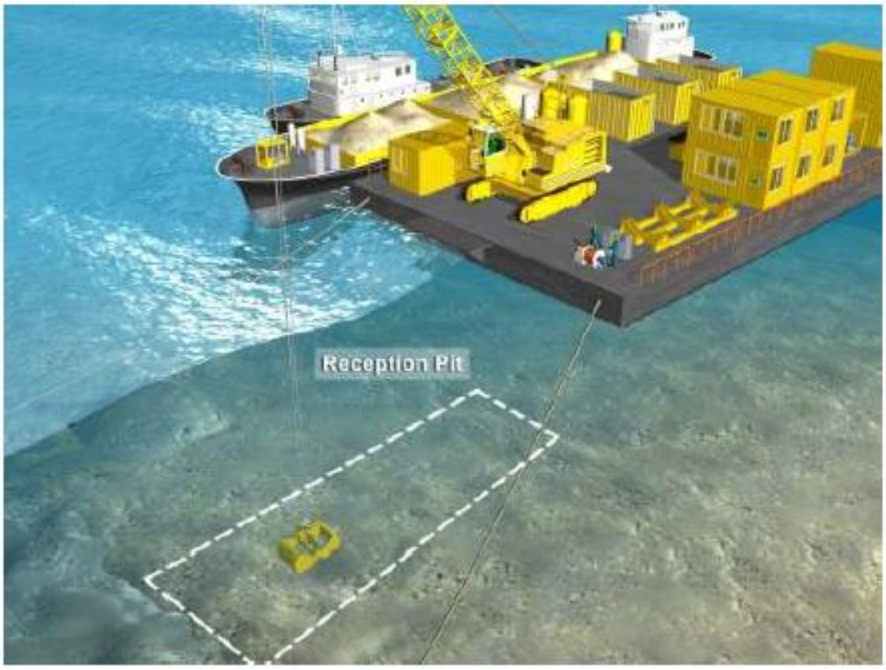


Figure 3-7 Uncovering of the TBM using a special suction system or excavator (from Linde, 2015).

3.4.2 Construction activities

An overview of the construction activities will be presented and outlined for the landfall based on a tunnel diameter of DN2000 mm (outer diameter approx. 2,500 mm) to allow access for people. The activities related to tunnelling are expected to include sheet piling only during daytime only and continuous tunnelling 24/7 (for avoiding being stuck in the ground) during approximately 20 weeks. The overall construction methodology for tunnelling consists of the following operations (see Figure 3-8):

1. Establish a launch shaft for the tunnel.
2. Set up necessary machinery:
    a. pipe jacking station;
    b. TBM including control container and power supply;
    c. slurry separation plant (if relevant).
3. Deliver pre-fabricated tunnel elements to site.
4. Start tunnelling:

   a. Push TBM into soil while excavating;
   b. Lower tunnel elements into launch shaft;
   c. Push tunnel elements forward while excavating;
   d. repeat steps b. and c.
5. Retrieve TBM off-shore, including all necessary operations to seal off the machine and excavate it from below the seabed.

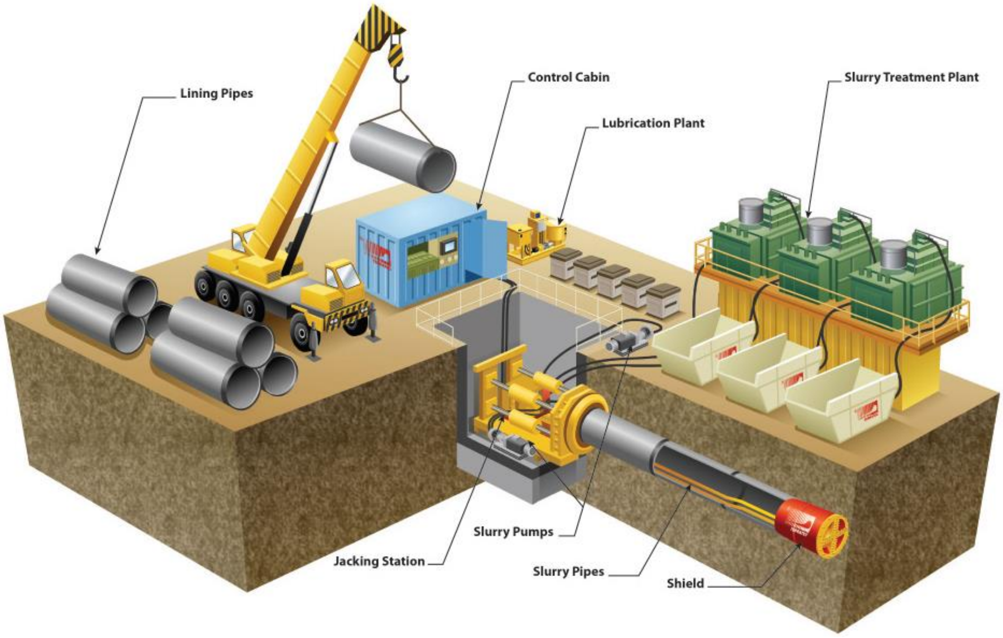


Figure 3-8 Visualisation of the launch shaft for a pipe jack tunnel. Source: www.terratec.co.

The tunnel must be constructed under water pressure and the cutterhead must be accessible in case obstructions (such as boulders) are encountered. Closed-face TBMs can excavate soil and rock under high pressure from both the surrounding soil/rock and water because the pressure from the surroundings is counteracted either by (i) a slurry suspension or (ii) using the excavated soil. Two methods for excavating the soil using closed-face TBMs are optional for this method; (i) Slurry TBM and (ii) Earth Pressure Balance TBM. The preferred method depends on the geotechnical conditions.

Slurry TBM and separation plant
The Slurry TBM (see Figure 3-9) uses a bentonite suspension (called slurry) to counteract the earth and water pressure. The slurry is used for two purposes:

1. Achieving and maintaining the desired pressure;
2. As a transport medium for the excavated soil.

The pressure is controlled by the flow of slurry to and from the excavation chamber in a closed circuit of pipes. The “loaded” slurry is pumped through the entire tunnel to a separation plant at the launch shaft, where the excavated material is separated from the slurry. The excavated material can be disposed of according to the local regulations (clean soil for e.g. filling or reclamation, contaminated soil for disposal), and the slurry can (for the most part) be reused in the excavation chamber.

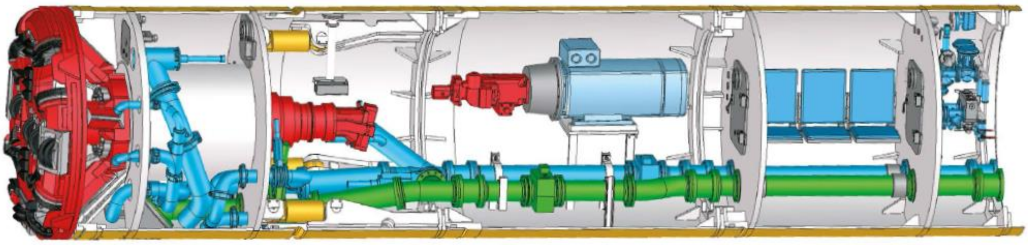


Figure 3-9 Schematic of Slurry TBM. Source: Herrenknecht.de.

The use of slurry requires a separation plant to separate the excavated soil from the slurry suspension. The most basic form of separation plant is a precipitation tank but often a more advanced system with screens and centrifugal pumps or cyclones is installed, as it is more efficient.

The slurry TBM uses very few additives for the tunnelling operation. The main additive is the bentonite used for the slurry suspension, which is a clay type/mineral. In case "hard water" is used in the slurry, bi-carbonate can be added to optimize the mixing.

Further to this, the challenges with separating fine particles from the slurry has in some cases been solved by adding flocculants to the slurry, which has not been properly separated. Some oil and grease used for lubrication of motors and pumps can also be expected.

The tunnelling works for one landfall gives rise to approximately 8,200 m^3 of excavated material. While no evidence of contaminated ground has been found, it may be reasonable to expect that around 1.5% of the soil excavated at the landfalls may be contaminated and therefore subject to treatment as such. A total slurry volume of approximately 1,000 m^3 is expected for each landfall. The slurry is prepared from a mixture of water and bentonite, of which the raw bentonite content is expected to be approximately 50 tonnes. The slurry with its content of bentonite will be disposed of according to applicable legal requirements.

Earth Pressure Balance TBM

Earth Pressure Balance (EPB) TBM (see Figure 3-10) does not use slurry to counteract the surrounding earth and water pressure but instead uses the excavated soil. The excavated soil is extracted from the excavation chamber with a screw conveyor and by controlling the rate of extraction, the pressure in the excavation chamber can be controlled.

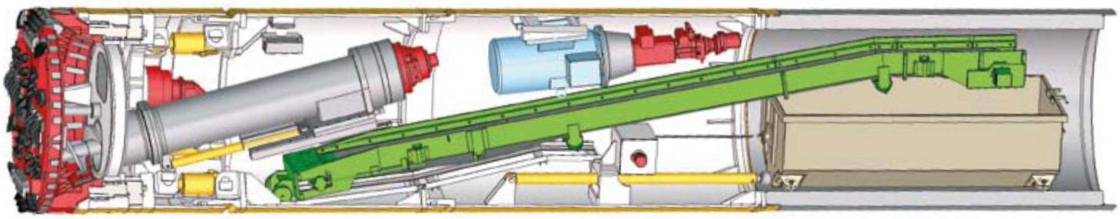


Figure 3-10 Schematic of EPB machine. Source: Herrenknecht.de.

The excavated soil is then transported by a muck wagon to the launch shaft, where it is picked up and emptied and the soil can be disposed of (clean soil for e.g. filling or reclamation, contaminated soil for disposal). In order to condition the soil in front of the cutterhead, it is common to use different types of additives. This is done in order to optimize the boring and aims at improving consistency and clogging behaviour.

It is common to use additives such as cement-based materials, dispersants and foams, including polymers and other chemicals that usually require an authority permit. The dispersants, foams and polymers are used to condition the material in front of the cutterhead and most of these additives are excavated and transported to the launch shaft. The cement-based materials are used along the circumference of the final tunnel lining (pipes) to fix the position of the tunnel. These will remain in the ground. Some oil and grease used for lubrication of motors and pumps can also be expected.

Interventions
Both EPB and Slurry TBMs are designed to work under soil and water pressure. When access to the cutterhead is necessary to inspect and replace cutting tools, the TBM is fitted with a pressure chamber at the rear end of the machine. This allows decompression for divers that have carried out inspections and replacement of cutterhead tools at the excavation front under pressure delivered by compressed air.

When inspection and maintenance of the cutterhead and tools are necessary, the tunnelling must stop, and the stability of the excavation front is maintained by an air pressure. The intervals between these interventions and their locations depends very much on the geology of the project and must be carefully planned. The duration of an intervention depends on the need for exchanging cutting tools.

Pipeline pull-in
The pipeline will be installed pulling the pipeline ashore from a shallow water lay-barge anchored off the coast, following completion of the tunnel. The pipeline will be welded together on the lay barge, and the pipe string will be pulled ashore using a pull winch at the onshore work site.

The landfall construction for the pull-in operation includes set-up pull winch spread at the onshore work site, establishing pipeline trench until a water depth of approximately 10 m, installing pull-wire from onshore work site to offshore pick-up location and mobilization of shallow-water lay barge and shore-pull operations.

3.4.3 Construction equipment

Table 3-6 provides an overview of construction activities as part of establishing the working area site and launch shaft at the landfall, including restoration and examples of the types of equipment needed.

Table 3-8 Construction equipment used at the landfall.

Equipment	Power (kW)
Clearing of working area site	
Excavator	30
Dozer	100
Truck	250
Sheet-piling and excavation	
Sheet-piling rig	250
Dredger, large	400
Dredger, small	30
Lift of tunnel elements and pull-in equipment	
Truck crane	250
Restoration	
Dredger	400
Compression machine	10

An overview of the construction activities and equipment needed in relation to the exit point nearshore is shown in Table 3-7.

Table 3-9 Construction equipment used nearshore (TBM recovery).

Equipment	Energy (kWh)
Excavation of exit point	
Backhoe dredger	1,500
Split hopper barge	1,000
Recovery of tunnel boring machine	
Heavy lift vessel with crane	1,000
Restoration of exit point	
Backhoe dredger	1,500
Split hopper barge	1,000

The tunnelling machinery (TBM, jacking frame, pumps, etc.) needs electric power to run, which is expected to be provided from diesel generators to ensure proper power supply. Based on a reference project, applying an uncertainty factor of 1.2, the power consumption of a slurry TBM, which has a higher power consumption than an EPB, is estimated to be approximately 1,200 kW (1,500 kVA).

3.5 Offshore construction

Offshore construction includes the following overall activities: seabed preparation, pipe-lay and seabed interventions.

3.5.1 Seabed preparation

When the data from the geophysical and geotechnical surveys have been analysed, the detailed pipeline route will be defined. This route will be selected so that objects resting on the seabed (possible wrecks, munitions objects etc.) will be avoided to the greatest extent possible.

A detailed magnetometer survey covering a corridor around the pipeline route will be executed before seabed interventions and pipe-lay activities are executed. This is to re-assure that no buried munitions objects or similar are present in the area. The magnetometer survey will be planned in agreement with national authorities responsible for unexploded ordnance (UXO). The authority in Denmark is Værnsfælles Forsvarskommando and Søværnets Minørtjeneste. Unless the UXO poses a general safety risk, UXO clearance cannot be carried out before a constrction permit has been obtained.

Clearance of possible munitions objects identified by the magnetometer survey in Danish waters will, if required, be executed by Søværnets Minørtjeneste. Due to the fact that objects resting on the seabed are avoided as much as reasonably practicable when designing the route, the possible occurrence of munitions objects identified from the magnetometer survey is considered an unplanned event and is dealt with in the risk chapter of this report (Chapter 4).

3.5.2 Pipe-lay

Pipe-lay will take place in several steps and with different methods, which are described in the following.

Offshore pipe-lay methods

The possible pipeline installation method for the 36” gas transmission pipeline is by S-lay vessel, with a typical configuration being presented in Figure 3-11.

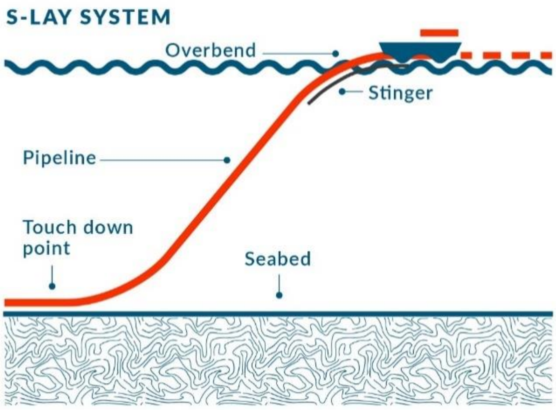


Figure 3-11 A typical pipeline installation by S-lay vessel.

Onboard the lay vessel, the coated pipe joints are welded onto the pipeline, which leaves the vessel via the stinger from where it follows an S-curve to touchdown on the seabed. The critical locations during pipe-lay are the overbend on the stinger and the sag bend at the touchdown point. The overbend stresses are controlled by a suitable stinger configuration, while buckling at the sag bend is prevented by tension in the pipeline, provided by tensioners on the lay vessel.

In deep waters (i.e. greater than 20-25 m water depth) the lay vessel may be provided with a dynamical positioning system (DPS) and powerful thrusters, enabling it to maintain position and move forward.

In shallower water (e.g. less than 20-25 m water depth), the DP vessel will not be able to operate. In these areas, it is necessary to use a shallow-water lay barge. The lay barge moves forward from under the pipeline by pulling itself on anchors, which are periodically shifted forward by anchor handling vessels.

Use of DP pipe-lay vessel has some advantages compared with use of anchor positioning. The choice of positioning system for pipe-laying will, however, in general depend on availability of the vessels, also at water depths above 20-25 m.

Above water tie-in
The installation of the shore approach and at Rønne Bank is envisaged to be carried out by a shallow-water lay barge. Here the pipeline is picked up by a deep-water lay barge, which will perform the rest of the offshore pipeline installation and lay down the pipeline at the other shallow water section alongside the shore approach section left there by the shallow water barge.

Above water davit lift tie-in is an operation where two laid down pipeline sections on the seabed are welded together after being lifted above water using vessel davits. The procedure, which is outlined in Figure 3-12, comprises the following:

- Both pipeline ends are provided with pre-installed clamping sections and laid down on the seabed next to each other, with an over length for the tie-in;
- Davit lift cables are connected to the pipelines, which are lifted and clamped in position;
- The pipeline ends are cut to measure, aligned, and welded together on the side of the vessel;
- After application of field joint coating, the joined pipeline is lowered to the seabed as the vessel moves sideward to avoid overstressing the pipeline.

The number of davit lift tie-ins will depend on the detailed design of the pipeline installation scenario; i.e. whether part of the offshore route needs to be installed by a low-water barge. In total two davit tie-in lifts are anticipated.

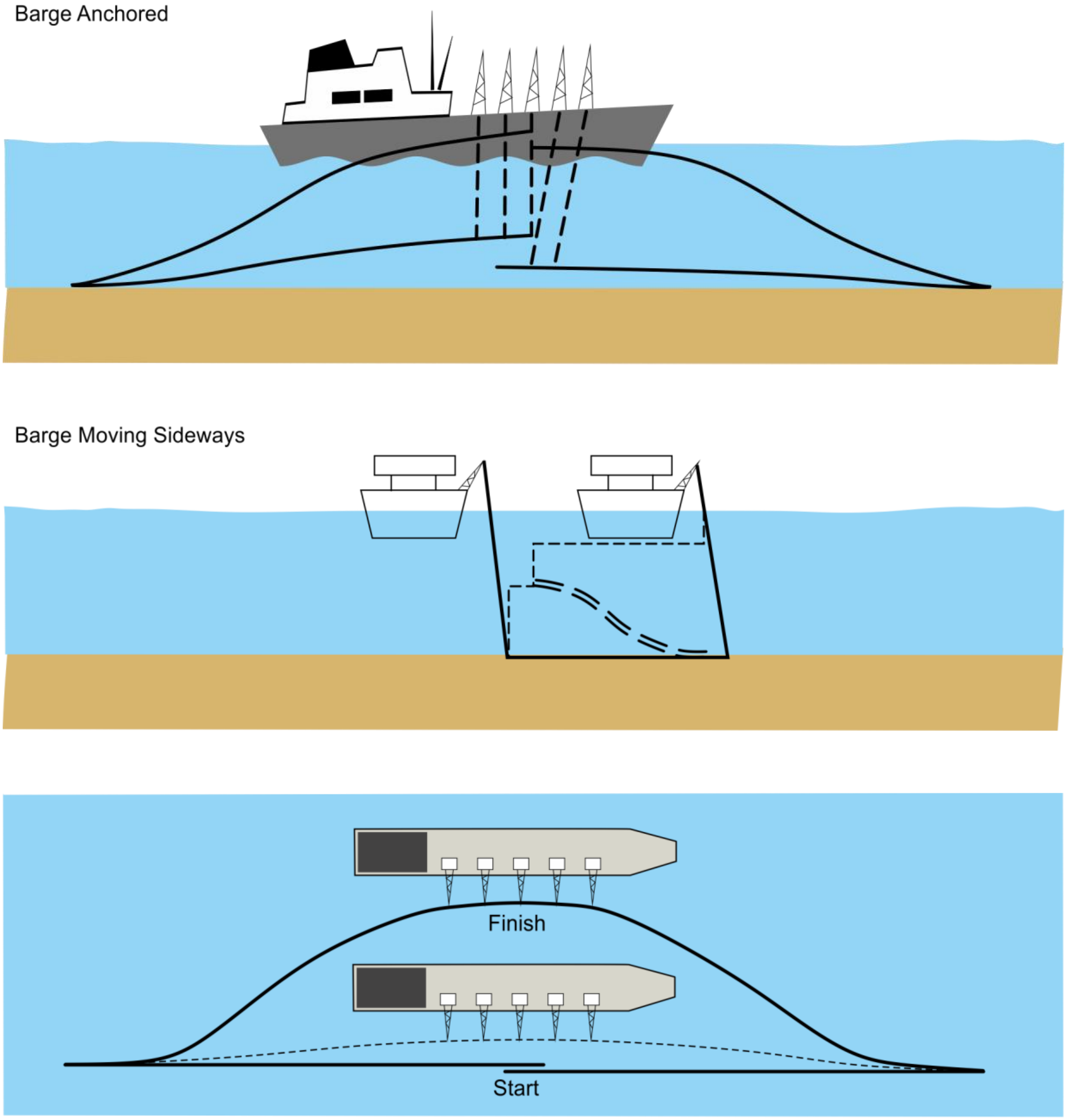


Figure 3-12 Typical davit lift tie-in procedure. The pipeline ends are raised, connected, and laid down at the seabed again. The top and middle figures show profiles, whereas the figure in the bottom is seen from above (after Braestrup *et al.*, 2005).

3.5.3 Seabed interventions

Seabed interventions are planned at some sections of the pipeline route to ensure stability and protect the integrity of the pipeline. The locations where seabed interventions are required are identified based on stability analysis and quantitative risk assessments, taking into consideration the water depth, local seabed conditions, ship traffic density, etc.

In general, seabed interventions that may be needed, include:

- Trenching at landfalls;
- Protection of existing pipelines or cables at crossings;
- Intervention at boulder areas to reduce free spans;
- Intervention at Rønne Bank;
- Rock installation or trenching to reduce the actions from waves and current;
- Trenching or/and rock cover at large shipping lanes.

All of this is to maintain pipeline integrity. Reduction of free spans is also to minimise the risk of interference with trawl gear.

Trenching will be performed either pre-lay by dredging (e.g. using backhoe dredgers on barges) or post-lay trenching (e.g. using a plough). Trench backfilling will be based on either backfilling with the excavated material (soil), backfilling with rock, or not backfilling at all, allowing natural backfill with seabed sediments , depending on the design requirements. In Danish waters the seabed will be restored by backfilling to at least 7 m water depth.

Rock may also be installed on the seabed and over the pipeline without trenching where the design requires it (typically where trenching is not feasible or practical to achieve, or where free spans need to be mitigated).

Concrete mattresses will be installed at pipeline and cable crossings to ensure minimum separation between the services.

Trenching and backfilling
Trenching is assumed to take place down to at least approximately 2 m below the seabed surface, to ensure a buffer of approximately 1.0 m between the mean seabed level and top of pipe (TOP). In shallow waters, coastal sediment transport causes variations in the seabed profile as illustrated in Figure 3-13, which shows the actual cross-sectional profile and the profile after 50 years, as modelled using the coastal model XBeach from Delft Hydraulics (Rambøll, 2018e). In these areas, the pipeline will be installed in a tunnel to a greater depth, so that there is at least 1.0 m between TOP and the Lower Envelope Curve (separating the stable seabed from the dynamic surface sediment layer), which will ensure stability during the lifetime of the pipeline.

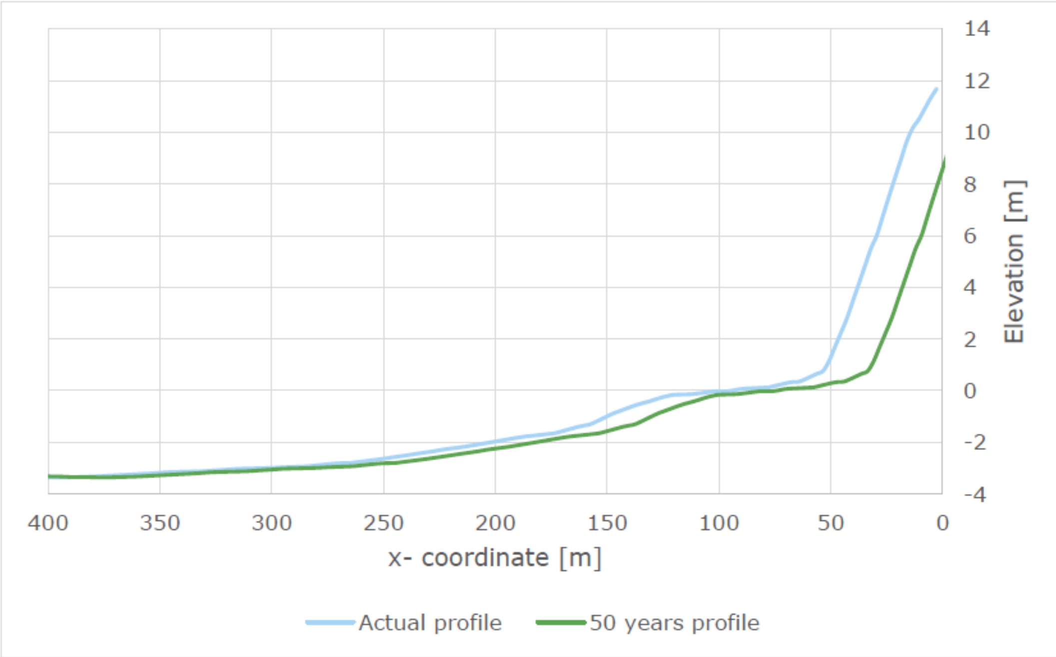


Figure 3-13 The actual cross-shore coast profile at Faxe South, shown together with the profile after 50 years, as calculated using geomorphological modelling (Rambøll, 2018e).

In water depth less than approximately 12 m, trenching can be performed using backhoe dredgers on barges; an example is shown in Figure 3-14.

Figure 3-14 Typical backhoe dredge for trenching in shallow water.

For this method, the trench is excavated before pipeline installation, the side slope in sand (or other soft sediments) being 1:6; a sketch is shown in Figure 3-15. For stiff clay, a side slope of 1:1 is assumed.

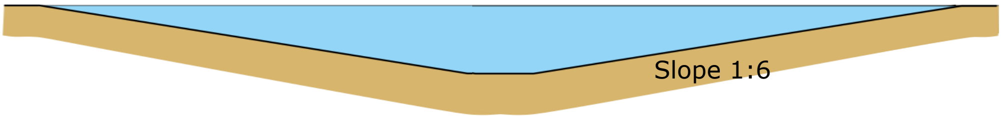


Figure 3-15 Sketch of typical trench excavated using a backhoe dredger.

The bottom of the trench will have a width of 5 m, and the average depth is assumed to be approximately 2 m. The total width of the pre-lay trench will thus be between 10 m and 30 m, depending on the sediment type.

The excavated material will be left on the seabed immediately adjacent to the trench and will be excavated back into the trench after pipeline installation.

Trenching *after* pipeline installation is the simplest solution at water depths greater than approximately 12 m. Trenching in these instances is planned by post-lay ploughing, possibly assisted by jetting.

Ploughing implies using a pipeline plough (see Figure 3-16) deployed onto the pipeline from a vessel located above the pipeline. A tow wire and control umbilical will be connected to the plough from the vessel, which will pull the plough along the seabed, laying the pipeline into the ploughed trench as the plough advances. The approximately 12 m water depth is the limit at which the DP vessels, which tow the plough, can operate.

Depending on the seabed conditions, other excavation methods such as cutter suction dredging or trailer suction hopper dredging might be required for parts of the pipeline route. Also, ploughing might be assisted by water jetting.

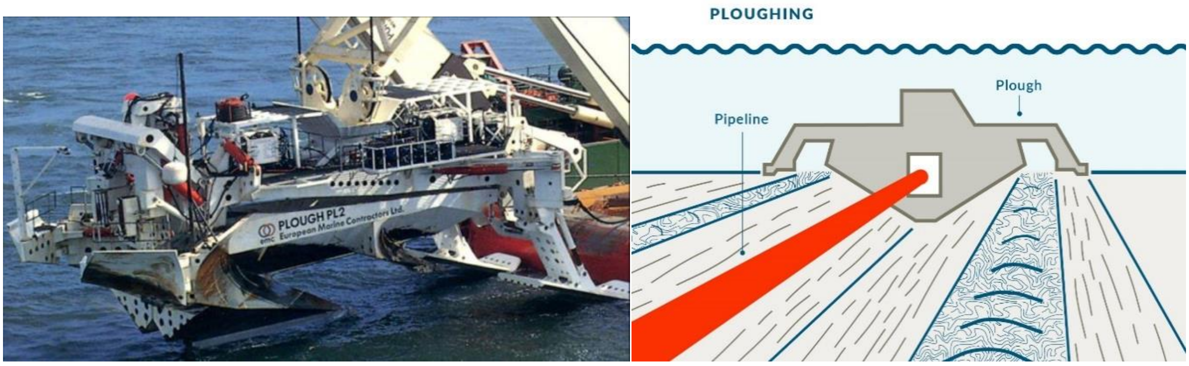


Figure 3-16 Pipeline plough before being lowered to the seabed from the towing vessel (left) and sketch showing a trenching operation using ploughing (right).

The excavated material displaced from the plough trench (also known as spoil heaps) will be left on the seabed immediately adjacent to the trench. Where backfilling is required, the spoil heaps will be pushed back into the trench after pipeline installation. A principle sketch of a cross section of a trench is shown in Figure 3-17.

Excavation for TBM recovery

At the tunnel exit point, a deep pit will need to be excavated to allow for recovery of the tunnel boring machine (TBM). The excavated material is expected to be deposited at the seabed at least 7 m water depth (see Figure 3-4) and reinstated after pipeline installation.

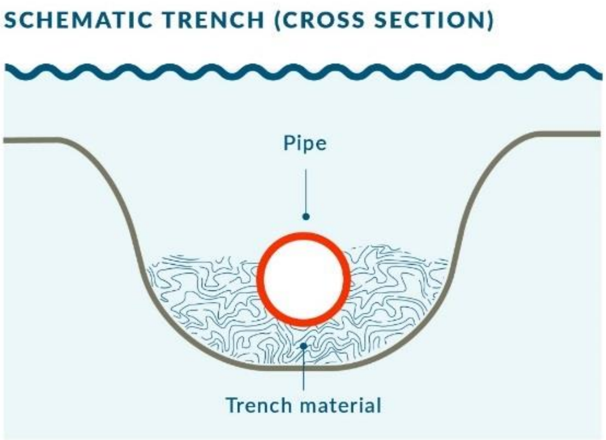


Figure 3-17 Principle sketch showing the cross section of a trenched pipeline (not to scale).

Rock installation

Rock installation is the use of unconsolidated rock fragments graded in size to locally reshape the seabed, thereby providing support and/or cover for sections of the pipeline system to ensure its long-term integrity. Rocks are supplied from onshore sources in Scandinavia.

Rock installation is planned to be performed by a rock installation vessel. A DP fall pipe vessel (FPV; see Figure 3-18) or a side stone dumping vessel will be used, depending on the activity to be carried out (the side stone dumping vessel will typically be used at shallow water, where the FPV cannot operate). The rock design is shown in Figure 3-19.

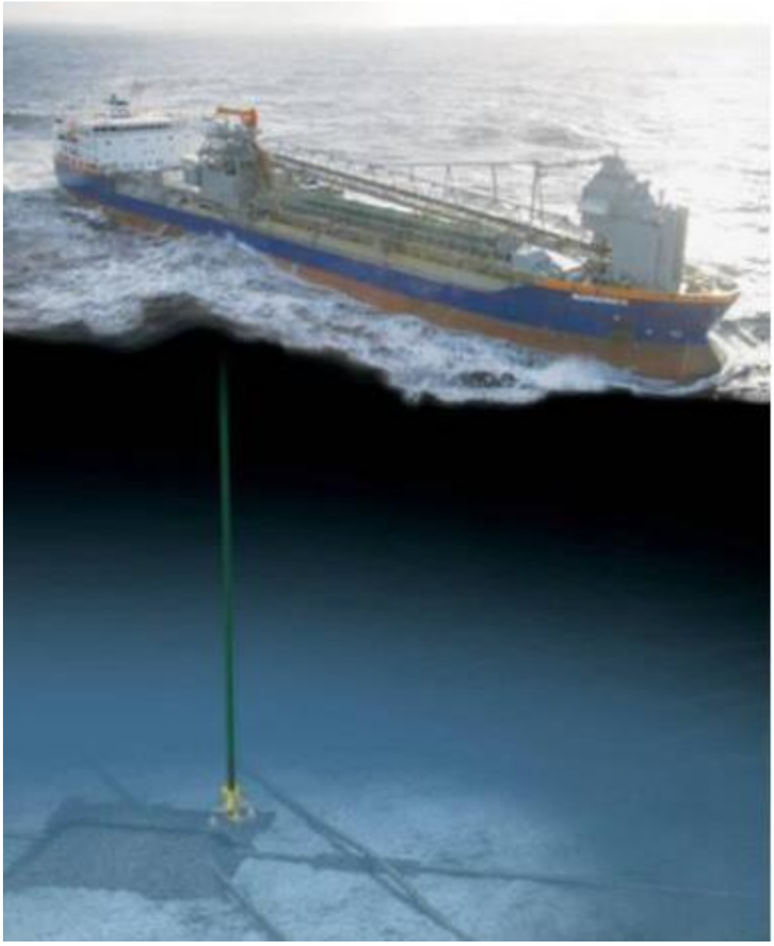


Figure 3-18 Fall pipe vessel for rock installation (Beemsterboer, 2013).

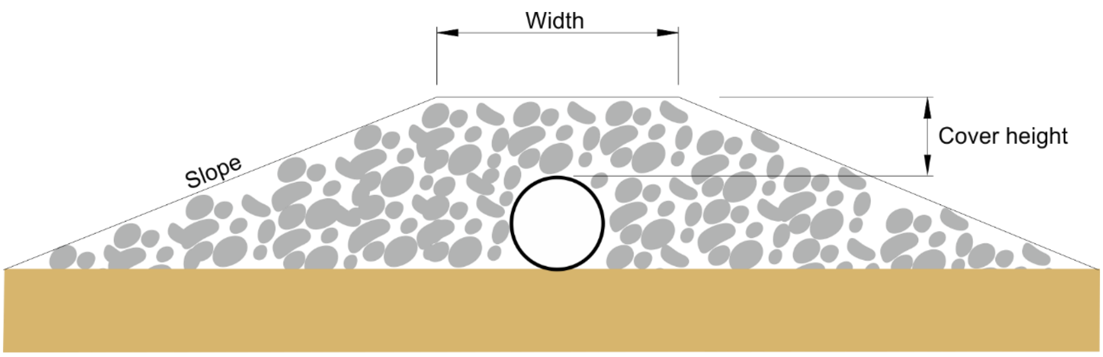


Figure 3-19 Sketch of post-lay rock design.

Crossing of marine infrastructure (pipelines and cables)

The Baltic Pipe route crosses existing pipelines, telecom cables and power cables at the seabed of the Baltic Sea. The infrastructure that will be crossed has been identified after consultation with the relevant authorities in Denmark, Sweden, Germany and Poland.

Before construction of the offshore part of the Baltic Pipe, agreements will be reached with all involved owners of the infrastructure to be crossed. Furthermore, the exact position will be established through detailed geophysical surveys.

Crossing of Nord Stream and Nord Stream 2

For crossing of Nord Stream a detailed crossing design will be prepared. The crossing design will be based on survey results and will provide input to the rock installation design. If Nord Stream 2 is constructed (see Chapter 11), the same approach will apply for crossing this pipeline system.

The crossing design will be a combination of rock fill and concrete mattress to ensure a 0.3 m separation between the pipelines. A sketch of the design is shown in Figure 3-20. After installation, the Baltic Pipe will be covered to TOP for protection. For both pre-lay and post-lay, a side slope of 1:2.5 is assumed to be sufficient.

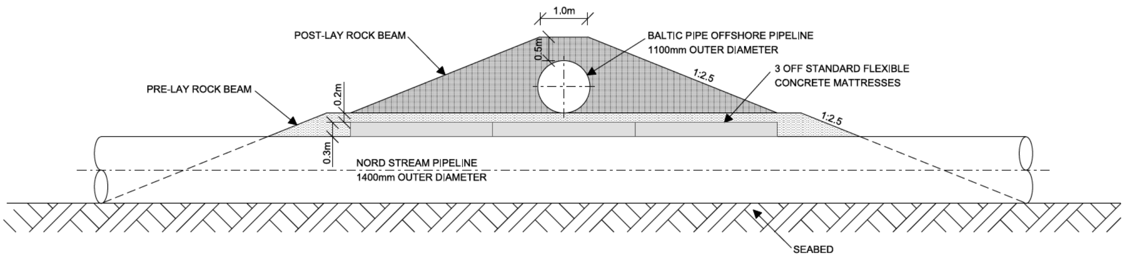


Figure 3-20 Schematic drawing of a pipeline/pipeline crossing.

Crossing of cables

The cable crossings will be constructed using concrete mattresses as separation between the lines. The mattress shall have a thickness of 0.3 m to ensure a sufficient separation. No post-lay cover is expected. An example of a cable crossing design is shown in Figure 3-21.

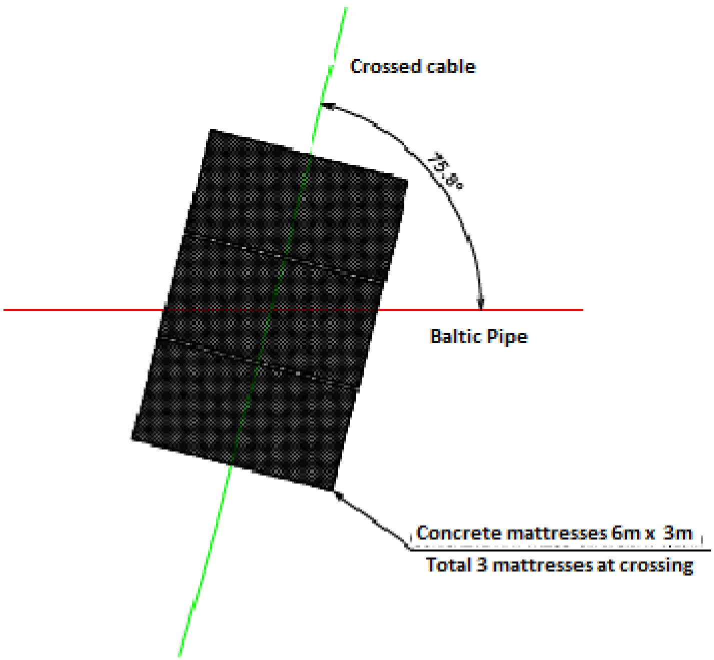


Figure 3-21 Example of crossing design of buried cable using concrete mattresses

Overview of seabed intervention works

Figure 3-22 presents an overview of the seabed intervention required along the Baltic Pipe route. In the figure it has been assumed that trenching takes place at 0-20 m water depth and where crossing shipping lanes, and that rock installation takes place where crossing pipelines and cables.

The quantities presented in the following are approximate numbers only, as the planned seabed interventions works will be optimised during the detailed design process.

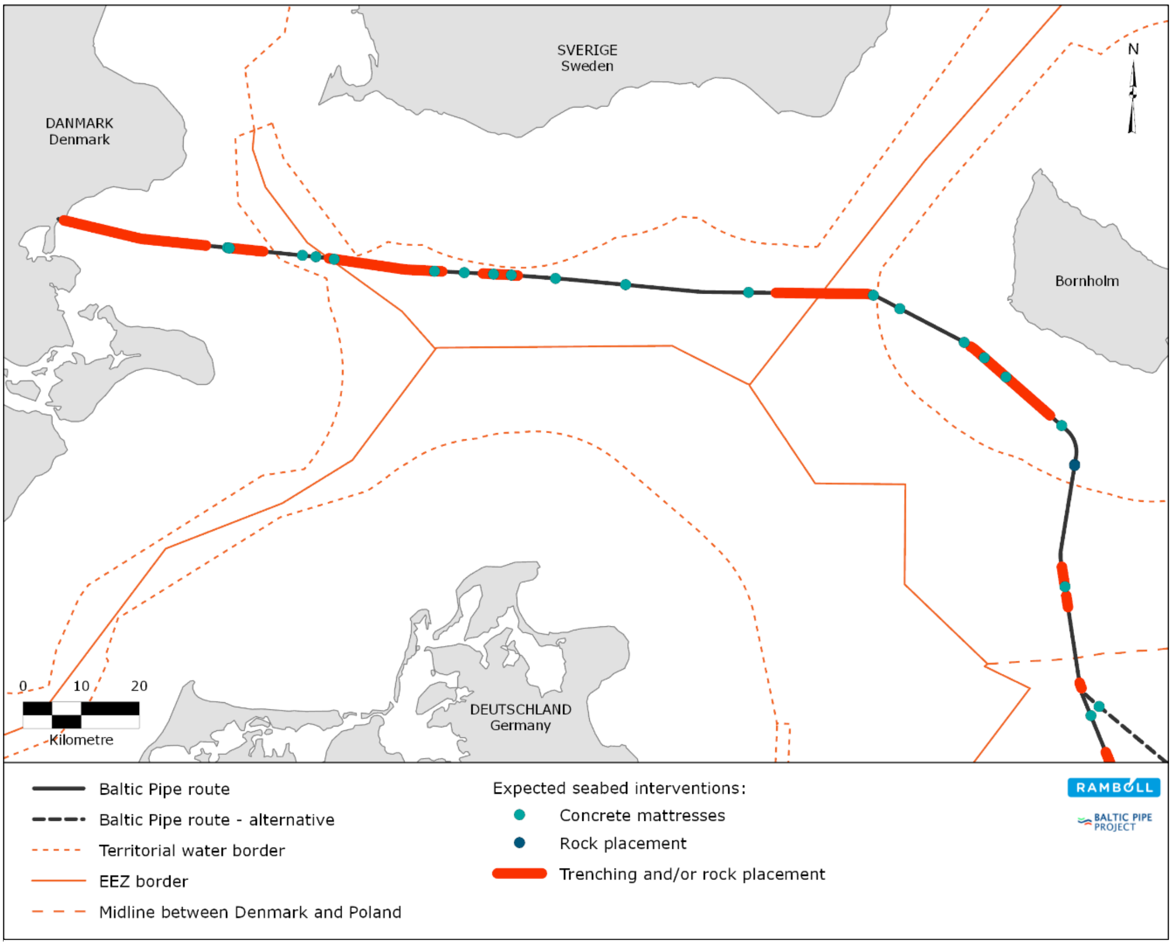


Figure 3-22 Overview of the anticipated seabed interventions works. In the figure it has been assumed that trenching takes place at 0-20 m water depth and where the pipeline crosses shipping lanes, and rock installation is planned where crossing of pipelines and cables takes place. The final seabed interventions design at the shipping lane will be optimized during the detailed design phase.

Trenching quantities

The need for pipeline protection due to ship traffic has been established based on a quantitative risk assessment (QRA). The main reason for the pipeline protection requirements considered in the QRA study is the risk from dragged anchors. Furthermore, the pipeline is expected to be trenched at a water depth of less than 20 m, due to large hydrodynamic loads.

The *lengths* of the sections where offshore trenching is anticipated are presented in Table 3-8. At water depths of less than 12 m, the types of seabed material will influence the cross-sectional geometry and therefore determine the volumes that will be handled (In this report, a side slope of 1:6 is conservatively assumed for all sediment types). The trenched *volumes* are presented in Table 3-9 together with the expected excavated volumes for recovering the TBM nearshore.

In some areas where trenching is planned for stability reasons (water depth <20 m), the geological seabed conditions might cause unexpected problems for post-lay trenching. In such areas, it might be required to use rock installation instead as a means of protection.

Table 3-10 Trenching lengths in Danish waters and disputed area.

Route section	Trench lengths		Total length
Water depth	*<12 m*	*>12 m*	
Disputed area	*n.a.*	7.0	7.0
Danish EEZ/Territorial waters	15.1 km	41.4 km	56.5 km

Table 3-11 Trenching and excavation volumes in Danish waters and disputed area.

Route section	Trench volumes		Excavated volumes	Total volume
Water depth	*<12 m*	*>12 m*	*TBM recovery*	
Disputed area	*n.a.*	68,000 m^3	*n.a.*	68,000 m^3
Danish EEZ/Territorial waters	514,000 m^3	402,000 m^3	10,500 m^3	926,500 m^3

<u>Rock installation quantities</u>

The inventory of rock volumes for pipeline and cable crossings for different route sections are shown in Table 3-10. The volumes are based on the Concept Report (Rambøll, 2017) but are expected to increase upon completion of the detailed design (a maximum increase of a factor 2 is assumed).

Table 3-12 Rock volumes for pipeline and cable crossings in Danish waters and disputed area, based on concept design. Each pipeline crossing includes two Nord Stream pipelines.

Route section	Cable crossing	Pipeline crossing	Pre-lay	Post-lay
Danish waters and disputed area	11	2	12,000 m^3	8,000 m^3

As a base case, the pipeline is expected to be protected in shipping lanes by trenching and backfilling. However, in some areas, the detailed design studies may conclude that rock installation is required. The maximum rock volume to be used for the entire route (assuming rock installation is used instead of trenching in all shipping lane areas) is approximately 610,000 m^3, corresponding to a mass of approximately 900,000 tonnes.

3.6 Construction timeline

The construction activities for the whole project are planned to commence in July 2020 and to end in March 2022. Construction of landfalls is expected to commence in October 2020, and the pre-lay seabed interventions work is planned to take begin in November 2020. The actual pipeline installation is expected to be carried out within the period April – August 2021. Post-lay seabed interventions are planned to be carried out within the period September 2021 – January 2022, and first gas is expected to take place, after pre-commissioning and commissioning, on 15 March 2022.

With respect to the Danish part of the project, the following timeline is expected (and is subject to changes as the detailed planning progresses):

Landfall site preparation:	Q4 2020;
Tunnelling:	Q1 – Q3 2021;
Seabed Intervention (pre-lay, post-lay):	Q3 2020 – Q2 2022;
Pipeline Installation:	Q3 2021 – Q2 2022;
Pre-commissioning:	Q2 2022;
Landfall site re-instatement:	Q3 2022 (after pre-commissioning).

3.7 Logistics scenario

The construction of the offshore pipeline and tunnel will require offshore as well as onshore logistics support at shore bases and landfalls. Furthermore, there will be a minor need for logistics support offshore during operation of the pipeline.

Transportation of the prefabricated pipelines to the shore bases is not a part of this EIA.

3.7.1 Onshore logistics at the Danish landfall

The onshore logistics support at the Danish landfall involves transport of materials, soil and personnel.

The volumes of materials and the number of trucks needed for the landfall is shown in Table 3-11. It is assumed that each truck will drive a distance of 50 km to or from the landfall, meaning that each truck will drive 100 km in total. The soil will be transported to an approved storage area, assumed to be approximately 50 km from the construction site.

Table 3-13 Inventory of materials and transportation at the landfall. It is assumed that each truck loads approximately 9 m^3 of earth materials.

	Amount	No. of trucks
Delivery of equipment and materials to work site	-	50
Excavated soil from tunnelling (incl. bulk factor of 1.4)	8,200 m^3	920
Delivery of prefabricated tunnel elements	300 pcs.	150
Demobilisation of work site	-	60
Total		**1,180 trucks**

3.7.2 Coating plant

The pipe joints are coated with concrete and an iron ore mixture in order to obtain the necessary weight for stability of the pipeline. The coating process requires steel pipes (with anticorrosive treatment), cement, steel reinforcement wire and iron ore as a weight additive. It is expected that an existing coating plant will be used. If a new coating plant should be required for the project, the size would be in range of 20,000 m^2 to 40,000 m^2. Storage of uncoated steel pipes is dependent on the transport pattern. The total area for coating and storage is estimated to be approximately 100,000 m^2 to 120,000 m^2 for the planned 23,115 pipes (Rambøll, 2018b).

If it is not possible to use an existing coating plant as expected, and a new coating plant must be built in Denmark, the plant will be regulated by the legislation in force and an environmental approval is required. This will be dealt with in a separate process from this EIA.

3.7.3 Onshore logistics at shore bases

It is expected that shore bases will be established at 1-3 ports in the Baltic Sea. Storage of pipe joints will take place at these ports.

An analysis of the existing ports in the Baltic Sea has identified the following potential support bases (Rambøll, 2018b):

Poland: Swinoujscie;
Germany: Mukran;
Sweden: Malmö, Karlshamn;
Denmark: Køge, Rønne.

Pipe joints for the offshore pipeline will be imported by ships, trains or trucks. Transportation of the prefabricated pipe joints to the shore bases is not included in this EIA. It is estimated that approximately 23,000 pipes will be needed for the total project from Denmark to Poland. The length of the pipes is 12.2 m, and the coated pipe outer diameter is approximately 1.1 m (Rambøll, 2018b). If all pipes are to be stored at the same port, the storage area will occupy an area of approximately 86,000 m^2. An example of storage of weight coated pipe joints is shown in Figure 3-23.

Figure 3-23 Example of storage of weight coated pipe joints in a port (Rambøll, 2018b).

From the shore bases, the pipe joints will be transported by supply vessels to pipe-lay vessels.

3.7.4 Offshore logistics during construction and operation

The offshore logistics during construction includes a number of activities as part of preparation for and construction of the pipeline. The detailed planning of the offshore construction will be undertaken at a later stage by GAZ-SYSTEM S.A. with the contractors that will be selected to carry out the work. A possible inventory of equipment is outlined in Table 3-12, which shows an example based on previous experience with comparable projects.

Table 3-14 Overview of the use of machinery for the construction works for the offshore part of the pipeline. The scenario shown is an example, based on experience from comparable projects.

Activity	Equipment example	Power [kW]
Trenching and backfilling		
Trenching (0-12 m)	Backhoe dredger	1,500
Backfilling (0-12 m)		
Postlay trenching	Ploughing vessel / jet sled vessel	24,000
Backfilling, ploughing		
Rock installation		
Rock installation (sailing)	Fall pipe vessel	6,500
Rock installation (rock installation)	Fall pipe vessel	3,700
Pipe-lay		
Pipe-lay (deep water)	Allseas Solitaire	36,000
Pipe-lay (shallow water)	Allseas Tog More	3,750
Pipe-lay (shallow water)	Anchor handling vessels	10,000
Tie-in (Davit-lift)	Allseas Solitaire	36,000
Pipe supply	Pipe supply vessel	7,700
Other marine logistics		
Crew exchange	Helicopter	3,600
Survey	Survey vessels	7,200

During operation, there will be a minor need for maintenance work related to the rock installations. Furthermore, survey vessels will be used during the entire operating life of the pipeline for geophysical pipeline surveys. Such surveys are expected to take place every year during the first five years of operation and every third-year hereafter. In Table 3-13, the vessels expected used during operation are shown.

Table 3-15 Information about vessels used offshore during operation of the pipeline in the Baltic Sea.

Activity	Equipment example	Power [kWh]
Survey	Survey vessels	7,200
Rock supply (maintenance)	Fall pipe vessel	6,500

3.8 Waste production and management

Waste will be generated during the construction of the Baltic Pipe in both the offshore and onshore areas. Waste production and management within each area is described below.

3.8.1 Waste production and management offshore

Construction of the offshore pipeline will produce some waste, mainly onboard the vessels participating in the construction work. The waste will be managed according to the applicable national and international regulations and standards, including IMO MARPOL 73/78 Annex V, which defines the Baltic Sea as an area where special mandatory methods for the prevention of marine pollution by garbage is required (IMO, 2013). Under MARPOL, the discharge of all garbage to the sea is prohibited, except for 1) cleaning agents and additives (if not harmful to the environment) contained in deck and external surfaces wash water and 2) comminuted or ground food waste if the vessel is ≥ 12 NM from the nearest land and *en route*.

Due to the similarities between the types of projects, the waste types produced from the construction of the Baltic Pipe offshore part is expected to be comparable with the distribution of waste types from the construction of the Nord Stream pipelines (NSP). The distribution of waste from NSP is shown in Table 3-14.

Table 3-16 Distribution of types of waste from offshore construction for the NSP2 project (Rambøll / Nord Stream 2 AG, 2017a).

Waste type	Weight % of total
Concrete (from the concrete coating of the pipes)	46%
Metals (scraps from end millings from the bevelling and welding processes)	25%
General/domestic waste (combustible; plastic, paper, cardboard, food)	23%
Chemicals/hazardous (greases, other oils, paints, electric waste, etc.)	3%
Other (wood from pallets etc.)	3%

Experience from comparable pipeline projects suggest that the total amount of waste when constructing offshore pipelines is approximately 3-4 tonnes per kilometre, i.e. approximately 1,000 tonnes for the offshore part of the Baltic Pipe project.

Concrete waste, which comprises the largest proportion, is typically reused in road construction, and metal waste is recycled. The other types of waste are disposed according to the waste hierarchy of Directive 2008/98/EC on waste (Waste Framework Directive).

The produced waste will be sorted at the source and stored in suitable containers. It will be transported to shore and subsequently transported to licenced waste contractors, which will treat the waste in compliance with local legislation.

Waste management plans will be prepared for vessels participating in the project for ensuring that waste water is delivered to approved port reception facilities in compliance with the HELCOM requirements.

3.8.2 Waste production and management at landfalls

Waste produced at the landfall site in Denmark (and Poland) will be segregated at the source and disposed of according to the waste hierarchy. Special focus will be given to waste from the tunnelling as outlined in Section 3.4, and in particular the slurry and possibly contaminated soil from tunnel drilling activities.

3.9 Pre-commissioning

Before commissioning of the pipeline, pre-commissioning will be conducted. Pre-commissioning includes the activities described in the following (Rambøll, 2018c).

3.9.1 Flooding, cleaning, gauging and hydrotesting

Hydrotesting is carried out after all construction activities (pipe-lay, tie-in and seabed intervention works, including crossing construction) have been carried out.

Hydrotesting requires that the pipeline be water-filled, using seawater pumped into the pipeline through a simple water winning arrangement that includes filtering. To prevent internal corrosion of the line-pipe steel, the seawater may be treated with an oxygen scavenger. A typical oxygen scavenger is sodium bisulphite ($NaHSO_3$), with a required dosage of 65 mg/l (ppm) for an oxygen concentration of 10 ppm. In total, approximately 20,000 kg of sodium bisulphite is expected to be required for flooding of the entire pipeline system (Rambøll, 2018c).

The chemicals planned to be used in the pre-commissioning operation include oxygen scavenger (OR-6045), Mono Ethylene Glycol (MEG) and nitrogen gas. According to the OSPAR classification system for offshore chemicals, these are all classified as chemicals which are considered to Pose Little Or No Risk to the Environment (PLONOR) (Rambøll, 2018c). The environmental concern related to the chemicals is therefore more focused on the fact that the discharged pressure test water will be oxygen-depleted, rather than the possible residual amounts of the used chemicals.

No other chemical additives are planned for the pressure test water. Ultraviolet treatment may be applied to reduce the number of bacteria present in the pressure test water.

If no chemicals are used, the test water is environmentally harmless and may be disposed of at the beach. It may be unsightly, however, and to prevent fouling of the beach, an outlet pipeline may be installed into the surf area. The outlet would be provided with a diffuser head, ensuring that any chemicals (if topical) are diluted to concentrations (of remaining chemicals and of dissolved oxygen) that are not harmful to aquatic wildlife.

The layout of the work site which will be established for hydrotesting is the same area as shown in Figure 3-4.

Intake of the water will occur in Faxe Bugt. After hydrotesting, the hydrotest water will be discharged back to sea via temporary discharge lines in Denmark, also in Faxe Bugt. The end of the discharge lines will be placed at a minimum of 4 m water depth. A discharge permit will be applied for in accordance with the applicable Danish statutory requirements before discharge can take place.

It shall be documented that there are no dents in the line-pipe wall which could induce failure over the long term or obstruct the passage of cleaning and batching pigs. For this purpose, gauging and caliper pigs are propelled through the pipeline during water filling. The caliper pig is a so-called intelligent pig, equipped with sensors that measure the internal diameter at a number of points around the circumference.

During and after water filling, the pipeline interior shall be cleaned. The cleaning trains include both brush pigs and swabbing pigs, the latter removing any brushes that may have broken off. The pig trains are normally propelled by the treated seawater pumped in for the purpose of the hydrotesting, but further cleaning by running brush and swabbing pigs in air may take place during and after de-watering. In Figure 3-24 a typical flooding, cleaning, and gauging pig train is shown.

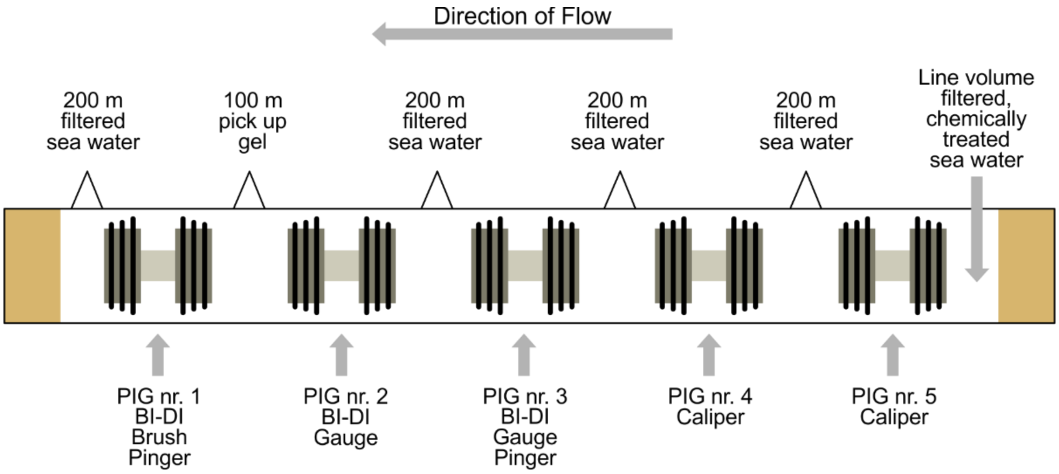


Figure 3-24 Example of pig train used for flooding, cleaning and gauging. For the present project, four pigs are anticipated.

The cleaning operation may be facilitated by gel-plug technology. A gel (pick-up gel) is a plastic fluid with the capability to pick up loose and loosely adhering solids. The gel slug is inserted into the pipeline, followed by an appropriately designed scraper pig. Approximately 10-20 m3 of biodegradable pick-up gel is expected to be used. The debris and pick-up gel will be deposited at a controlled waste plant at the receiving end in Poland.

In total 170,000 m3 sea water will be used for the precommissioning activities. The volume of filtered sea water for flooding, cleaning and gauging (FCG) is approximately 720 m3 (0.4% of total). The filtered sea water used for the FCG operation will need to be collected upon arrival at the Polish land in temporary water storage tanks (Rambøll, 2018c). The temporarily stored water will be led back to the pipeline system along with 720 m3 fresh water, used to desalt the pipeline system. As mentioned previously, a discharge permit will be applied for in accordance with the applicable Danish statutory requirements before discharge can take place.

3.9.2 De-watering and drying

For the Baltic Pipe, a temporary outfall pipeline will be constructed so that the hydrotest water can be discharged at sea, after separation of solids in a settling pond. The water is discharged through a diffuser head to ensure dilution to a concentration that reduces risk to marine life. These problems can be mitigated by flooding with untreated test water, as discussed above, or using oxygen scavenger only. During the dewatering operation, the test water is not envisaged to be treated.
Pipeline de-watering runs are carried out by means of air-propelled pig trains during or after cleaning, see above. A typical de-watering pig is shown in Figure 3-25.

Figure 3-25 Typical de-watering pig.

As the pipeline is to be used for natural gas, complete removal of moisture is necessary, as any residual water may react with the gas to form hydrates, which may obstruct the flow and impair the proper functioning of valves. The presence of water will also make any impurities of hydrogen sulphide (H2S) and carbon dioxide (CO2) highly corrosive. To dry the pipeline, the following methods may be used, alone or in combination:

- MEG conditioning;
- Dry air drying;
- Vacuum drying.

With the MEG conditioning method, a batch of MEG is enclosed between pigs and propelled through the pipeline by compressed air. Residual water will be dissolved in the hygroscopic substance, leaving a film that is mostly MEG.

An alternative procedure, which combines cleaning and drying in one operation, is gel pigging, as described above. Modern gel-forming agents can produce gels from an array of liquid components. By incorporating gels based on hygroscopic fluids, such as MEG, into the cleaning train, the water is removed along with the debris. For this project, the volume of pick-up gel (which will be biodegradable) is expected to be 10-20 m3. The debris and the pick-up gel will be delivered to a controlled waste plant.

Dry air drying utilises the ability of dry air to contain a large amount of water as vapour, whereas vacuum drying relies upon the lowering of the boiling point of water at low pressures. For the 250-300 km long offshore portion of the Baltic Pipe, the vacuum pumps would need to work for several days to decrease the pipeline pressure below a few millibar. To limit the required time, vacuum drying is often used as the last step, i.e. after most of the water has been removed by MEG conditioning or gel pigging.

3.9.3 Nitrogen purging and gas filling

To prevent any internal corrosion between pre-commissioning and operation, in case the pipeline is not immediately operational, the pipeline may be filled with a non-corrosive gas, such as nitrogen.

When completed, the pipeline is found in what would normally be the final 'hand-over' condition, and the installation or pre-commissioning contractor will de-mobilise. Gas filling of the pipeline takes place during commissioning of the pipeline system, including the onshore sections and the compressor station(s). The commissioning procedure, prepared by the pipeline operator, shall focus on the onshore compressor stations, and not be limited to the activity related to the offshore pipeline section.

3.9.4 Pigging and monitoring

As explained above, the pre-commissioning activities entail the insertion of pig trains, thus temporary facilities for launching and receiving pigs will need to be installed at each landfall and removed again prior to tie-in of the adjoining onshore sections. As the medium is dry sales gas, no operational pigging is foreseen, but to monitor the integrity of the pipeline system, inspection pigging using intelligent pigs should be carried out at regular intervals. The corresponding bi-directional pigging facilities will typically be installed at the compressor station in Denmark and the receiving station in Poland.

The internal inspection monitors the following aspects:

- Internal diameter (presence of dents);
- Wall thickness (metal loss due to corrosion).

In addition, external inspections by remotely operated vehicles (ROV) and cathodic protection (CP) measurement equipment are carried out at regular intervals, to monitor the general condition of the pipeline, the as-built survey serving as a baseline.

The external inspection monitors the following aspects:

- General condition (debris or snagged equipment);
- Free span development (scouring);
- CP performance (functioning of anodes).

3.10 Commissioning and operation

3.10.1 Commissioning

Commissioning includes the filling of the pipeline with gas for the first time and includes all activities that occur after pre-commissioning until the moment when the pipeline is ready for gas transfer.

After pre-commissioning, the pipeline will be filled with dry air. To prevent a mixture of air and dry gas immediately before injection, the pipeline will be filled with nitrogen (an inert gas), which will work as a buffer between the air and the gas.

The pipeline volume is approximately 170,000 m^3. Assuming that the pipeline will be completely nitrogen filled to a pressure of 12 bar, the standard nitrogen volume will be approximately $2 \cdot 10^6$

Nm^3. A typical capacity for mobile nitrogen plants is 5,000 Nm^3/hr; therefore, assuming that two mobile nitrogen plants will be used, it will take 1-2 weeks to fill the entire Baltic Pipe pipeline to a nitrogen pressure of 12 bar.

When adequate separation has been provided by nitrogen, the natural gas is introduced from one end (Danish compressor station). At the opposite end, the air and nitrogen will be discharged through an air silencer or flare, until gas content/traces are detected (Polish receiving terminal).

The air and nitrogen emissions do not cause any environmental impact, and it will be ensured that the emission facilities are designed to ensure that there also will be no health impacts.

3.10.2 Operation

The expected pipeline life is 50 years. During that period, constant supervision of the gas transfer as well as scheduled and unscheduled checks and works related to maintenance will be carried out.

During the pipeline operation, technical operations will be conducted with the purpose of ensuring the integrity of the pipeline, and in particular maintaining the proper pressure and securing the infrastructure.

These activities will include geophysical surveys to control the integrity of the pipeline and the surrounding seabed. Also, pigs will be used for monitoring the wall thickness and the possible corrosion of the pipeline.

Supervision of the gas transfer will be carried out from the project management centre at a location to be designated at a later stage of the project.

3.11 Decommissioning

The Baltic Pipe offshore pipeline will be constructed based on a design life of 50 years of operation. After this period (and a possible prolongation), the pipeline system will be decommissioned.

Below is an overview of the existing legislation and best practice with respect to decommissioning of offshore pipelines. The actual method of decommissioning will be agreed with the relevant authorities in due time before the decommissioning activities. In addition, an EIA (or equivalent) will be prepared to assess the impact on the environment. It is not possible to detail the method to be used at this time, as it will depend on the legislative regime as well as the technical options available at the time of decommissioning.

3.11.1 International legislation and best practice

The overriding principle of all international regulations and guidance is that decommissioning activities should not result in any harm to other users of the sea or to the environment (IOGP, 2017).

The process of decommissioning is regulated by international, regional and national conventions and legislation in terms of the removal of installations (primarily concerned with safety of navigation and other users of the sea) and disposal of materials (primarily aimed at pollution prevention). The primary conventions are noted below:

- **United Nations Convention on the Law of the Sea (UNCLOS), 1982**. Article 60 contains provisions on the construction and removal of offshore installations and requires coastal State authorization for any installation or structure intended to remain on the seabed.

- **London (Dumping) Convention, 1972.** The convention (and the subsequent 1996 Protocol) promotes effective control of all sources of marine pollution and provides generic guidance for any wastes that can be dumped at sea. New guidelines, which specified different classes of waste, including platforms and other man-made waste, were adopted in 2000.
- **International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, 1978.** MARPOL sets the standards and guidelines for the removal of offshore installations worldwide.
- **Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention), 1992, 1998.** The OSPAR Convention seeks to prevent and eliminate pollution of the marine environment in the North-East Atlantic from land-based sources, dumping and incineration, and offshore sources. The OSPAR Convention does not include the environment of the Baltic Sea, which is regulated by the HELCOM Commission.

None of the international guidelines provide guidance in relation to pipelines or cables (IOGP, 2017). And no specific guidelines exist for decommissioning in the Baltic Sea.

For the North Sea / North Atlantic, Norway and the UK have developed guidance notes on decommissioning. They mainly concern decommissioning of offshore installations, but they also address decommissioning of pipelines and cables.

The Norwegian requirements regarding decommissioning of pipelines have been expressed in the Norwegian Parliament White Paper No. 47 of 2001 (Norwegian Parliament, 2001). As a general rule, pipelines and cables may be left in place as long as they do not cause obstruction or present a safety risk for bottom fishing, considering the costs of burial, covering or removal of these items. Final decisions on the disposal of infrastructure within Norwegian territory are made by the Norwegian authorities. The following disposal solutions are usually considered:

- Clean and leave *in situ*;
- Burial/trenching;
- Rock installation;
- Removal.

As a response to the above, Norwegian industry guidelines on environmental impact assessment for offshore decommissioning were developed (DNV, 2001). An overview of the various technical options for decommissioning is provided in DNVGL-RP-N102, 2017.

The UK authorities have issued guidance notes on decommissioning of offshore oil and gas installations and pipelines (BEIS, 2017). As these are most likely the best-developed existing guidelines, they are briefly outlined below.

The general approach to decommissioning of pipelines includes the following:

- All feasible decommissioning options should be considered, and a comparative assessment should be made;
- Any removal or partial removal of the pipeline should be performed in such a way as to cause no significant adverse effects upon the marine environment;
- Any decision that a pipeline may be left in place should be regarded as to the likely deterioration of the material involved and its present and possible future effect on the marine environment;
- Account should also be taken of other users of the sea, and the future fishing activities in the area.

Determination of any potential effect on the marine environment at the time of decommissioning should be based upon scientific evidence. The factors to be considered should include (BEIS, 2017):

- The effect on water quality and geological and hydrographic characteristics;
- The presence of endangered, threatened, or protected species;
- Existing habitat types;
- Local fishery resources;
- The potential for pollution or contamination of the site by residual products from, or deterioration of, the pipeline.

To evaluate the potential environmental impact, it is necessary to evidence the contents of the pipeline and outline the cleaning operations that will be undertaken (BEIS, 2017).

Where it is proposed that a pipeline should be decommissioned in place, either wholly or in part, then the decommissioning programme should be supported by a suitable study which addresses the degree of past and likely future burial/exposure of the pipeline and any potential effect on the marine environment and other uses of the sea. The study should include the survey history of the pipeline with appropriate data to confirm the actual status of the pipeline including the extent and depth of burial, trenching, spanning and exposure. It should also detail levels of fishing activity in the area (BEIS, 2017).

Where rock-dump has been used to protect a pipeline, it is recognised that removal of the pipeline is unlikely to be practicable and it is generally assumed that the rock-dump and the pipeline will remain in place. Where this occurs, it is expected that the rock-dump will remain undisturbed (BEIS, 2017).

3.11.2 Danish legislation and best practice

Generally, the same legislation that is applicable for the construction and operation of offshore pipelines are relevant for the decommissioning phase. This legislation will naturally have been updated when it is time for decommissioning of the Baltic Pipe offshore pipeline.

A group of Danish oil & gas industry companies carried out an exercise for describing future decommissioning of offshore facilities in the Danish sector of the North Sea in 2013 (Fornyelsesfonden, 2013). The study included plans for the decommissioning of three pipelines by *in situ* decommissioning or by removal to shore for reuse, recycling, or disposal as appropriate.

The pipelines in the Danish North Sea have a history of stable burial, as demonstrated by survey records. Using a comparative assessment of the technical, safety, environmental, and societal impacts, the study recommended that pipelines be decommissioned by *in situ* decommissioning, with appropriate remedial work at the pipe ends and crossings by trenching, burying, or cutting out problematic sections where practical. The area would subsequently be subject to a post-decommissioning environmental survey, and the pipelines would remain the responsibility of the operator and be subject to an agreed monitoring programme to ensure that the lines remain free of hazards to other sea users (Fornyelsesfonden, 2013).

According to Section 4(2) of the Danish legal order on certain pipeline installations in the TW and the EEZ[3], the Danish Minister for Energy, Utilities and Climate (*Energi-, Forsynings- og*

[3] Danish Legal Order no. 1520 of 15/12/2017 on certain pipeline installations in the TW and EEZ *(Bekendtgørelse om visse rørledningsanlæg på søterritoriet og kontinentalsoklen)*.

klimaministeren) can in the permit to establish and operate pipelines, determine how the pipeline decommissioning shall take place.

3.11.3 Environmental impacts of decommissioning

In case the pipeline is left *in situ*, the potential environmental impacts will, for a number of years, be comparable to some of the impacts caused by the presence of the pipeline during the operational phase. This includes the continued presence of the pipeline on the seabed, which potentially leads to a "reef effect", and there can potentially be an impact on commercial fisheries. Also, there will be a continuation of the release of metal from the sacrificial anodes (see Section 5.2.5).

In addition to the above, there will be a release of mainly iron from the gradual corrosion of the steel pipelines in the marine environment. This release will be slow and is not expected to have any negative impact on the marine environment.

In case the pipeline is fully or partly removed, the potential impacts on the marine environment are expected to be comparable to the impacts of construction of the entire or parts of the offshore pipeline. In addition, there will be a large amount of materials recovered, which will partially cause waste creation, and partially provide resources for recycling (e.g. the pipeline steel).

4. RISK ASSESSMENT

4.1 Introduction

In Chapter 3, Project description, the planned activities have been described. As part of the design of the project, all significant hazards (i.e. potential sources of harm) have been identified (Rambøll, 2018f).

Risk is defined as the likelihood of an accidental event combined with the consequence of the event. For the offshore part of the Baltic Pipe project, detailed risk analyses have been carried out and documented in the Construction Risk Analysis, CRA (Rambøll, 2018g) and in the Quantitative Risk Assessment, QRA (Rambøll, 2018h) for the construction and operational phases, respectively.

In the following, a summary of the results of the risk assessment related to the risk of environmental accidents and the risk to the population (3rd party risk, or societal risk) is provided. With respect to the working environment and the risk to personnel participating in the construction work, reference is made to the above-mentioned CRA report.

The framework for controlling the risks during construction and operation is the Health, Safety and Environmental Management System of the operator Gaz-System S., as outlined in Appendix A.

4.2 Application of the ALARP principle

Design of the Baltic Pipe project has been carried out using the principle of reducing the risk to a level As Low As Reasonably Practicable (ALARP). This principle is illustrated in Figure 4-1.

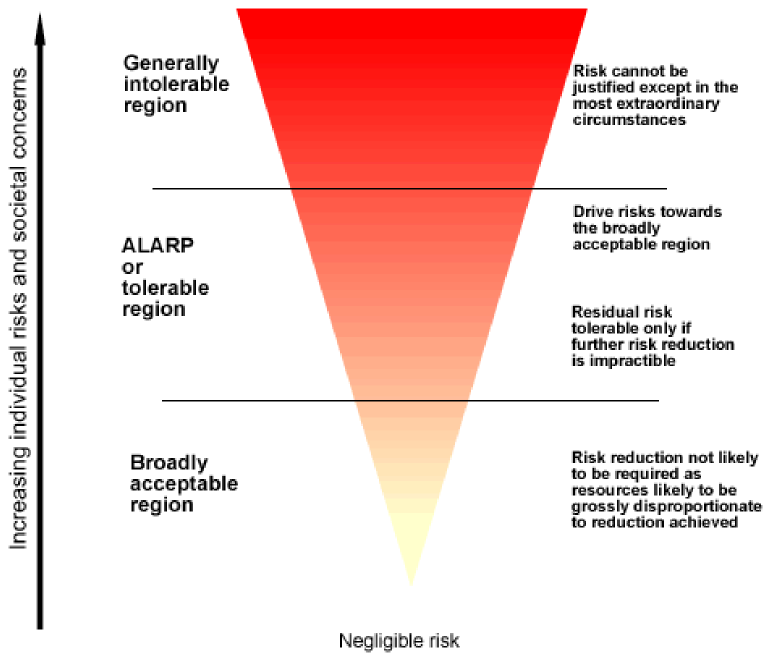


Figure 4-1 The ALARP triangle. Risks in the upper, generally intolerable region should always be reduced, as the risk exceeds legal requirements, company performance standards or similar. Risks in the ALARP region need to be reduced to a level As Low As Reasonably Practicable (ALARP), i.e. until the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained.

ALARP demonstration is the final step of the risk assessment methodology to identify whether there is any reasonably practicable additional safety measure that could be implemented to reduce the risks. ALARP demonstration for the offshore part of the Baltic Pipe project is documented in the ALARP report for the project (Rambøll, 2018i).

4.3 Risk acceptance criteria

The risk assessment criteria (RAC) established for the Baltic Pipe Offshore Pipeline are in line with the industry best practice based on previous experience from large offshore pipeline projects, as documented in the Design Safety Philosophy for the project (Rambøll, 2018j).

For human safety, a RAC has been established for individual risk (IR), which is the risk of loss of life for individuals (i.e. each individual person). The criterion is different for 1st and 3rd persons.

For 1st person (a person involved in work for the project, e.g. the installation contractor), the fatal accident rate (FAR) should be <10 per 10^8 exposure hours for pipeline installation.

A 3rd party is defined as any person from the public who could be exposed to activities originating from GAZ-SYSTEM S.A. (e.g. the public at landfalls or passengers on ships). Societal risk (or group risk) is the risk of loss of life for a population (i.e. a number of different individuals and groups of people). A tolerance criterion has only been defined for 3rd persons and it is described by the F-N curve in Figure 4-2. Risk levels below the unacceptable level are in the ALARP region and shall be evaluated according to the ALARP principle (see Section 4.2).

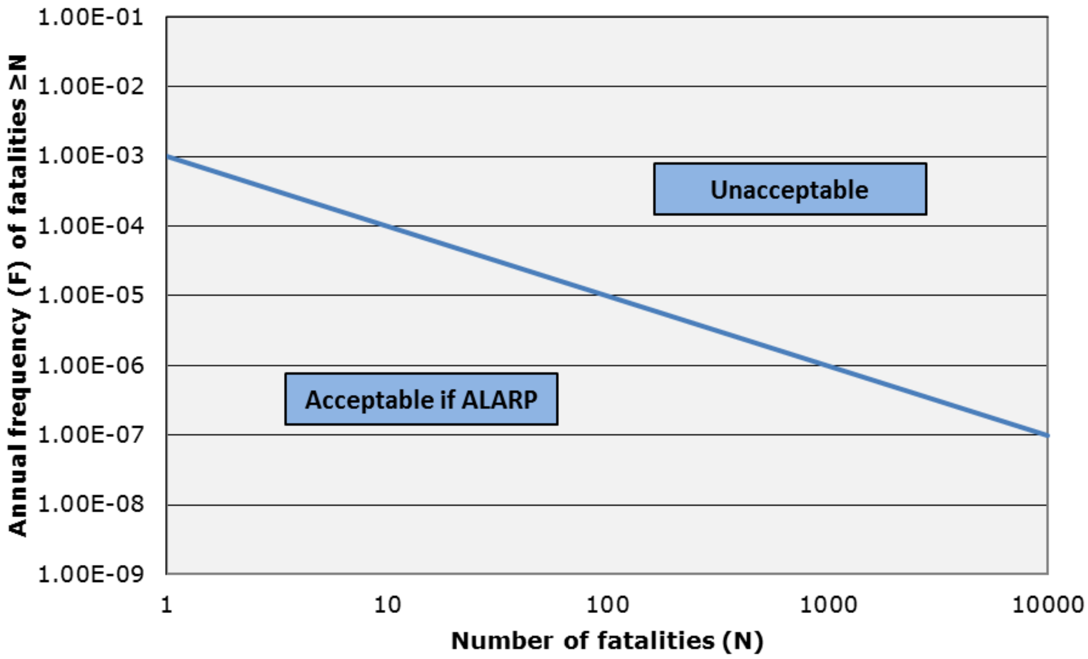


Figure 4-2 Risk acceptance criterion for 3rd person societal risk (Rambøll, 2018j).

The most critical 10 km section along the pipeline is evaluated against the tolerance criteria, including risks from all relevant accidental scenarios.

4.4 Hazard identification

A HAZID workshop was carried out in Copenhagen, Denmark on 20-21 June 2018 with the focus on identification of issues and hazards, which will influence the design and layout of the Baltic

Pipe offshore pipeline and form the starting point for the risk management process for the design of the offshore pipeline.

The conclusion from the HAZID study is that the main challenges related to the Baltic Pipe project are the following (Rambøll, 2018f):

- The pipeline will be routed through areas with a high density of ship traffic, making quantitative risk assessment (QRA) an important tool to ensure that appropriate protection is installed along relevant lengths of the pipeline.
- The pipeline will cross a number of cables and most importantly the Nord Stream pipeline(s). This requires a well-developed crossing design, where the crossing location, height of the crossing structure and avoidance of electromagnetic corrosion are taken into account.
- The pipeline will cross close to, and possibly into a military submarine exercise area (Note: this issue is no longer relevant, given the selection of the preferred route). The risk related to this shall be handled carefully.
- The pipeline will pass through one Natura 2000 site in Swedish EEZ and two in Polish waters. The planned EIA must focus on a number of key concerns and is expected to further clarify any complications related to pipeline installation through these areas.
- Most of the hazards in the installation phase are related to asset risks, in particular project delays.
- The planning of the installation phase as well as clearly defined requirements for all contractors involved in the installation phase are critical to reducing the risks for a variety of hazards.
- Seabed intervention work as well as potential UXO objects or chemical warfare agents (CWA) along the pipeline route.
- Man-access to the tunnel, which will require focus during the execution phase of the project. The hazards related to the tunnel are: operation in a confined space under compressed air, retrieval of the TBM and heavy/blind lifting at the work site. The latter two risks are considered level III human safety risks.

All identified hazards are detailed in a HAZID register, which includes 15 main actions and a number of sub-actions. The follow-up and closing of the actions, together with the residual risk assessment, is an important step of the risk management process in order to demonstrate that an effort has been made to eliminate, prevent, control and mitigate the hazards and that the risk has been reduced to ALARP, as outlined in Section 4.2.

4.5 Ship traffic

The ship intensity in the area of the pipeline has been analysed using historical Automatic Identification System (AIS) data from 2016. Only ships with a gross tonnage (GT) over 300 GT are obliged to have AIS equipment installed. To account for the increasing ship traffic intensity in the future, the ship traffic is estimated for the year 2032, which is 10 years after operation start, for use in further analysis.

The majority of the ship traffic in the area follows the various shipping lanes in the southwestern part of the Baltic Sea (see Figure 4-3). The main directions of ship traffic are east-west from the inner Baltic Sea and towards the Fehmarn Belt, north-south from southern Scania (Trelleborg/Ystad) to Swinoujscie, and north-southwest from southern Scania (Trelleborg/Ystad) to the Fehmarn Belt (Rostock/Lübeck). To increase navigational safety, the ship traffic between Bornholm and Sweden is regulated by the Bornholmsgat Traffic Separation Scheme (TSS), which separates the ship traffic towards the southwest from the ship traffic towards the northeast.

As seen in Figure 4-3, seven different critical zones have been identified along the pipeline. All the critical zones are located within the major traffic lanes where the release frequency is high.

Red dots indicate KPIs (Kilometre Point Intervals; i.e. one-kilometre distance from the Kilometre Point (KP) to the forthcoming KP) in which the release frequency is critically high and yellow dots indicate KPIs included in the critical zone to extend it zone to a fitting length.

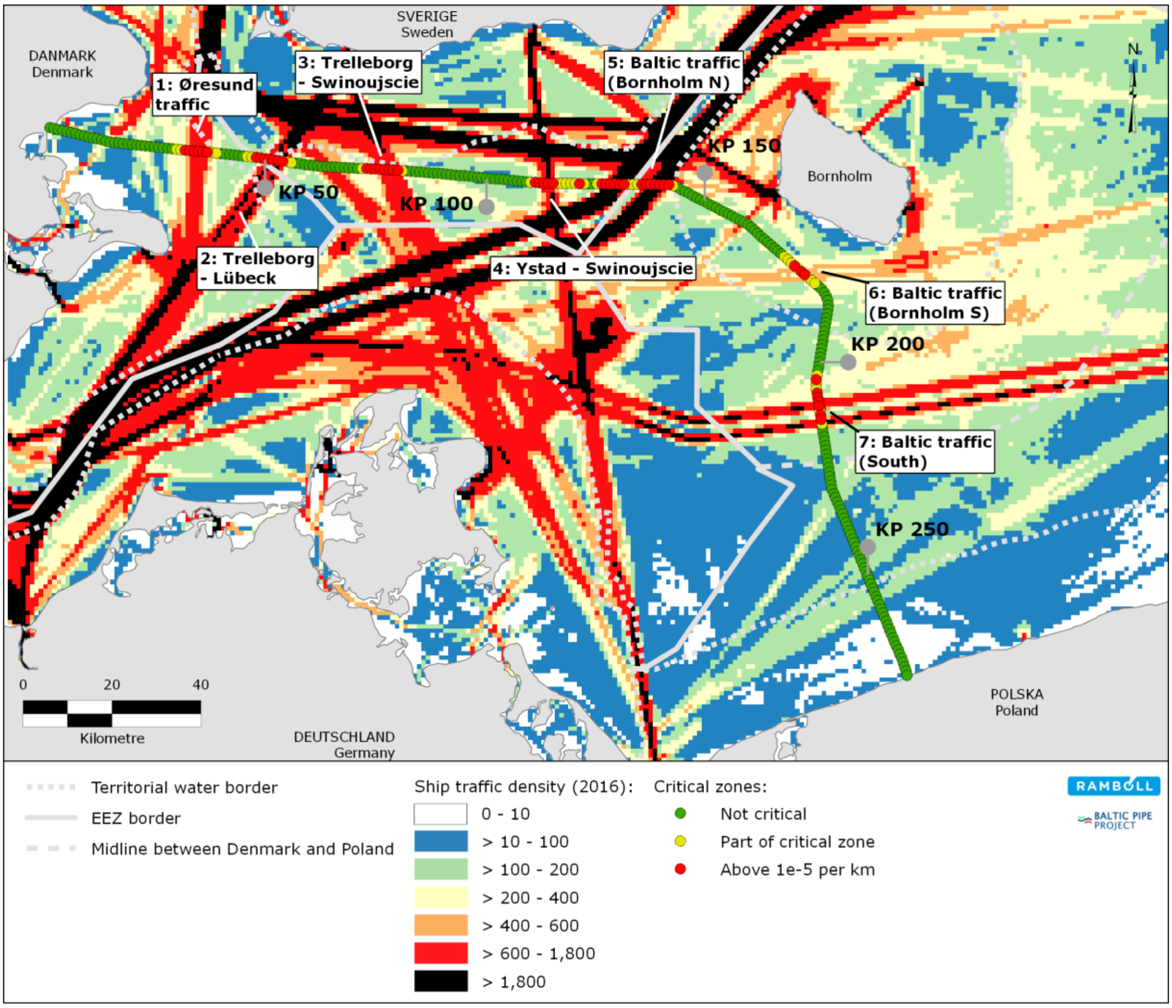


Figure 4-3 Ship traffic intensity map based on AIS data from 2016 (Rambøll, 2018h).

The yearly ship traffic across the pipeline route is shown in Figure 4-4. To account for the increased maritime activity in the future, ship traffic is estimated for the year 2032, which is 10 years after operation start.

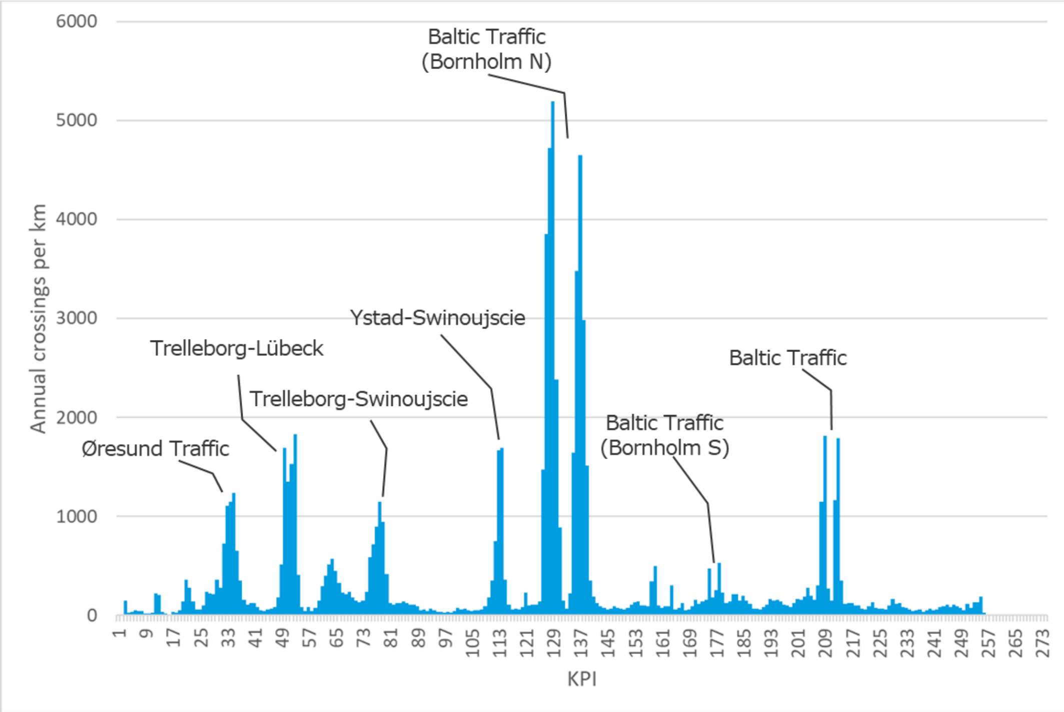


Figure 4-4 Expected annual ship crossings along the Baltic Pipe route in 2032 (Rambøll, 2018h).

4.6 Hazards and risks during the construction phase

4.6.1 Methodology

During construction of the offshore Baltic Pipe pipeline, there will be an incremental increase in ship traffic in the project area, due to the presence of the work vessels. The main contribution to the incremental increase is by the pipe-lay and seabed interventions work vessels travelling along the pipeline route, and the pipe carrier vessels supplying the lay barge from one or more shore bases. The shore base(s) to be used during the construction phase have not been selected yet, but the considered locations are outlined in Section 3.7.3, Onshore logistics at shore bases. In order to be able to carry out a risk analysis regarding the pipe carrier vessel, the calculations have been made assuming that Rønne is used as the shore base for the storage of the pipe sections. The pipe-lay vessel, the seabed interventions work vessels and the pipe carrier vessels all cross ambient ship traffic lanes (see Figure 4-3), which increases the risk for ship-to-ship collisions that result in loss of life or substantial oil releases.

As part of the Baltic Pipe CRA, Rambøll, 2018g, it was concluded that mitigation measures will be recommended for pipe-lay and rock lay vessels, in order prevent potential collisions with ambient traffic. Mitigation measures include the use of notices to nearby mariners, safety zones and AIS (Automatic Identification System) communication technology. These mitigation measures have been included in the following results.

4.6.2 Risk related to oil spills

The risk of larger oil spills during the construction phase is related to the risk of third-party vessels colliding with one of the work vessels participating in the construction works. In addition to this, there is a risk of minor oil spill from e.g. bunkering operations. The main risks of oil spill are related to third-party collision with the lay barge, and, to a minor extent, third-party collision with other construction vessels. In particular, these risks are linked to the critical zones where the pipeline crosses shipping lanes (see Figure 4-3, Figure 4-4 and Table 4-2).

The frequencies of oil spills of various sizes have been calculated for the various parts of the pipeline route (see Table 4-1). Spills from bunker operations, which can have a size of 0-200 tonnes of bunker oil, are in a separate row. The spills in the remaining rows have been calculated for lay barges and seabed interventions work vessels after implementation of mitigation measures, and for the pipe carried without mitigation measures. The methods and assumptions for the calculations are documented in Rambøll (2018g).

Table 4-1 Frequencies of oil spills of various size during the construction period. Bunker spill, which is in the range 0-200 t, is shown in a separate row.

Oil spill size [tonnes]	Denmark	Sweden	Poland	Disputed zone	Total
200 (bunker)	7.12×10^{-5}	8.56×10^{-5}	1.47×10^{-6}	1.34×10^{-5}	1.72×10^{-4}
500	1.67×10^{-5}	1.89×10^{-5}	2.26×10^{-7}	3.53×10^{-6}	3.93×10^{-5}
1,000	7.70×10^{-6}	$8,80\times10^{-6}$	9.73×10^{-8}	1.57×10^{-6}	1.82×10^{-5}
10,000	4.82×10^{-6}	5.39×10^{-6}	6.59×10^{-8}	1.01×10^{-6}	1.13×10^{-5}
50,000	1.06×10^{-6}	1.32×10^{-6}	8.79×10^{-9}	1.98×10^{-7}	2.58×10^{-6}
100,000	1.26×10^{-7}	1.59×10^{-7}	5.41×10^{-11}	1.64×10^{-8}	3.02×10^{-7}
>100,000	2.52×10^{-8}	3.18×10^{-8}	1.08×10^{-11}	3.28×10^{-9}	6.03×10^{-8}
Total	$\mathbf{1.02\times10^{-4}}$	$\mathbf{1.20\times10^{-4}}$	$\mathbf{1.87\times10^{-6}}$	$\mathbf{1.97\times10^{-5}}$	$\mathbf{2.43\times10^{-4}}$

As expected, the frequencies of small spills from bunker operations are higher than the frequency of larger spills as a consequence of a potential collision between a third-party vessel (oil tanker) and a work vessel. The frequency of oil spills caused by vessel collision is highest in Danish and Swedish waters, which coincide with the areas where the ship crossing traffic is highest, as outlined in Figure 4-4.

Risk acceptance criteria are usually related to human safety and not to the risk of oil spills. Also, because larger oil spills are fortunately relatively rare, it is difficult to find statistics to compare with for establishing whether the calculated spill frequencies are acceptable. Figure 4-5 shows FN-curves for annual spill frequencies of oil and chemicals, respectively, for an average offshore installation on the UK continental shelf during the period 2005-2010. This figure is not directly comparable with the conditions related to construction of a pipeline in the Baltic Sea, but it does, however, give an indication of what is considered acceptable in other industries with very high safety requirements and in a comparable environment.

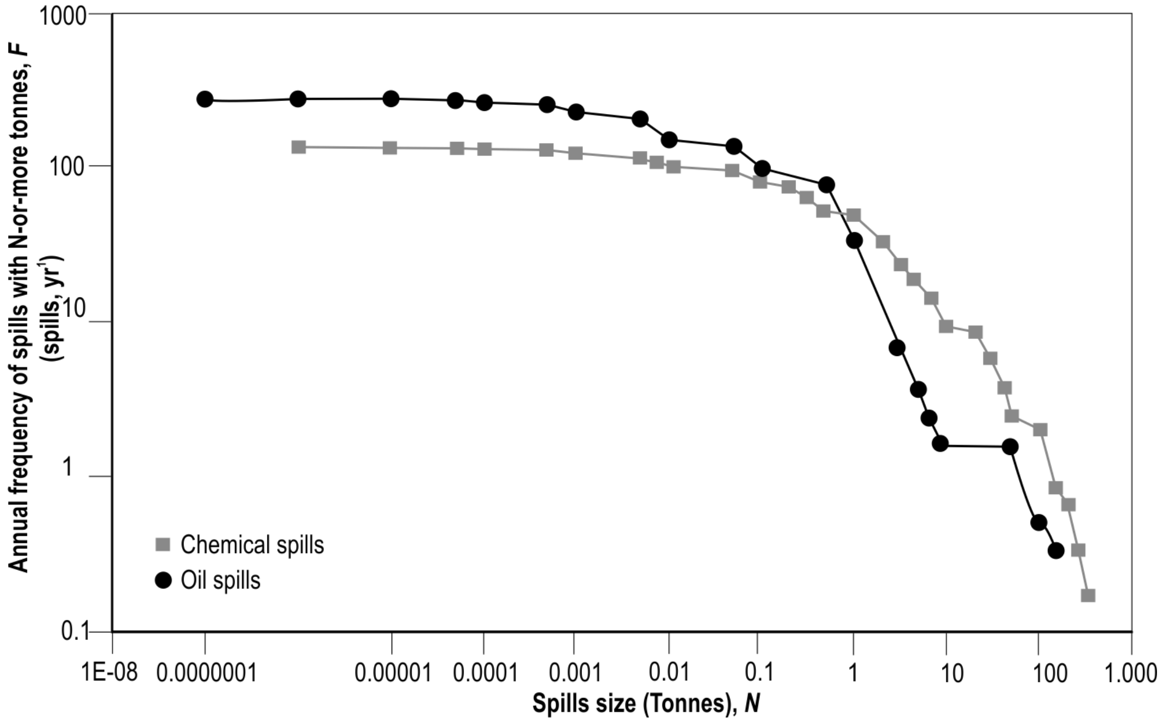


Figure 4-5 FN-curve for accidental releases of oil and chemicals, respectively, normalised to an average offshore installation (drilling or producing platform) on the UK continental shelf. The data are based on statistics for all UK offshore installations for the period 2005-2010 (after Energy Institute, 2012).

Figure 4-5 shows that no oil spills larger than 2-300 tonnes occurred in the area/period serving as the basis for the figure. The annual frequency of a spill in the range of 10-100 tonnes is on the order of magnitude of 10^{-2} to 10^{-3} for an average offshore installation on the UK continental shelf during the period 2005-2010. When comparing with the calculated frequencies for the construction period for the Baltic Pipe (Table 4-1), these are on the order of magnitude of 10^{-4}-10^{-5} spills, i.e. the likelihood of an oil spill as a consequence of the construction of the Baltic Pipe is on the order of magnitude of 10^{-2}-10^{-3} of the yearly likelihood of an oil spill from an offshore oil and gas installation on the British continental shelf. It is expected that this proportion is also the same for larger oil spills than the spills coverer by the statistics shown in Figure 4-5.

The above shows that the frequencies of possible oil spills as a consequence of the project are low, relative to e.g. oil and gas exploration and production, which have an inherent risk of oil spills. This is due to the fact that the project does not introduce oil to the area, except for bunker oil on the vessels. Therefore, the risk of a major oil spill as a consequence of the project is solely related to the possible interaction between work vessels and third-party tankers etc. The risk of oil spill introduced by the Baltic Pipe project is comparable to the risk introduced by many other maritime activities in the Baltic Sea, including commercial fishing, shipping, etc.

4.6.3 Risk to human safety (3rd party)

The risk to third-party personnel has been calculated using the same ship traffic data that were used for the oil spill frequency calculations. The method and assumptions are documented in Rambøll, 2018g.

Societal (3rd party) risks are evaluated using an FN-curve, which plots the number of fatalities (N) against the annual frequency (F) of incidents with fatalities ≥N. The FN-curve is presented for the pipeline construction phase for a situation with no mitigation for the lay barge and pipe carrier, for a situation with mitigation for both the lay barge and the pipe carrier, and for a situation with mitigation for the lay barge only in Figure 4-6.

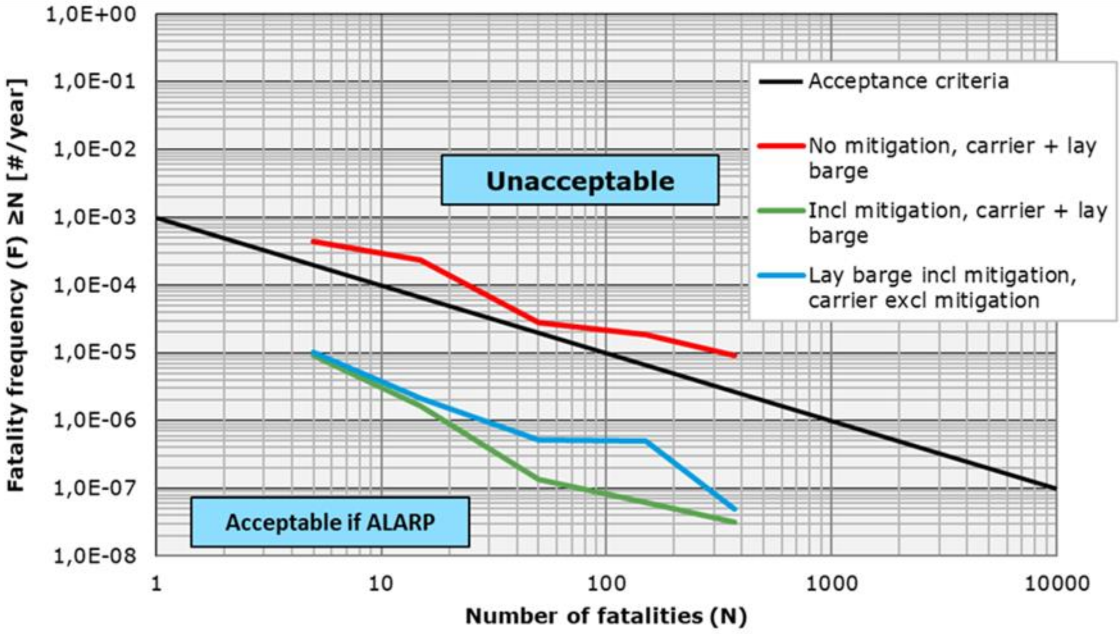


Figure 4-6 FN-curve illustrating societal risk (3rd party) for the construction phase, for the most critical 10 km sections of the pipeline. The frequencies have been calculated before and after mitigation measures have been implemented for the lay barge and the pipe carrier, and for the situation with mitigation measures for the lay barge, but not for the pipe carrierpipe carrier and rock installation vessel (Rambøll, 2018g).

When comparing with the risk acceptance criteria (Section 4.3), the risk to third-party is well below the acceptance criteria for the situations with mitigation for the lay barge, i.e. in the ALARP zone, where risks need to be reduced to a level as low as reasonably practicable.

4.6.4 Environmental consequences of oil spills during construction

Due to the low probability of oil spills of the consequence of the Baltic Pipe construction works (see Section 4.6.2), no modelling of the dispersion of oil has taken place for this project. The below is a short qualitative overview of the potential consequences of a possible oil spill.

Oil spilled to the marine environment will rapidly spread out and move on the sea surface with wind and currents, while undergoing a number of chemical and physical changes (weathering). Some of these processes, such as the natural dispersion of the oil into the water, lead to the removal of the oil from the sea surface, and facilitate its natural breakdown in the marine environment. Others, particularly the formation of water-in-oil emulsions, cause the oil to become more persistent, and remain at sea or on the shoreline for prolonged periods of time (ITOPF, 2014a).

Oil may impact the environment by one or more of the following mechanisms (ITOPF, 2014b):

- Physical smothering with an impact on physiological functions;
- Chemical toxicity giving rise to lethal or sub-lethal effects or causing impairment of cellular functions;
- Ecological changes, primarily the loss of key organisms from a community and the takeover of habitats by opportunistic species;
- Indirect effects, such as the loss of habitat or shelter and the consequent elimination of ecologically important species.

More specifically, if oil spill is introduced to the Baltic Sea, direct impacts can occur on seabirds and marine mammals by smothering of feathers and skin and ingestion of oil adhered to the food source (HELCOM, 2018a). More indirectly, oil spill introduces a severe threat to marine life throughout the food web from plankton to seabirds, where especially polycyclic aromatic hydrocarbons (PAHs) can cause impacts on both invertebrates and vertebrates due to their carcinogenic, mutagenic and lethal effects. PAHs can accumulate in fatty tissue and be introduced via plankton to higher level organisms.

As the risk of oil spill from the Baltic Pipe project is low, the risk and detailed impact assessments will not be dealt with further.

4.7 Risk related to possible munitions finds

As outlined in Section 5.1.4, the pipeline route extends through areas where there is a risk of encountering both conventional and chemical munitions. Potential munitions objects will as far as possible be avoided by designing the route based on the findings from the geophysical surveys (see Section 3.5.1 Seabed preparation). There is, however, a risk that e.g. buried munitions objects may be encountered during the detailed magnetometer survey carried out prior to pipe-lay.

An overall UXO hazard location plan is shown in Figure 5-8. The pipeline route in Danish waters extends through an area where British mine fields were established during WWII and where German mines have also been placed. For the part of the pipeline near the Danish landfall, there is also a risk of encountering shells from the artillery at Stevnsfortet, which was in operation until 2000; namely, small munitions objects with charges of approximately 10 kg TNT each (Rambøll, 2018k). For the part of the pipeline southwest of Bornholm, there is additionally a risk of encountering chemical munitions.

Identification of unexpected occurrences of munitions objects are in the following denoted unplanned events, whereas accidental events related to munitions are events where uncontrolled detonation of explosives or exposure to CWA takes place.
A plan for UXO strategy has been developed and is presented in Appendix B.

4.7.1 Risk related to unplanned conventional munitions encounter

The strategy for identifying and mitigating possible munitions objects along the pipeline route is outlined in Section 5.1.4, Conventional and chemical munitions. It is difficult to quantify the risks caused by the presence of munitions, due to the limited experience with infrastructure projects in the area. During construction the Nord Stream pipeline in 2010-2012, no munitions objects had to be cleared in Danish waters. The same is assessed to be the case for the Nord Stream 2 project (Rambøll / Nord Stream 2 AG, 2017a), if construction of this pipeline is to take place.

With regard to conventional munitions, the risks to personnel, marine life and assets comes from the possible detonation of the munitions objects. The risk can be divided into the unplanned event of having to clear identified munitions objects and the risk of accidental detonation of munitions.

The risk of having to clear munitions is mitigated by, as far as possible, re-routing the pipeline to avoid munitions objects visible at the seabed. Following a dedicated munitions survey using magnetometers to identify munitions, including those buried in the seabed, additional munitions objects might be identified. In some cases, re-routing is not feasible at that stage (e.g. re-routing would require an additional munitions survey covering the changed route), and detonation triggered by a donor charge might be required. Such will be carried out by the Søværnets

Minørtjeneste (the Explosion Ordnance Disposal unit of the Danish Navy) in compliance with their very strict safety procedures. The risk to personnel is therefore considered negligible.

The main issue in the case of munitions clearance is the possible impacts on marine mammals and fish caused by the underwater noise. The results of modelling of the dispersion of underwater noise from possible munitions clearance are presented in Section 5.1.5, Underwater noise. The potential impacts of possible munitions clearance on fish and marine mammals are presented in Sections 9.12 Fish and 9.13 Marine mammals, respectively.

The likelihood of accidental detonation of munitions is much smaller than the likelihood of having to clear munitions objects. The consequences of such an accidental event would be greatest in the nearshore areas, where back-hoe dredging takes place, i.e. personnel could in theory be exposed in the case of an accidental detonation. Further offshore, a possible detonation could only cause damage to the pipeline or equipment during the construction phase, i.e. when the pipeline is not gas-filled.

Based on the fact that detailed geophysical surveys and a dedicated munitions survey have been carried out, and the experiences from other projects in the Baltic Sea, the risk related to possible accidental detonation of munitions is considered negligible.

4.7.2 Risk related to unplanned chemical munitions encounter

As outlined in Section 5.1.4, Conventional and chemical munitions, the pipeline route extends through a chemical munitions risk area, in which fishing vessels are required to have first aid gas equipment onboard. The pipeline route does not, however, pass through the designated chemical munitions dumping site, which is situated to the northeast of Bornholm. Moreover, it does not extend through areas in which sea dumped chemical warfare materials have been encountered during the period 1961-2012 (see Figure 5-8).

Therefore, it is very unlikely that any chemical munitions objects will be encountered during the construction of the Baltic Pipe. The vessels participating in the construction work in the risk area southwest of Bornholm will be required to have first aid gas equipment onboard, and to have procedures in place for dealing with possible encounters. Exposure to e.g. lumps of mustard gas could take place in case of contamination of the trenching plough, anchors or other equipment in contact with the seabed.

4.8 Hazards and risks during the operational phase

4.8.1 Methodology and hazards considered

During the operational phase, the hazards and risks relate to possible leaks of gas in the case of damage to the integrity of the pipeline system. A QRA has been undertaken in compliance with DNV, 2010 and DNV GL, 2017. The assessment is documented in Rambøll, 2018h. The overall methodology applied is illustrated in Figure 4-7.

The HAZID study conducted during the detailed design phase for the Baltic Pipe project identified the following main hazards during the *operational phase* of the pipeline system (Rambøll, 2018f):

- Interaction from anchors (emergency anchoring and unintentionally dragged anchors);
- Sinking ships;
- Ship groundings;
- Dropped objects.

Other risks were identified during the HAZID workshop risks related to, *inter alia*, UXO, internal corrosion, material defects, earthquakes and slugging. These risks are either very unlikely to occur or will be handled through proper operational planning and management. Therefore, these risks were rated as negligible and therefore not considered further (Rambøll, 2018f). The remaining hazards are described below.

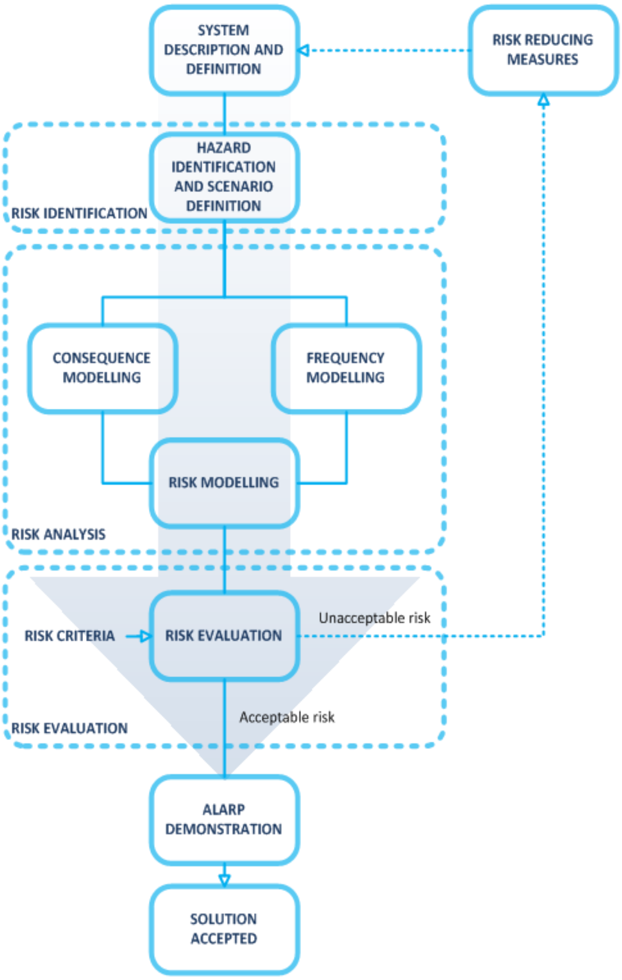


Figure 4-7 Overview of the overall methodology for the QRA.

Dropped & dragged anchors

Incidents where dropped anchors have hooked and damaged or ruptured subsea cables have occurred numerous times in the Baltic Sea. It is believed that dropped and dragged anchors represent one of the main hazards to the Baltic Pipe (Rambøll, 2018f).

Sinking ships

There are also examples of ships sinking following a collision in the area. An example of this is the Chinese bulk carrier Fu Shan Hai, which sunk following a collision with the container vessel Gdynia in 2003. The risk of collision is inherently increased in highly trafficked shipping lanes, such as those crossed by the Baltic Pipe, and it is believed that there is probability that a sinking ship could hit and severely damage the pipeline (Rambøll, 2018f).

Ship groundings

The draught of ships entering and exiting the Baltic Sea is limited by the water depth below the Great Belt Bridge, which is 19 m going into the Baltic Sea. Thus, a grounding ship with a direct impact on the pipeline is only considered possible at water depths of less than 19 m. This is the case near the landfalls and at Rønne Banke. As the grounding frequency at Rønne Banke is expected to be extremely low, and the significance of groundings at the nearshore areas are expected to be very low, the hazard for grounding ships is disregarded and has not been further quantified (Rambøll, 2018f).

4.8.2 Gas release frequencies

The ship traffic scenario that has made the basis for the QRA includes the input and cases outlined in Figure 4-8.

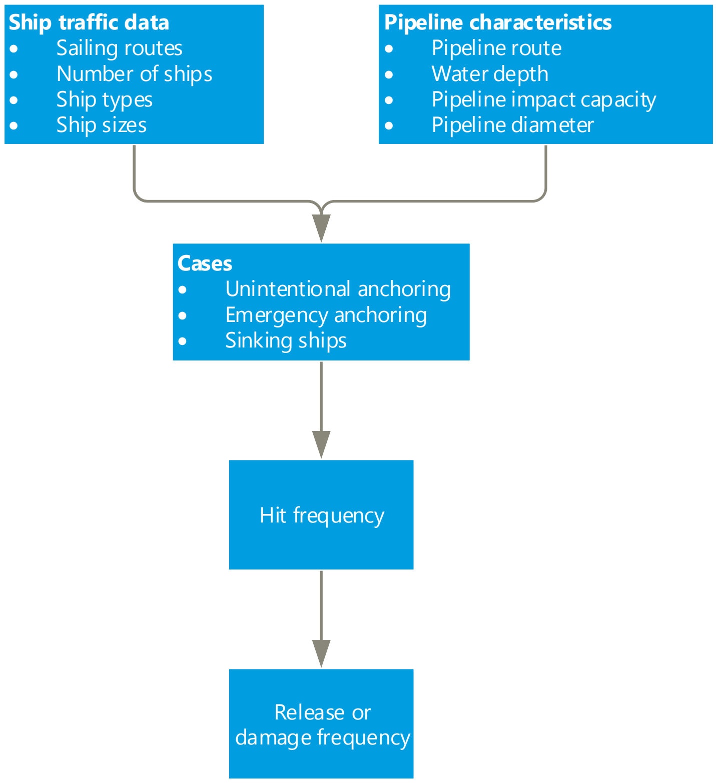


Figure 4-8 Methodology for ship traffic frequency assessment (Rambøll, 2018h).

Figure 4-9 shows the release frequencies calculated for the individual KPIs along the pipeline route, using the above methodology. The figure is based on the expected number of ships of various size classes crossing the pipeline in 2032 (see Figure 4-3). The highest numbers of crossings are found at KPI 129 (in Swedish waters) and 137 (in Danish waters), with approximately 5,200 and 4,700 crossings, respectively. These maxima and the remaining local peaks correspond clearly to crossings of the various main traffic lanes crossed by the pipeline.

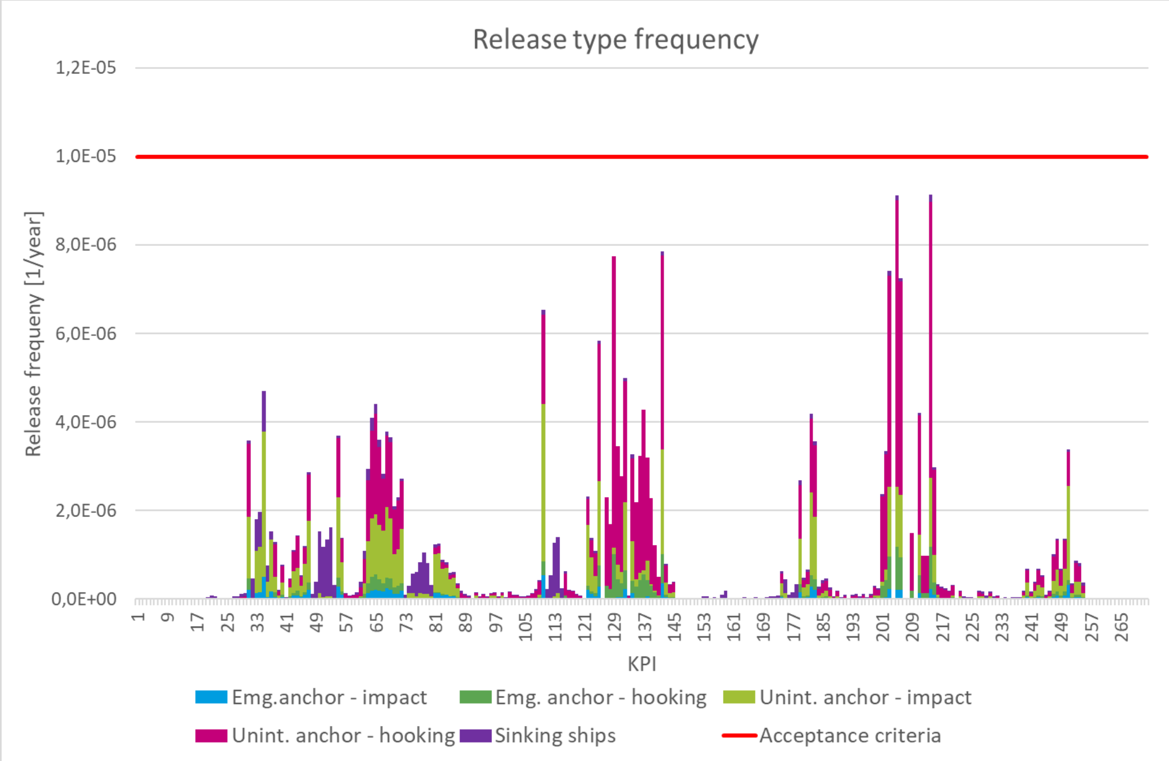


Figure 4-9 Overall yearly release type frequencies for individual KPIs of the pipeline, after adding protection to reach the 10^{-5} acceptance criterion for each KPI, distributed on causes of leaks.

Critical zones, which are parts of the pipeline (of at least 10 km each) where the release frequency is higher than the acceptance criteria of 10^{-5} incidents per year, have been defined. The identified critical zones are shown below in Table 4-2. The table also shows the dimensions of additional protection in the form of rock cover placed on top of the pipe, and the release frequencies with this additional protection in place. The release frequencies are, with this protection, in all cases below 10^{-5} incidents per year.

Table 4-2 Description of critical zones along the BP pipeline route, release frequencies without protection, the protection applied, and the release frequencies with protection (Rambøll, 2018h). The crossings are in Danish waters (DK), Swedish waters (S) and in the Disputed Area (DA).

Critical zone	Description	Initial KP	Final KP	Unprotected release frequency [$year^{-1}$]	Protection thickness [m]	Protection length [km]	Protected release frequency [$year^{-1}$]
1 (DK)	Øresund traffic	30	39	5.28×10^{-4}	0.9	6	1.65×10^{-5}
2 (S)	Trelleborg-Lübeck	46	56	1.21×10^{-3}	0.9	7	1.56×10^{-5}
3 (S)	Trelleborg-Swinoujscie	72	81	6.35×10^{-4}	0.9	8	8.57×10^{-6}
4 (S)	Ystad-Swinoujscie	110	122	5.18×10^{-4}	0.8-1-1	6	2.65×10^{-5}
5 (S/DK)	Baltic Traffic (Bornholm N)	125	142	2.97×10^{-3}	1.0-1-1	13	7.16×10^{-5}
6 (DK)	Baltic Traffic (Bornholm S)	172	181	1.27×10^{-4}	0.6-0.9	3	7.58×10^{-5}
7 (DA)	Baltic Traffic (South)	203	214	4.28×10^{-4}	1.2-1.3	7	8.07×10^{-5}

The critical zones 1 and 6 are situated in Danish waters, whereas critical zone 5 is situated partly in Swedish and partly in Danish waters; it includes the TSS Bornholmsgat, as outlined in Section 4.5.

4.8.3 Consequence assessment

The release of gas from a subsea gas pipeline can result in a gas cloud close to the sea surface. If the gas cloud reaches a critical air-to-gas ratio, an explosion may occur due to an ignition source (e.g. a passing ship), which can cause a fatal accident. Therefore, it is important to clarify the dispersion and consequence of such a gas leakage.

In order to evaluate the plume distribution of the dispersed gas into the atmosphere, the extent of the leakage has to be specified. The size of the leakage relates to the size of the inflicted hole. Four different hole sizes are considered and are presented in Table 4-3.

Table 4-3 Hole sizes and size intervals of gas releases.

Leak size	Size interval [mm]	Applied size [mm]
Small	< 20	20
Medium	20 – 80	50
Large	> 80	80
Rupture	Rupture	914

Approximations of the gas mass flows have been calculated using PHAST (Process Hazard Analysis Software, by DNV GL), version 8.11. In order to adjust the PHAST calculations to the underwater situation, the pressure inside the pipeline has been reduced to compensate for the water pressure. The calculations assume a release depth of 40 m, which corresponds to a water pressure of roughly 4 bar (Rambøll, 2018h).

Release types

The distribution of leak sizes is given for generic failures and for ship traffic related releases in Table 4-4, together with the corresponding release rate. The shown release rates for small, medium and large releases are calculated as the initial mass flow rate, while the rupture flow rate is calculated as the weighted mean mass flow of the initial 20 minutes of the release.

Table 4-4 Leak size distribution and corresponding release rate for generic and ship traffic related releases.

Leak size	Ship traffic release distribution	Generic release distribution	Release rate [kg/s]
Small	0%	74%	7.9
Medium	0%	16%	49.2
Large	50%	2%	125.8
Rupture	50%	8%	3613

Small, medium and large releases exhibit a relatively constant mass flow throughout the first hour, as the released mass is small compared to the mass available, while the flow rate of a rupture decreases exponentially.

As illustrated in Figure 4-10, the gas from a ruptured subsea pipeline will disperse into the surrounding water column in a cone-like shape while heading towards the sea surface. This underwater dispersion can be divided into three flow zones; Zone of Flow Establishment (ZOFE), Zone of Established Flow (ZOEF) and Zone of Surface Flow (ZOFS).

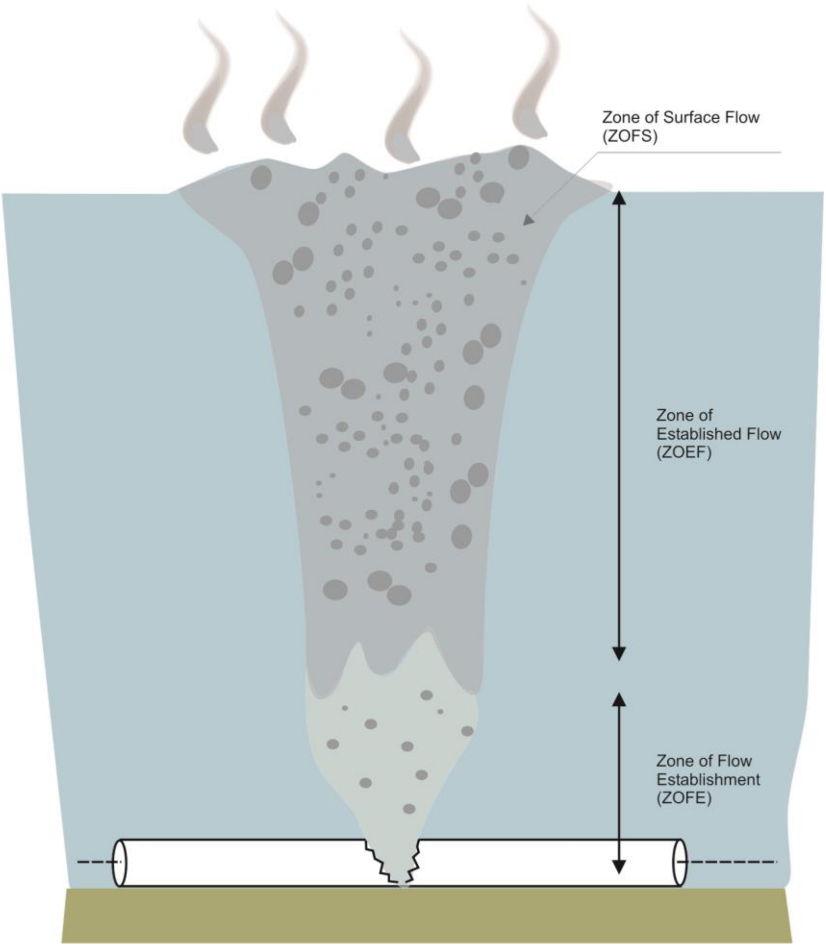


Figure 4-10 Gas release from a ruptures subsea pipeline (Rambøll, 2018h)

In most cases, a gas leak will not become ignited. In that case, the gas will escape to the atmosphere and contribute to the global pool of greenhouse gases (GHG). Methane (CH_4), which is the main constituent of natural gas, is a strong GHG, and has a global warming potential (GWP) of approximately 28 times relative to CO_2 (IPCC, 2014).

Calculations of the dispersion of released gas in the atmosphere using computational fluid dynamic (CFD) simulations have been carried out as part of the QRA. These calculations have been used for quantification of the likelihood of explosion, which subsequently has been used in the analysis of risk to human safety (Rambøll, 2018h).

4.8.4 Risk to human safety (3rd party)

The risk to human safety is assessed both in terms of individual risk (3rd party) and societal risk (3rd party). Individual risk (IR) presents the summarized frequency per year for fatality of the person who is expected to be the most exposed to risk based on the total failure frequency of the pipeline system and the consequences following a release of gas from the pipeline. Societal risk represents the summarized frequencies per year for fatal accidents and the expected number of fatalities for these accidents based on the total failure frequency of the pipeline system and the consequences following a release of gas from the pipeline (Rambøll, 2018f).

The individual risk (3rd party) was evaluated for the most exposed individual crossing the 10 most critical KPIs of the pipeline. Evaluation was performed with respect to ship traffic and generic failure related accidents. Individual risk (3rd Party) was found to be 4.28×10^{-6} incidents per year prior to protection and 1.07×10^{-6} incidents per year post-protection. The individual risk (3rd party) is thus considered acceptable, as it is below the acceptance criteria of 10^{-5} per year both prior to and post-protection (Rambøll, 2018h).

The societal risk was evaluated using a FN-curve. The FN-curve prior to and post-protection is seen in Figure 4-11. It clearly shows that the societal risk (3rd party) is lowered to an acceptable level when subject to the ALARP principle, when the above-mentioned protective measures are introduced.

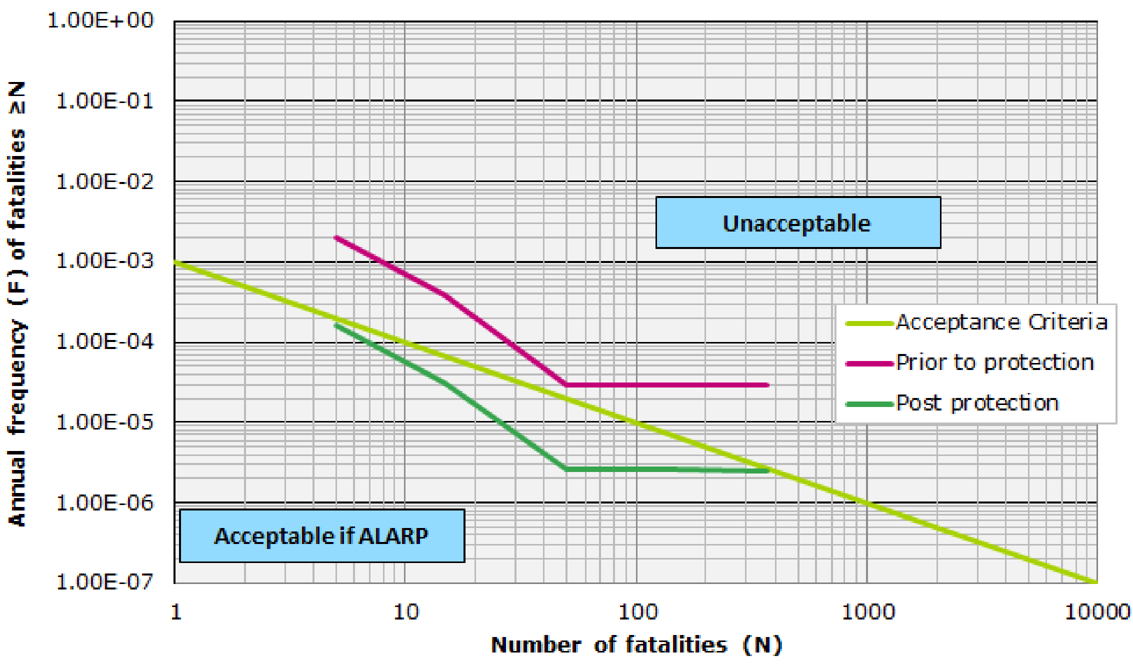


Figure 4-11 FN-curve illustrating societal risk (3rd party) for unprotected and protected pipeline (Rambøll, 2018h).

4.8.5 Environmental consequences of gas leaks during operation

A potential gas leak will cause vertical mixing of the water column above the rupture, as shown in Figure 4-10. A large rupture will damage marine life (e.g. marine mammals, fish and birds) in the plume, which can have a diameter expanding to up to approximately 40 m at the water surface in the case of a full rupture (Rambøll, 2018h). The vertical mixing of the water column will potentially impact salinity, water temperature and oxygen conditions above the rupture. There can additionally be a potential impact on the seawater temperature due to the cooling effect of the gas expansion caused by the pressure drop. The above-described potential impacts will be local and short-term only.

The solubility of natural gas in seawater is low, and almost all the leaked gas will end up in the atmosphere. If the gas is ignited, the explosion will impact marine life in the impacted area. If the gas is not ignited, it will mix with the atmospheric air and contribute to the global pool of GHG, (see Section 4.8.3). The pipeline has a total length of L = 273.7 km and an inner diameter of ID = 0.8728 m, i.e. the total volume of the pipeline is approximately V = 163,755 m^3. The maximum density of the gas in the pipeline under operational conditions will be approximately ρ= 85.6 kg/m^3 (Rambøll, 2018l). Conservatively assuming that this maximum density prevails in the entire pipeline system, the pipeline can contain up to approximately 14,000 tonnes of natural gas. Assuming that all of the gas is methane, and that the GWP is as outlined in Section 4.8.3, this amount is equivalent to approximately 392,000 tonnes of CO_2. For comparison, this corresponds to 2.7% of the yearly CO_2 emissions from all vessels in the Baltic Sea in 2016, or to 1.1% or the total annual emissions in Denmark (see Section 9.4.2, Baseline).

4.9 Emergency response (ER)

4.9.1 General

An emergency response (ER) setup will be developed by GAZ-SYSTEM before construction and operation, respectively, takes place. The ER setup will be tailored according to the activities which are planned to take place and the risks associated with these activities, as outlined above.

The framework for the ER setup is the HSE management system of GAZ-SYSTEM, which has been developed in accordance with the standards OHSAS 18001 / ISO 45001: Occupational Health and Safety Management Systems, and ISO 14001: Environmental Management Systems.

The HSE management system of GAZ-SYSTEM is further described in Appendix A: Health, Safety and Environmental Management System.

4.9.2 Emergency Response during the construction phase

A Project Health Safety and Environment Plan (GAZ-SYSTEM, 2019a) has been prepared and is further developed as the project progresses. The plan is applicable to all work carried out as part of the Baltic Pipe Offshore Pipeline Project, whether work is carried out in the Project or at the Contractor’s offices, construction sites or on marine construction and associated vessels.

Complementary to the above plan is a Contractor HSEQ Requirements Specification (GAZ-SYSTEM, 2019b) and the Contractors’ HSE Management Plans, which they will develop prior to commencement of any worksite activities. The ER Plans and Procedures for all construction sites and vessels will be detailed within the Contractors’ HSE Management Plans. Prior to mobilization of rigs and vessels, the necessary combined operations bridging documents will be developed between the relevant parties.

GAZ-SYSTEM will forward information about the ER setup, including the setup for handling possible oil spills, to the DEA on a yearly basis during the construction period.

4.9.3 Emergency Response during the operations phase

GAZ-SYSTEM will, in cooperation with Energinet, establish an ER setup for the operations phase. GAZ-SYSTEM will own and operate the offshore interconnector between Denmark and Poland and will therefore be responsible for the ER setup for this part of the system. Details about the ER setup for the operations phase will be developed at a later stage, and it will be part of the application for permit to operate the pipeline system.

4.10 Conclusion

The main risks of accidental events, both during the construction and operational phases, are related to the fact that the pipeline route crosses a number of shipping lanes. This means that there is a risk that third-party vessels collide with one of the construction vessels, which might cause harm to humans and/or spills of oil to the sea. This also means that there is a risk of interference between vessel traffic and the pipeline during the operational phase, e.g. from dropped/dragged anchors or sinking ships.

The likelihood of an oil spill during the construction phase has been shown to be low, comparable with other maritime activities in the Baltic Sea not involving transport or production of oil. Comparing the likelihood of oil spills during the period of constructing the Baltic Pipe system with the likelihood of oil spills from offshore installations in the North Sea confirms this conclusion. With respect to possible gas leaks, the environmental impacts of such will be local and short-term. In the case of a large rupture, the methane escaped to the atmosphere will contribute to the global pool of GHG. In such an unlikely major event, the possible impact on human lives will, however, be the main concern.

Munitions objects are, as far as reasonably practicable, avoided by re-routing. If re-routing is not possible, there is a risk that munitions clearance will have to take place. In such a situation, the mitigation measures outlined in Section 13.2, Mitigation measures for unplanned events will be implemented.

Mitigation measures have been included in the design of the pipeline system, so the risk to human safety (3rd party) is below the risk acceptance criteria, and measures are being implemented to ensure that the risks are further reduced to a level as low as reasonably practicable (ALARP). This is the case for both the construction and operational phases.

5. POTENTIAL IMPACTS

The various activities and phases related to construction and operation of the pipeline have been outlined in Chapter 3, Project description. These activities, and the presence of the pipeline, can have an impact on the surrounding environment.

Experience from other marine infrastructure projects has been used in combination with the technical knowledge from this specific project to identify and quantify the potential environmental impact mechanisms (hereafter potential impacts).

The purpose of this chapter is to make the connection between the project description and the impact assessment chapters; i.e. to outline the mechanisms causing changes to the e.g. physical and chemical environment. For some of the mechanisms, the results of numerical modelling of the expected changes are presented.

Further details about the various potential impacts are provided below. The potential impacts are outlined for construction offshore (including pre-commissioning), for operation offshore, and for construction onshore (including pre-commissioning). No impacts are expected from operation onshore with regard to the part of the overall project covered by this EIA, as there will be no operational activities at the landfall area.

5.1 Offshore construction

For construction offshore, the potential impacts and their receptor interaction are listed in Table 5-1.

Table 5-1 Potential impacts for construction and pre-commissioning offshore and identification of potential receptor interaction.

Potential impact	Receptor*
Physical disturbance of seabed	Bathymetry; surface sediments and contaminants; benthic habitats, flora and fauna; fish; biodiversity; protected areas; shipping and shipping lanes; commercial fisheries; cables, pipelines and wind farms
Suspended sediments	Hydrography and water quality; benthic habitats, flora and fauna; fish; marine mammals; seabirds and migrating birds; biodiversity; environmental monitoring stations; tourism and recreational areas; protected areas
Sedimentation	Bathymetry; surface sediments and contaminants; benthic habitats, flora and fauna; fish; biodiversity; protected areas
Contaminants and nutrients	Hydrography and water quality; surface sediments and contaminants; benthic habitats, flora and fauna; fish; marine mammals; seabirds and migrating birds; biodiversity; protected areas
Underwater noise	Benthic habitats, flora and fauna; fish; marine mammals; biodiversity; protected areas; commercial fisheries
Physical disturbance above water	Marine mammals; seabirds and migrating birds; biodiversity; protected areas; commercial fisheries; raw material extraction sites and dumping sites; military practise areas; tourism and recreational areas
Safety zones	Shipping and shipping lanes; commercial fisheries; tourism and recreational areas; raw material extraction sites and dumping sites; military practice areas; environmental monitoring stations
Emissions to air	Climate and air quality; population and human health
Non-indigenous species	Benthic habitats, flora and fauna; biodiversity

Potential impact	Receptor*
Employment generation	Population and human health
Discharges to sea	Hydrography and water quality; protected areas

* Assessments of potential impacts on Natura 2000 sites and Annex IV species follow the methodology of Sections 8.3 and 8.4.

Waste production and management have been addressed in Chapter 3, Project description. As waste will be handled according to regulation, it will have no impact on the environment, why this will not be dealt with further.

5.1.1 Physical disturbance of seabed

When carrying out seabed interventions work during construction, the seabed will be impacted (see Section 3.5.3, Seabed interventions). Box 5-1 summarizes the physical disturbance of the seabed for the pipeline in Denmark. The potential impacts will be elaborated in the following sections, divided into tunnelling, trenching, pipe-lay and rock installation.

BOX 5-1: Physical disturbance of seabed in Denmark during construction

PIPELINE:
Pipeline length in Danish waters and disputed area: 137.6 km
Trench length (expected): 63.5 km
Trench width: 10-30 m, depending on water depth and sediment type. Spoil heaps from the trenched sediment will be placed along the trench (approx. 5 m on each side)
Trench depth: 2.0-2.5 m
Rock installation: Approximately 13 locations

TUNNELLING, OFFSHORE:
Distance from coast to exit point:

- Perpendicular to the coast: 400 m
- Length of tunnel: 600 m

Exit point:

- Area at seabed level: 40 x 60 m
- Depth: 5.4 m

Dredged volume from exit point: 5,000 m^3 (in-situ volume) / 6,500 m^3 (excavated volume)
Dredged volume from transition zone: 5,500 m^3 (in-situ volume) / 7,000 m^3 (excavated volume)
Suggested temporary disposal area for dredged material: 70 m x 100 m at a water depth of 7 m

CONSTRUCTION VESSELS:
DP vessel area of influence on the seabed: Corresponding to width of the applied ship, approximately 40 m
Anchors and anchor chains area of influence on the seabed: Approximately 1,500 m around the pipeline

Tunnelling: The pipeline will be led onshore from Faxe Bugt by tunnelling. Tunnelling will be based onshore and have an exit point nearshore, approximately 400 m from the coastline (the tunnel distance will measure approximately 600 m), at approximately 5.4 m water depth. The tunnel boring machine must be lifted from the seabed at an exit point and a transition zone from the exit point to the trench of the pipeline at 2 m below seabed surface will be established. Dredged material from the exit point and transition zone will transported to a temporary disposal area on the seabed at a water depth of a minimum of 7 m in order to minimise the potential impact on eelgrass. After the tunnel boring machine has been removed and pipe-lay nearshore has taken place, the hole will be backfilled. The planned duration of this part of the construction works, including nearshore pipe-lay, is as a worst-case scenario 16 weeks in total, divided in four phases. There will, however, be breaks between the different phases of the construction works.

Trenching: Where the pipeline is trenched into the seabed, the seabed surface sediments in the trench may vary from the surrounding seabed. Also, the seabed surface sediments might be different from the surrounding seabed where spoil heaps are present. Over time, however, the surface sediment conditions will develop towards the seabed sediment composition of the surrounding seabed because of the natural sediment transport processes.

Pipe-lay: Pipe-lay will also cause temporary disturbance of the seabed. The pipe-lay vessels will use either a dynamical positioning system (DPS) with powerful thrusters or anchors to keep the lay vessel in position (see Section 3.5.2 Pipe-lay). In general, DP vessels for pipe-lay will be used where the water depth is greater than 20 m, and the anchor vessel where the water depth is less than 20 m. If a DP vessel is used, the strong turbulence caused by the operation of the thrusters may impact the seabed surface, with the impact depending on the size of the thrusters, water depth and the seabed condition (i.e. presence of stones, size of stones, grain size of sediment etc.). If anchors are used, the anchors and the anchor chains will impact the seabed surface where they are in contact with the seabed. In general, the anchor lay vessel is controlled by a system of up to 12 anchors (weighing up to 25 tonnes each), anchor wires and winches. Anchor-handling tugs place the anchors on the seabed at fixed positions. The distance between the pipeline centre line and the outer anchors is expected to be up to approximately 0.5 km. An example of an anchoring pattern is outlined in Figure 5-1.

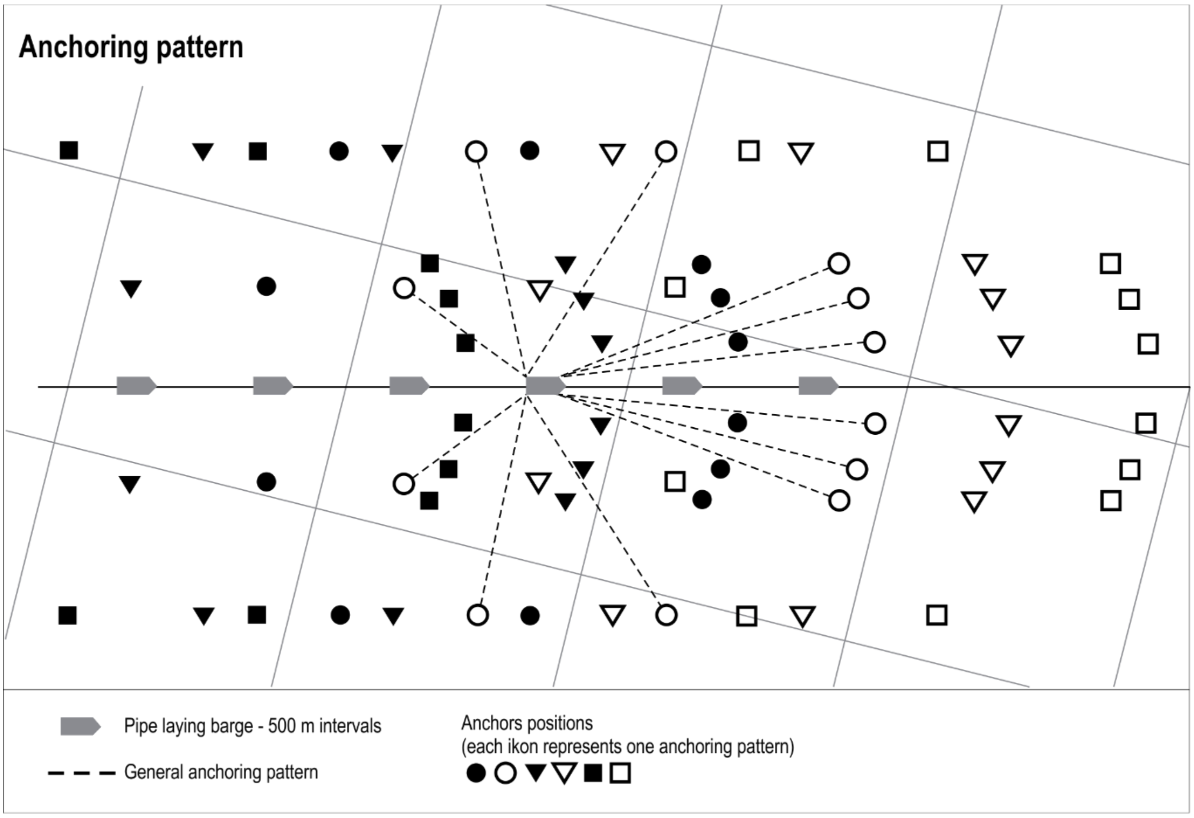


Figure 5-1 Schematic anchor pattern for a lay vessel at 50 m water depth.

Rock installation: Rock installation is a means to protect the pipeline and will be used when crossing existing marine infrastructure (pipelines, telecom and power cables) and potentially also in shipping lanes. The rocks will be placed at the seabed using a dynamic positioning fall pipe vessel equipped with a flexible fall pipe, making sure the rocks are placed correctly. The physical disturbance of the seabed during construction will be limited to the specific area where rock installations will take place (expected to be at 13 locations in Danish waters, see Figure 3-22 in Section 3.5.3, as well as potentially in shipping lanes).

5.1.2 Suspended sediments and sedimentation

Construction activities such as trenching, rock installation, pipe-lay, and excavation of the exit point for the TBM give rise to an increase in suspended sediment concentration (SSC), when sediment is resuspended from the seabed to the water column (also called sediment spill). Sediment spill can then be dispersed from the construction site to areas away from the construction site, and an increase in SSC can then impact the surrounding environment.

Numerical modelling of the sediment spill from the construction activities has been executed. Conditions e.g. spill rates, the basis for the modelling and the modelling results are presented in the following sections.

Sediment spill rates from various activities

Sediment spill primarily originates from the seabed where the seabed interventions take place. Sediments are dispersed in the water column and transported with the currents before they re-settle to the seabed. The sediment spill rate is the mass of sediments being suspended in the water column per time unit (e.g. kg/s) during the time the activity takes place.

The sediment spill rate depends on different factors, including the type of construction activity (e.g. trenching or rock placement), the type of material to be handled and the equipment used (e.g. plough or backhoe dredger) (Lorenz, 1999). The latter includes factors such as exposure to currents and waves.

In the following sections, the basis for the various sediment spill rates that have been applied in the numerical modelling is outlined.

<u>Trenching using back-hoe dredgers</u>
Experience from sediment spill measurements for backhoe dredging at the Øresund Fixed Link project showed a sediment spill of on average 3.5% from dredging and 0.3% from reclamation. The dredging took place in clay till as well as in limestone; the percentage is an average, and there was a tendency towards greater spill when dredging in limestone and less spill when dredging in clay till. The relatively low reclamation spill resulted because reclamation took place behind closed bunds. The backhoe dredging for the Øresund Fixed Link took place in an area where strong currents (up to 2 m/s) prevail (Lorenz, 1999).

Rijn (2018) has gathered experience regarding turbidity caused by dredging and dumping of sediments. The sediment spill from mechanical dredging (which includes backhoe dredging) was found to have a median of 1.5% and a mean of 2%.

In the EIA work for the Femernbelt Fixed Link, backhoe dredging for tunnel elements were assumed to have a sediment spill of approximately 3.5%. Dredging in more sheltered areas for containment dykes, portals and ramps, working harbours and reclamation was assumed to have a sediment spill of 0.1-0.8%. The sediment spill from backfilling was assumed to be 0.1-0.8% for trench backfilling, 1% for sand backfilling at piers, and 5% for backfilling of access channels (FEHY, 2013a).

Experience from the construction and monitoring of the Nord Stream Pipeline project (NSP) was used when estimating the sediment spill from backhoe dredging at the German landfall for the Nord Stream 2 Pipeline project (NSP2). On this basis, the sediment spill from backhoe dredging at the German landfall has been assumed to be 3% of the fine-grained sediments (Rambøll / Nord Stream 2 AG, 2017a).

For the Baltic Pipe project, the spill rate is assumed to be 5% where seabed interventions work using back-hoe dredgers takes place. An exception is when establishing a temporary deposit for the seabed materials from the exit point of the TBM, as part of tunnelling. For this activity, the sediment spill rate has conservatively been set to 15% of the mass of the deposited materials.

<u>Trenching using post-lay ploughing</u>
A spill rate of 2% for spill from trenching by post-lay ploughing will be used for modelling of sediment spreading and environmental impact assessment prior to the construction work. This is based on experience from NSP (Valeur *et al.*, 2012). From *in-situ* measurements during ploughing, it was demonstrated that this assumption was conservative; the highest measured spill rate was only approximately one-third of this, i.e., below 1% (Rahbek & Valeur, 2012).

Due to the similarities between the Baltic Pipe project and NSP, both with regard to the project type and the geographical area, it is assumed that a conservative sediment spill rate from post-lay trenching of 2% can also be applied for the Baltic Pipe project where post-lay ploughing is planned to take place.

<u>Rock installation</u>
For rock installation, a conservative sediment spill rate of 0.15% of the handled rock mass was assumed for NSP2, based on analysis and experience from monitoring during NSP construction

during 2010-2012 (Rambøll / Nord Stream 2 AG, 2017a). The sediment spill was calculated based on the amount of seabed sediments expected to be resuspended due to the impact of the stones being installed at the seabed. It is assumed that the same sediment spill rate can be used as a conservative measure for the Baltic Pipe project.

Due to the limited sediment spill from rock installation compared to sediment spill from trenching, it is assessed not relevant to include in the modelling.

Modelling of sediment dispersion and sedimentation
To be able to assess the impacts caused by sediment spill, the dispersion of the mobilised sediments has been modelled using numerical modelling. It was chosen to use the 3-dimensional modelling system MIKE 3 developed by DHI. MIKE 3 provides the simulation tools needed to model 3D free surface flows and associated sediments or water quality processes.

Modelling of the dilution of sediment brought into suspension during construction works is carried out for hydrographic conditions as they are expected to be, when the actual works will be carried out. It is essential for the reliability of the results that the modelling covers typical hydrographic conditions. The sediment dispersion modelling has taken place assuming that the spilled sediments are distributed evenly in the water column.

It was decided that modelling should be carried out for normal conditions representative for the entire year. The modelling periods are set to one month each. The identification of a representative period is based on analysis of 10 years of modelled current fields from the metocean study (Rambøll, 2018m). The modelled period is 2008-2017 (including both years).

Taking the above assumptions into account, the amount of sediment spill from the project and the expected seabed intervention scenario (Figure 3-22), has been calculated and the results are presented in Table 5-2. These numbers have been used as the basis for the sediment dispersion modelling.

When numerical modelling for the seabed interventions works related to the TBM recovery activities were carried out, it was assumed that the seabed materials would consist primarily of clay till, and a tunnel pit volume of 3,800 m^3 was anticipated. Subsequent information from geotechnical borings at the location have shown that the area is dominated by sand. This means that the actual volume will probably be greater (see Box 5-1), due to the less steep walls in a pit dredged in sandy materials. Furthermore, the volume from the transition zone from the TBM exit point to the trench of the pipeline at 2 m below seabed surface have been added after the modelling took place. The sediment dispersion will, however, be less from dredging in sand than from dredging in clay till, as the vast majority of the sand will settle within the work area. Therefore, the results of the numerical modelling are considered as conservative and representative, even for greater excavated volumes.

Table 5-2 Sediment spill quantities in Danish waters used in the numerical modelling of sediment dispersion. Trenching includes both back-hoe dredging and post-lay trenching.

Activity/area	Sediment spill [tonnes]
TBM recovery activities	1,600
Trenching, Sjælland to Swedish EEZ	29,800
Trenching, southwest of Bornholm (including disputed area)	6,600
Total sediment spill Danish waters	38,000

Results of sediment modelling: Sediment dispersion

The sediment dispersion caused by sediment spill will add to the suspended sediments already naturally present in the water column (see Section 9.2, Hydrography and water quality).

Threshold values of 5, 10 and 15 mg/l have been chosen based on experience regarding comparability with the natural background values during strong winds, other infrastructure projects in the Baltic Sea such as the NSP, the Great Belt Fixed Link, the Øresund Fixed Link and coastal offshore windfarms.

- 5 mg/l is the concentration just above the normal concentration and the critical concentration for viability of cod eggs (see Section 9.12.2);
- 10 mg/l is the concentration, where some fish species react and flee from the area, and where fish fry show increased mortality (see Section 9.12.2);
- 15 mg/l represents the concentration where foraging of birds *can* be impacted, due to reduced visibility, if the visibility in more than 70% of the time (Thorkilsen, M., 1999).

In Figure 5-2, Figure 5-3 and Figure 5-4 the time in which the SSC from the construction activities exceeds 10 mg/l is presented. This concentration has been chosen as such an increase is comparable with the natural increase in SSC in periods with strong winds, i.e. it is within the natural variability.

Figure 5-2 shows the duration of the exceedance of SSC of 10 mg/l caused by the seabed interventions works related to the dredging and reclamation at the exit point. The figure shows that the exceedance is restricted to the immediate vicinity of the work area (not visible in the scale shown in the figure).

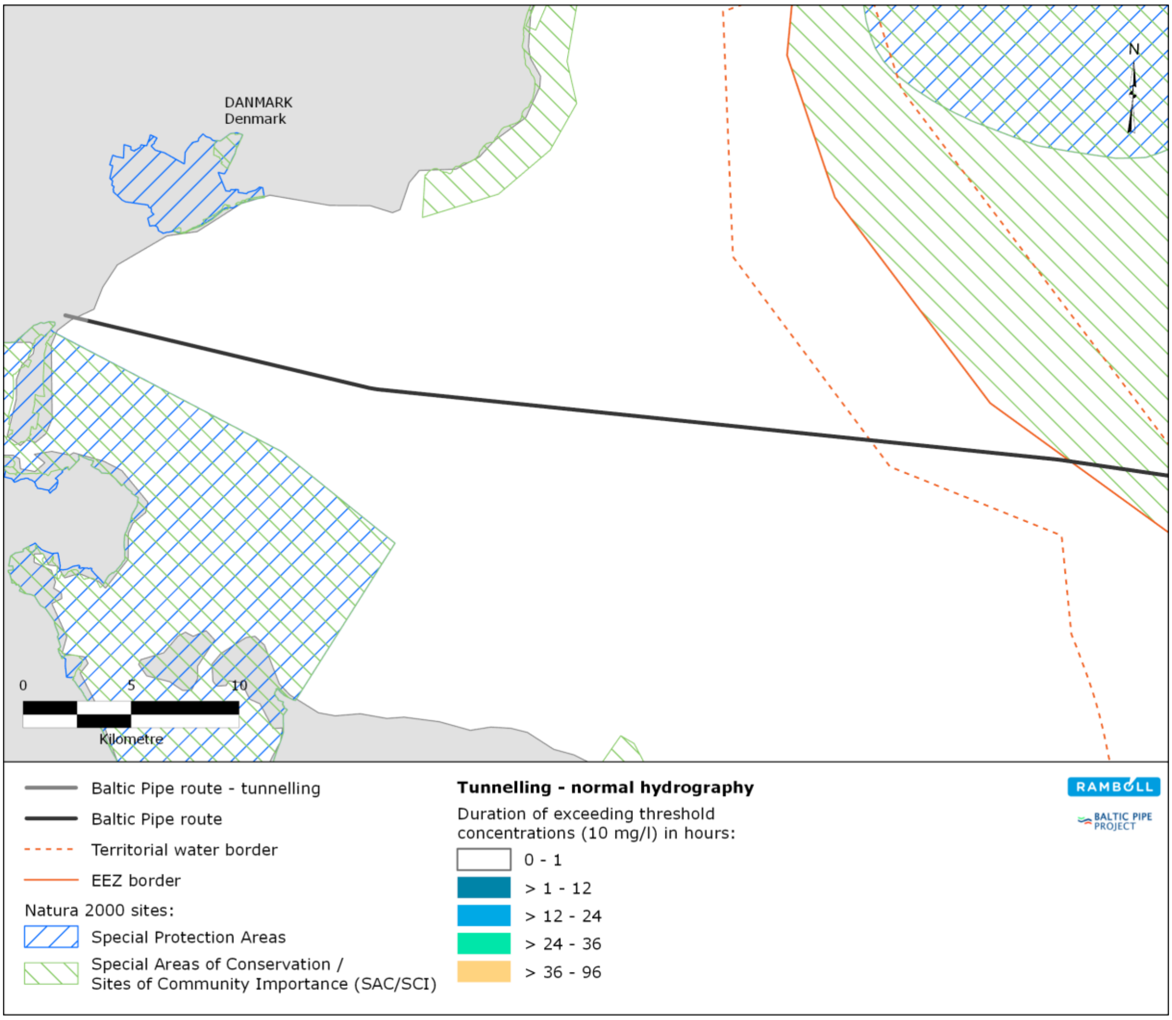


Figure 5-2 Simulation of the time the sediment concentration is increased to at least 10 mg/l due to the seabed interventions works for TBM recovery.

Figure 5-3 shows the duration of the exceedance of SSC of 10 mg/l caused by trenching in the area between Sjælland and the Swedish EEZ. The largest areas impacted will be in Faxe Bugt, because backhoe dredging will be employed as the trenching method, as the water depth is less than 12 m. This results in a spill percentage assumed to be 5%. When using post-lay ploughing at water depths greater than 12 m, the sediment spill percentage is assumed to be 2%.

In most of the impacted areas, the duration of SSC above 10 mg/l will be less than one day, and SSC above 10 mg/l occurs for no longer than 4 days in any area.

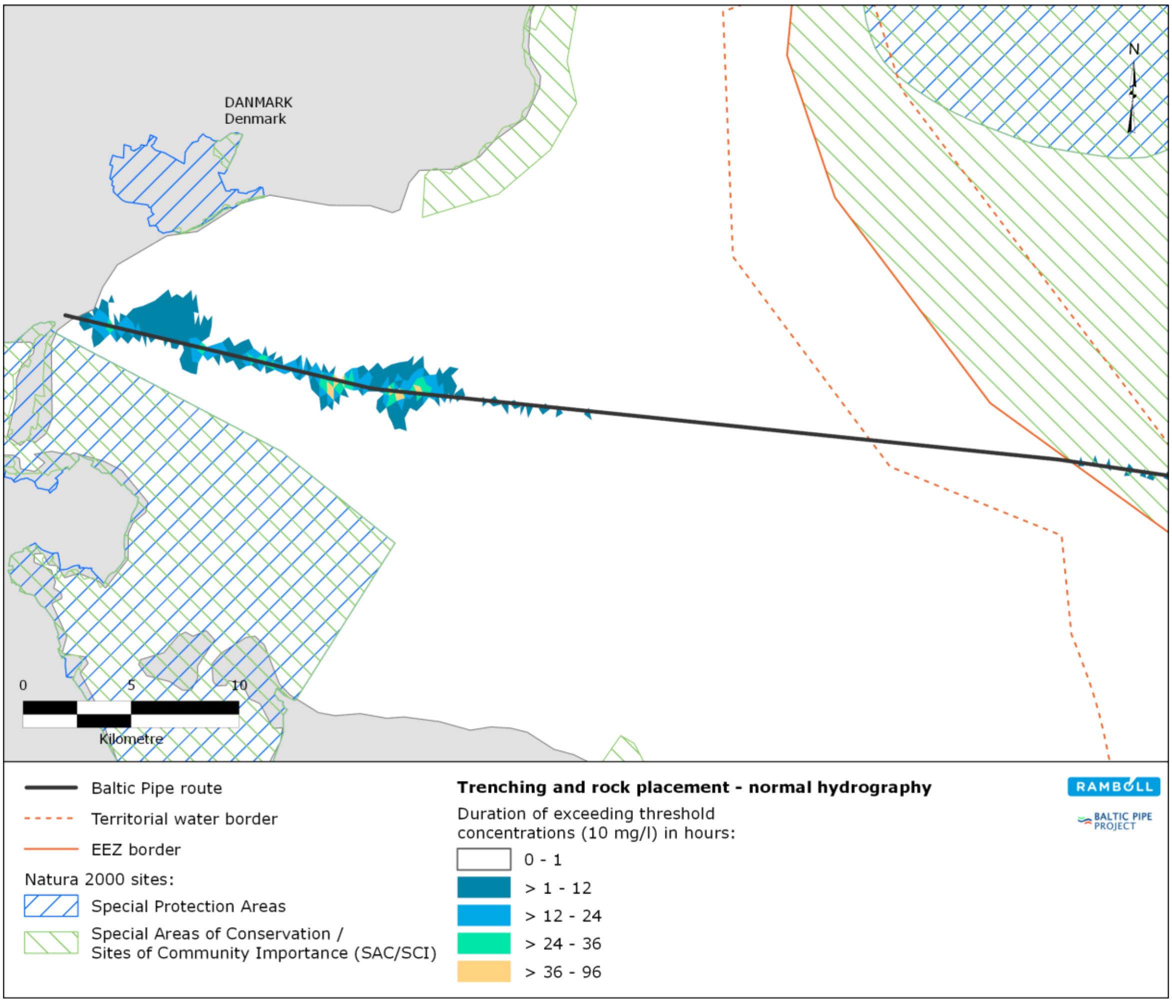


Figure 5-3 Simulation of the time the sediment concentration is increased to at least 10 mg/l due to trenching (using back-hoe dredging below 12 m water depth and post-lay ploughing above 12 m water depth) in the area between Sjælland and the Swedish EEZ.

Figure 5-4 shows the duration of SSC exceeding 10 mg/l caused by trenching in the area southwest of Bornholm. Because all trenching in this area takes place as post-lay ploughing and at relatively great water depths, SSC only exceeds 10 mg/l only in small areas and over short periods of time.

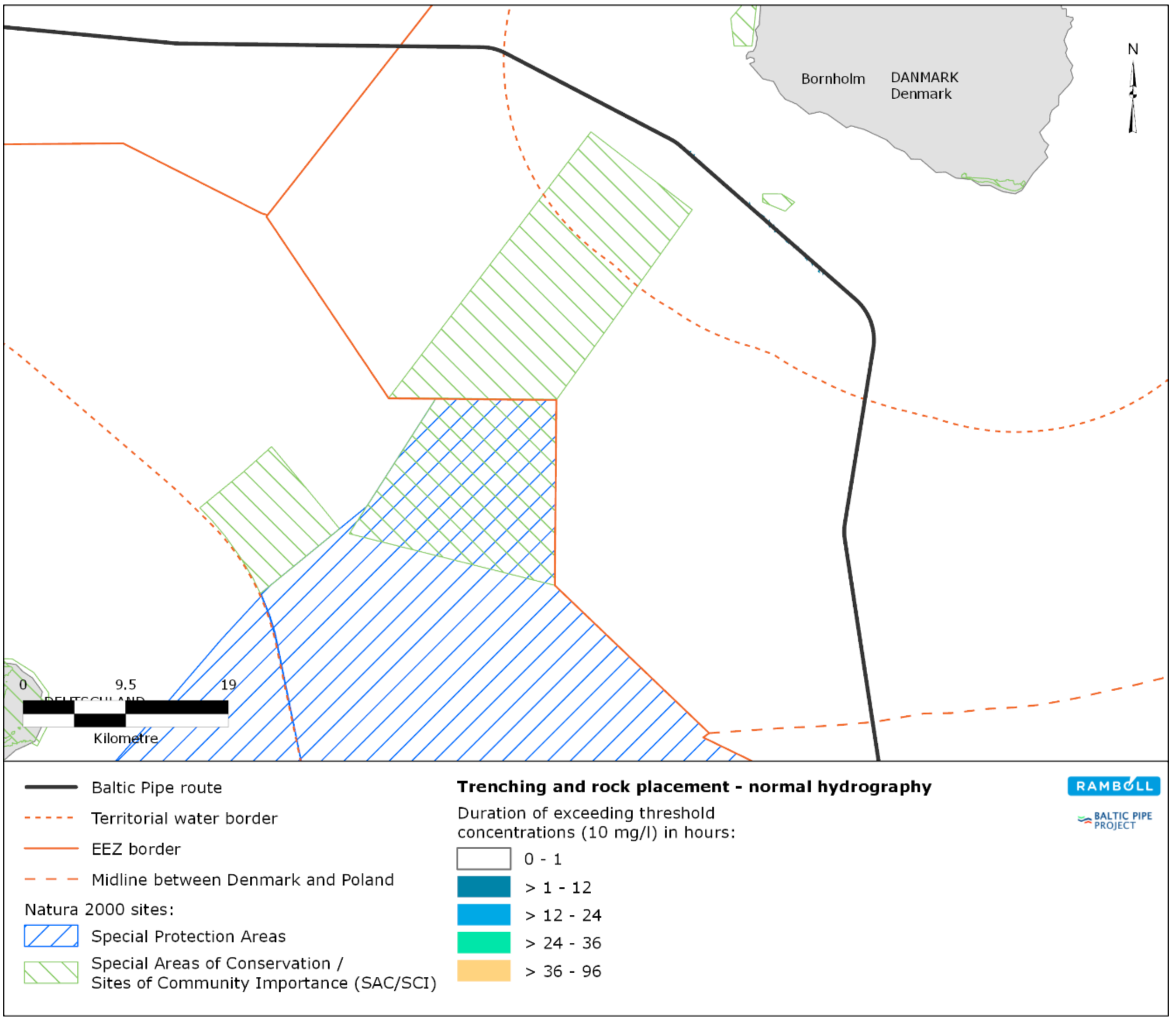


Figure 5-4 Simulation of the time the sediment concentration is increased to at least 10 mg/l due to trenching (using post-lay ploughing) in the area southwest of Bornholm.

Results of sediment modelling: Sedimentation

Following dispersion in the water column, the spilled sediments will gradually settle to the seabed at a rate depending on the characteristics of the sediments, the hydrographic conditions, and the water depth. This will add to the sedimentation already naturally taking place to the seabed in the Baltic Sea (see Section 9.2, Hydrography and water quality). In shallower water, fine-grained unconsolidated sediments, which are comparable to the spilled sediments, will be re-suspended in rough weather and eventually end up in the deeper areas, which will act as net deposition areas for fine-grained sediments. In these areas, the net accumulation will be on the order of 0.5-2 mm/year. For unconsolidated fine-grained seabed sediments, 1 mm corresponds approximately to 1 kg/m^2 of seabed surface (Valeur *et al.*, 2004).

In Figure 5-5, Figure 5-6 and Figure 5-7, the layer of spilled sediments (in the unit g/m^3) which will be deposited at the seabed one week after finalisation of the various seabed interventions works is presented.

Figure 5-5 shows the spilled sediment deposition as a consequence of seabed intervention works in connection with the exit point for the TBM. As expected, there is a relatively large deposition in a small area in the vicinity of the temporary deposit area (where a spill percentage of 15% has been applied for the deposition) and a smaller deposition (in a larger area due to the more prolonged period of operation in this area) in the vicinity of the TBM exit point. The deposition in this area is up to approximately 1 kg/m^2, which corresponds to a layer of approximately 1 mm, whereas the deposition in the immediate vicinity of the temporary deposition area is up to approximately 10-20 kg/m^3, which corresponds to a layer of approximately 10-20 mm. This is, however, only within a very limited area.

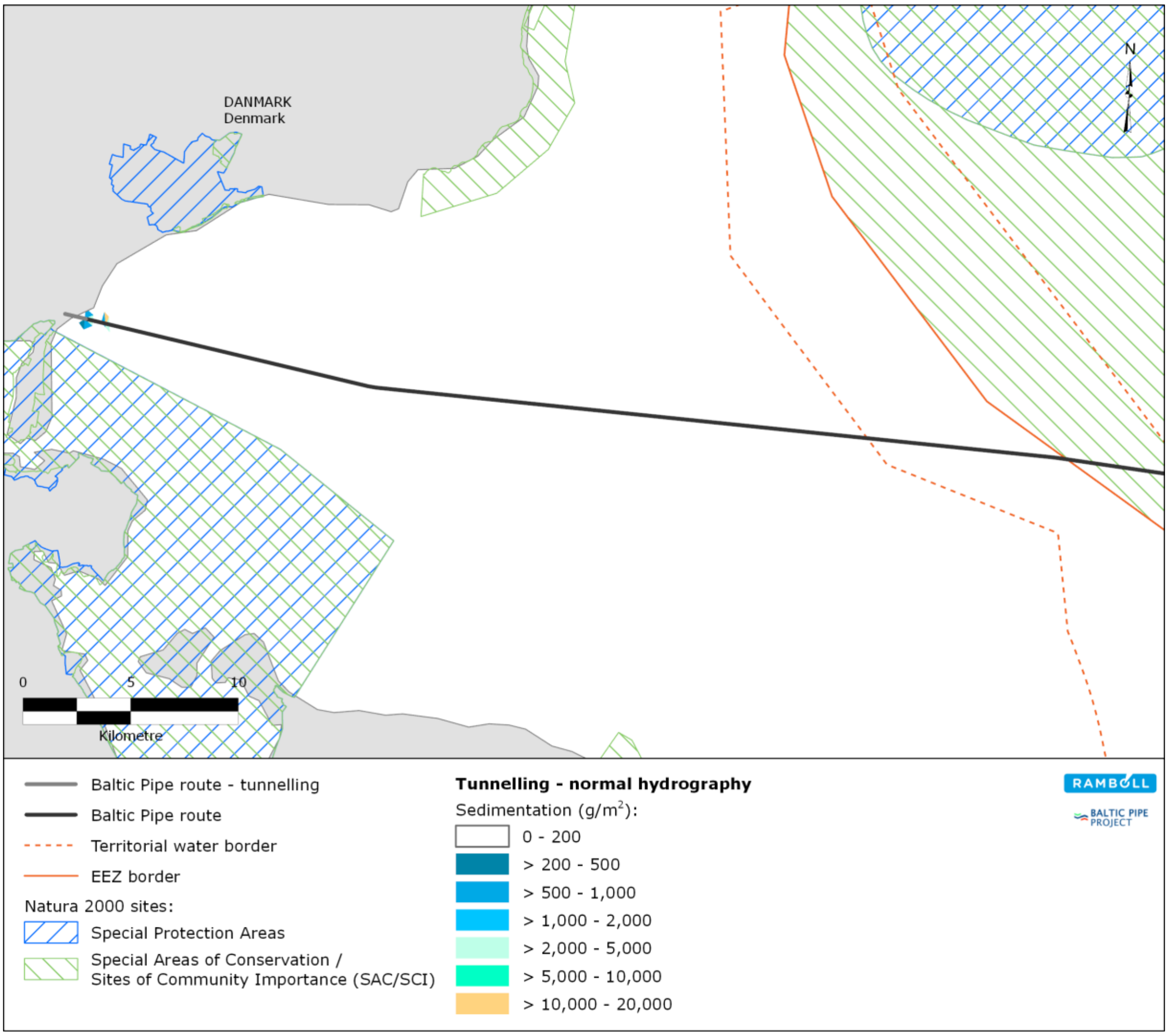


Figure 5-5 Simulation of spilled sediment deposits at the seabed one week after finalisation of the seabed interventions works for TBM recovery.

Figure 5-6 shows the spilled sediment deposition as a consequence of trenching in the area between Sjælland and the Swedish EEZ. The largest deposition will take place in the area of less than 12 m water depth, where back-hoe dredging and therefore the largest sediment spill is anticipated. The deposition exceeds 1 kg/m^2 only in the close vicinity of the pipeline. These deposits, and the deposits caused by the TBM recovery activities (Figure 5-5), are expected to be gradually resuspended and transported to accumulation areas for fine-grained sediments in the deeper parts of the Baltic Sea.

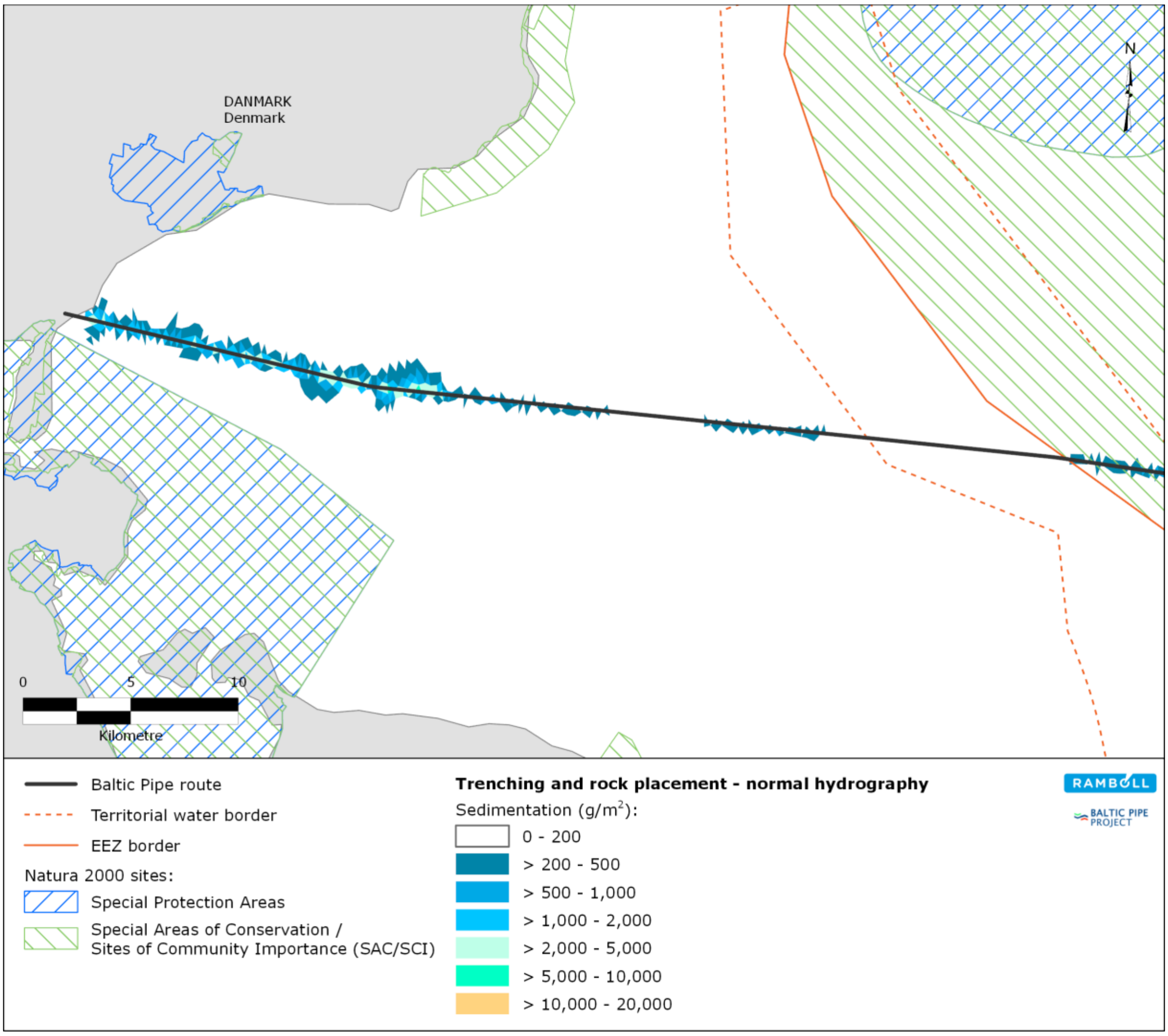


Figure 5-6 Simulation of spilled sediment deposits at the seabed one week after finalisation of trenching (using back-hoe dredging at water depths less than 12 m and post-lay ploughing at water depths greater than 12 m) in the area between Sjælland and the Swedish EEZ.

Figure 5-7 shows the spilled sediment deposition as a result of trenching by post-lay ploughing in the area southwest of Bornholm.

As is the case for spilled sediment concentrations (see Figure 5-4), the sediment deposition in this area is rather small compared with the areas where trenching with back-hoe dredgers take place.

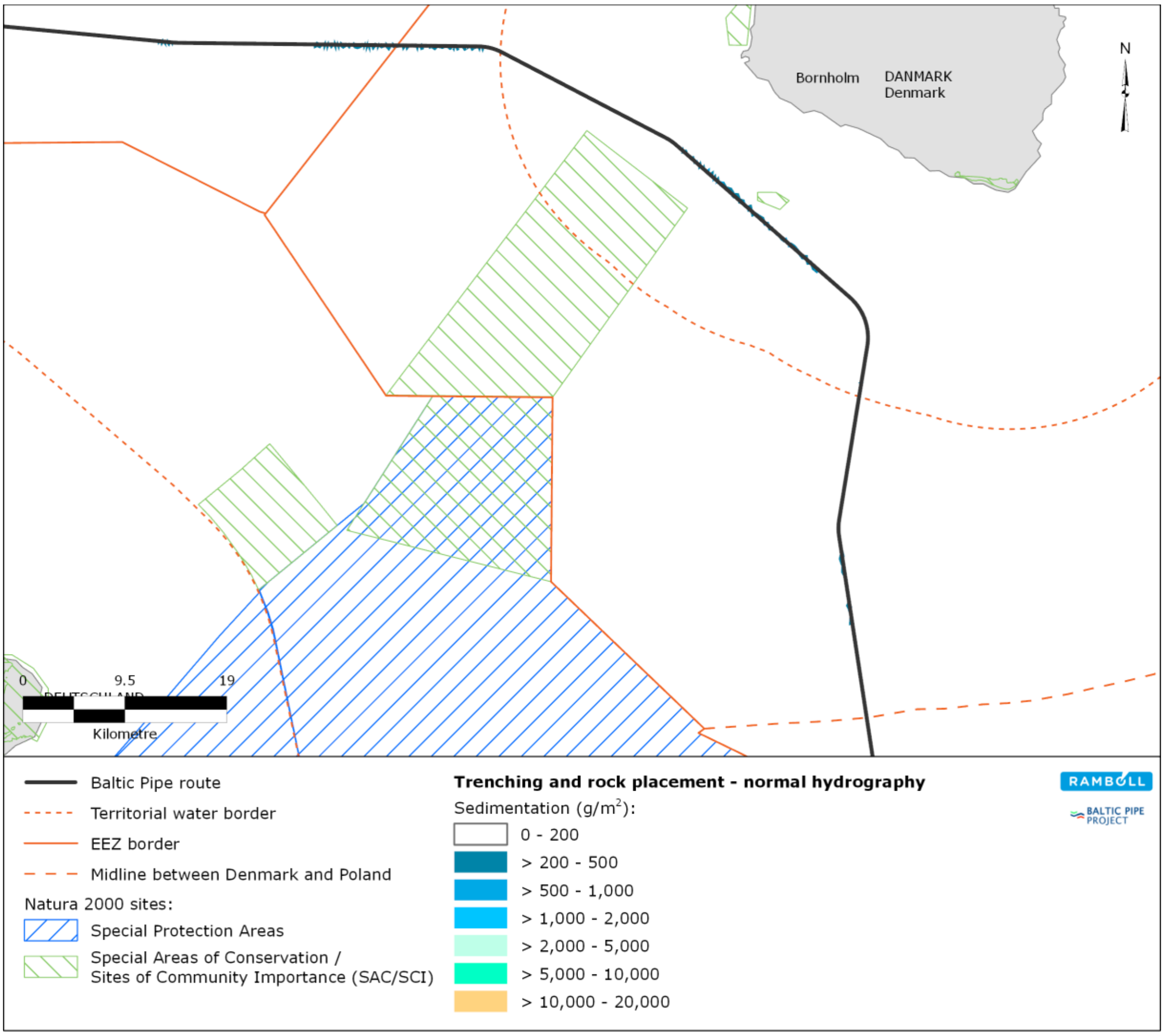


Figure 5-7 Simulation of spilled sediment deposits at the seabed one week after finalisation of trenching (using post-lay ploughing) in the area southwest of Bornholm.

5.1.3 Contaminants and nutrients

The sediments that are spilled and dispersed in the seawater may potentially include heavy metals and organic contaminants. This is particularly the case for fine-grained sediments and particulate organic matter (POM). A proportion of the particle-associated contaminants may be released to the water column as a result of the shift in the chemical environment when the particles are suspended in the water. The majority of the contaminants are, however, expected to continue being associated with the particles and will therefore settle back to the seabed.

Seabed sediments along the pipeline route have been analysed for the concentrations of contaminants and nutrients. The results of these analyses are outlined in Section 9.3, Surface sediments and contaminants. As expected, the level of contaminants and nutrients is highest in the deeper parts, where fine-grained sediments with a high organic content prevails. The concentrations of contaminants or nutrients were not higher than expected in any area, i.e. no contaminant "hot spots" were identified in the Danish part of the Baltic Sea. Therefore, the release of contaminants and nutrients per tonne of seabed sediments spilled to the water column from the seabed interventions works is expected to be comparable to the release caused by natural re-suspension in rough weather, trawling, etc.

When sediments are spilled and suspended in the water, a fraction of the particle-associated contaminants and nutrients will be released to the water column. This mechanism includes both the release of contaminants/nutrients in the sediment pore water and desorption of some of the contaminants/nutrients adsorbed to the sediment particle surfaces. A fraction of the released substances will be bioavailable.

It is difficult to estimate how large a fraction of the contaminants associated with the sediments will be released to the water column, and how large a fraction will stay associated to the sediment particles and settle back to the seabed. Moreover, it is difficult to estimate how large a fraction of the released substances will be bioavailable. For a comparable project in the Baltic Sea, it was assumed that the bioavailable fraction of the contaminants in general is approximately 10% (Rambøll / Nord Stream 2 AG, 2017a, based on information from Cantwell & Burgess, 2004; MacKay, 2001; Paquin *et al.*, 2002). It should be stressed that this is an order of magnitude only; it varies between the different contaminants. The above shows that only part of the contaminants in the suspended sediments are released to the water column, and only parts of the released contaminants are bioavailable.

Some of the N and P associated with the seabed sediments may be released to the water column from sediment spill caused by the construction works. This is mainly the case for the N and P which are dissolved in the pore water and adsorbed to the particle surfaces; the N and P which exist as an integral part of the POM are not likely to be dissolved in the water and will settle back to the seabed.

The average concentrations of contaminants and nutrients in the seabed sediments along the pipeline route are used to calculate the amounts of the various substances in the sediment spilled in Danish waters, see Table 5-3. It should be stressed that the amounts shown in the table are not the amounts that will be released to the water column; rather, they are the amounts present in the spilled sediments. The bioavailable proportion of the released substances will only be a fraction of the numbers shown in the table.

Table 5-3 Average concentrations of contaminants and nutrients in seabed sediments along the pipeline route (see Section 9.3) and calculated amounts of each in the sediments spilled in Danish waters (based on the total sediment spill in Danish waters from Table 5-2).

Substance	Average concentration in sediment [mg/kg DW]	Total amount in spilled sediments [kg]
Cd	0.36	14
Pb	20.80	790
Hg	0.05	1.9
As	6.18	235
Cr	15.19	577
Zn	41.50	1,577
Cu	11.58	440
Ni	9.36	356
Mn	106.00	4,028
Mineral Oil	54.40	2,067
Benz(a)pyrene	0.02	0.80
Total PAH	0.48	18
Sum PCB congeners	0.00	0.046
TBT	<0.01	<0.38
DBT	0.00	0.15
MTB	0.01	0.19
HCB	<0.005	<0.19
HCH	<0.04	<1.5
DDT	<0.04	<1.5
Chlordane	<0.01	<0.38
N	1,556.00	59,100
P	463.00	17,600

5.1.4 Conventional and chemical munitions

The Baltic Sea has a history of significant naval and strategic importance and the legacy of World War I (WWI) and World War II (WWII) is the presence of munitions. In the following section, munitions are categorised as:

- *Conventional munitions* - Munitions containing explosives, used in wartime or for post-war training purposes. These consist of sea mines, depth charges, torpedoes, aerial bombs, artillery shells etc.
- *Chemical munitions* - Munitions containing chemical warfare agents[4] which were mainly disposed (dumped) following WWII.

As part of the preparations for the Baltic Pipe project, a desk study was carried out in order to establish an overview of the munitions issue within the Baltic Sea in relation to the alignment considered for the Baltic Pipe (Rambøll, 2018k). The desk study was prepared using information from relevant public authorities and commissions, public domain studies, expert reviews and consultations. In summary, the desk study revealed the following munitions risk areas within the pipeline route corridor (see Figure 5-8) (Rambøll, 2018k):

[4] Chemical compounds used in chemical munitions.

- British mine gardens from WWII;
- German mines from WWII;
- Soviet mine fields from WWII;
- Expected shooting range from Stevns Fortet;
- Navy exercise areas;
- Risk area for the dumping site for chemical munitions.

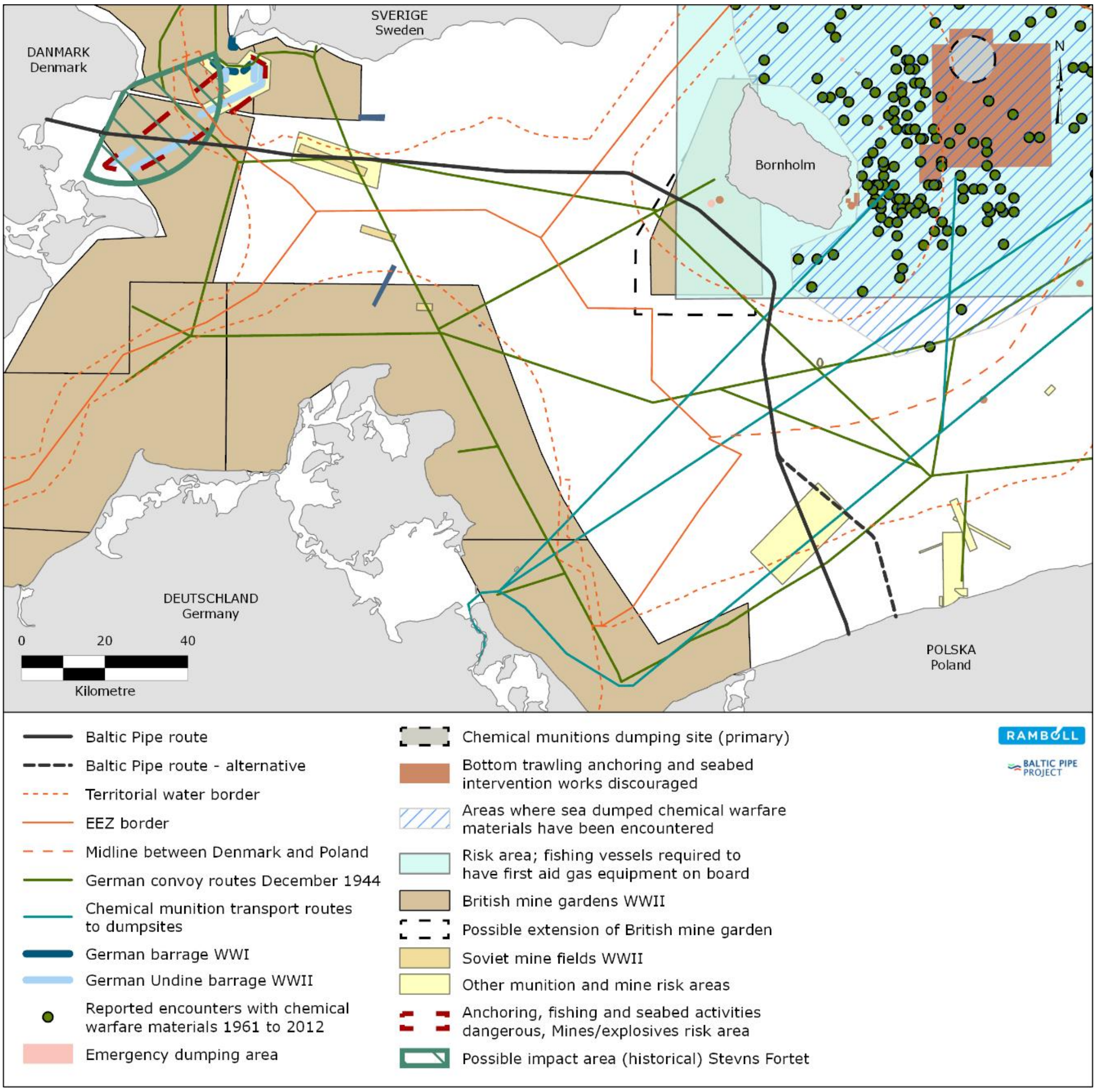


Figure 5-8 Overview map of munitions risk areas (Rambøll, 2018k). The areas are approximations only, based on the available information, including information from HELCOM, 2013c.

<u>Conventional munitions</u>

In the western part of the Baltic Sea, sea mines were used in great numbers during WWII by both Allied and Axis forces. Mines which did not explode during the War were subject to post-War clearance projects. Nevertheless, mines are still located and disposed of in the Baltic Sea even today. The mines found on the seabed will often be inoperative, but their charge often remains intact.

Not only mines were placed in the Baltic Sea during WWII. Other types of munitions were left on the seabed, such as torpedoes and depth charges, which were deployed against submarines.

Unexploded torpedoes rest on the seabed at the end of their range and the depth charges either fell overboard by accident or failed to explode due to malfunction. Torpedoes and depth charges are frequently found and disposed of by the Explosive Ordnance Disposal Service authority (Ammunitionsrydningstjenesten). Furthermore, the possibility that munitions have been moved from their original locations by sea currents cannot be ruled out.

In the period between the World Wars and particularly after WWII, quantities of surplus munitions were dumped in the western part of the Baltic Sea. In addition, vessels have been targeted and bombed on their convoy routes and wrecked vessels could potentially have carried munitions.

<u>Chemical munitions</u>
Chemical munitions were not used in Europe during WWII. However, both sides stockpiled large quantities of them. After WWII, these stockpiles needed to be handled, and dumping at sea was deemed the most appropriate solution at the time. Approximately 40,000 tonnes of chemical munitions were dumped into the Baltic Sea, originally containing approximately 15,000 tonnes of chemical warfare agents. The munitions have mainly been dumped item-by-item from ships headed for the designated dumping areas. Materials were thrown overboard in the dumping areas as well as *en route* from the loading harbours. Chemical warfare materials were scattered within the dumping areas marked on sea charts, in their vicinity and on the former transport routes. Uncertainty about the total amounts, types, and exact locations of dumped chemical warfare materials remains today (HELCOM, 2018b). Figure 5-8 shows the Bornholm basin and the transport routes.

The majority of the chemical warfare munitions dumped were aircraft bombs, followed by encasements and containers. A typical aircraft bomb is the K.C. 250 (Kampfstoff Cylindrisch), which is 160 cm long, weighs 250 kg and contains approximately 100 kg of chemical warfare agents, mainly mustard gas. More than half of the chemical munitions dumped (in tonnes) were aircraft bombs containing mustard gas. Due to its chemical properties, mustard gas is an agent that can remain stable on the seabed for decades after its metal encasings have corroded. The three different official dumping sites contain different types of chemical warfare agents: the area of Little Belt contains primarily of Tabun while the Bornholm Basin and Gotland Deep primarily contain mustard gas (Bełdowski *et al.*, 2014), of which the Bornholm Basin is partially relevant for this current project.

<u>Strategy for handling munitions in the Baltic Pipe project</u>
A detailed magnetometer survey covering a corridor around the pipeline route will be executed before seabed interventions and pipe-lay activities. This is to confirm that no buried munitions objects or similar are present in the project area. The magnetometer survey will be planned in agreement with the national authorities responsible for unexploded ordnance (UXO) (in Denmark: Værnsfælles Forsvarskommando and Søværnets Minørtjeneste). If objects are found, the main strategy is to re-route to avoid munitions. If clearance is unavoidable, this will be executed by Søværnets Minørtjeneste. Because objects resting at the seabed will be avoided as far as possible when designing the route, occurrences of munitions objects identified from the magnetometer survey is considered an *unplanned event* and will be assessed as such.

5.1.5 Underwater noise

The Baltic Pipe construction activities will cause emissions of underwater noise of varying frequencies and intensities, which may impact marine mammals and fish. The main construction activities that generate underwater noise are the following (sheet piling and similar are not planned for the Baltic Sea part of the project):

- Rock installation;
- Post-lay trenching;
- Back-hoe dredging;
- Pipe-lay;
- Anchor handling;
- Construction vessel movement;
- Operational noise (noise from gas flow);
- Munitions clearance (unplanned event).

Underwater noise measurements for post-lay trenching in Sweden were carried out as part of environmental investigations for NSP. These measurements showed that the source noise level from the trenching vessel were of the same magnitude as the noise level from three commercial vessels in the area. Furthermore, the underwater noise level of a pipe-lay vessel has been estimated to be at the same level as commercial vessels (Johansson & Andersson, 2012). The above findings are corroborated by the levels shown by WODA (2013) and Jones & Marten (2016). The literature suggests on the basis of measurements that the noise impact from rock installation is dominated by surface-generated noise from vessels (Nedwell & Edwards, 2004). Measurements have been conducted with and without rock placement taking place and with the presence of a vessel. It is stated that within the variability of the measurements, there was no evidence that the rock placement contributed to the noise level. The noise from rock placement is therefore considered comparable to regular shipping noise.

The underwater noise generated from the vast majority of the construction activities are not distinguishable from the ambient noise levels in the Baltic Sea, which is characterized by large volumes of ship traffic and therefore a relatively high background underwater noise level (see Section 9.5). Hence, only noise from munitions clearance is included in the underwater noise propagation modelling and the following impact assessment on marine life. Based on the route design strategy, munitions clearance is treated as an *unplanned event* (see Section 5.1.4) and is dealt with as such in the assessments.

The results of the modelling of underwater noise from the proposed project are presented in the following, while assessments of the potential impacts on fish and marine mammals are documented in Sections 9.12 and 9.13, respectively.

The underwater sound propagation model calculates estimates of the sound field generated from underwater sound sources, in this case from munition clearance. The modelling results are utilized to determine the potential impacts areas (contour plots) from the underwater noise sources for the various identified marine life for 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, Jensen *et. al.*, 2011). The sound propagation modelling uses acoustic parameters appropriate for the specific geographic region of interest, including the expected water column sound speed profile, the bathymetry, and geoacoustic properties for the seafloor, 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.

BOX 5-2: Underwater noise - definitions

The following definitions regarding underwater noise apply:

1. *Sound pressure level (SPL)* - Average noise level over the measurement period expressed in dB re 1 µPa. Continuous sources, such as vibro-piling and shipping, are commonly described in terms of an SPL.
2. *Sound exposure level (SEL)* – Total noise energy over the measurement period expressed in dB re 1 $\mu Pa^2 \cdot s$. The SEL is commonly used for impulsive sources because it allows a comparison of the energy contained in impulsive signals of different duration and peak levels.
3. *Peak level* – Maximum noise level recorded during the measurement period expressed in dB re 1 µPa. The peak level is commonly used as a descriptor for impulsive sources.

(Government of Australia, 2012)

Input for the underwater noise propagation model

The input parameters applied for the underwater noise propagation model are discussed in the following section.

Munitions clearance

The details regarding munitions clearance are thoroughly described in section 5.1.4. The underwater sound source levels used for munitions clearance at the locations in Danish waters are based on the expected charge weights of the munitions. The underwater noise propagation modelling has been performed with the total charge weights of the munitions as depicted in Table 5-4.

The modelling positions applied in the underwater noise propagation model have been determined on the basis of the munitions risks areas, see Figure 5-8. Hence the model results illustrate potential propagation impact zones and are not necessarily fixed positions in the risk areas.

Table 5-4 Overview over the total charge weights applied for the two locations in Danish waters at Faxe Bugt and southwest of Bornholm.

Munition clearance position	Blast monitor location UTM 33 WGS84 Northern	Eastern	Blasting depth [m]	Total charge weight (donor + munition) [kg]
Faxe Bugt	330,500	6,116,200	8	30
				340
Bornholm	478,000	6,093,000	17	340

The source levels of the munitions are expressed by the sound exposure level, SEL, and are calculated using the empirical equation given by:

$$\text{SEL} = 6.14 * Log_{10}\left(W^{1/3}\left(\frac{R}{W^{1/3}}\right)^{-2.12}\right) + 219$$

where SEL (Sound Exposure Level) is expressed in dB re 1 μPa²s @ 1 m, W is the charge weight in kg TNT and R is the measurement range in meters, in this case 1 meter (Soloway & Dahl, 2014).

The applied SELs are used as input parameters for both summer and winter conditions and are presented in Table 5-5.

Table 5-5 Calculated SELs for the applied charge weights for the present munitions.

Munition clearance position	Munitions type	Total charge weight (donor + munition, TNT) [kg]	Sound exposure level, SEL [dB re 1 μPa2s @ 1 meter]
Faxe Bugt	155 mm artillery grenades	30	228.4
	WWII torpedo, 0.5*4.0 m	340	235.2
Bornholm	WWII torpedo, 0.5*4.0 m	340	235.2

The munitions sound source spectrum for a charge weight of 340 kg TNT is depicted in Figure 5-9.

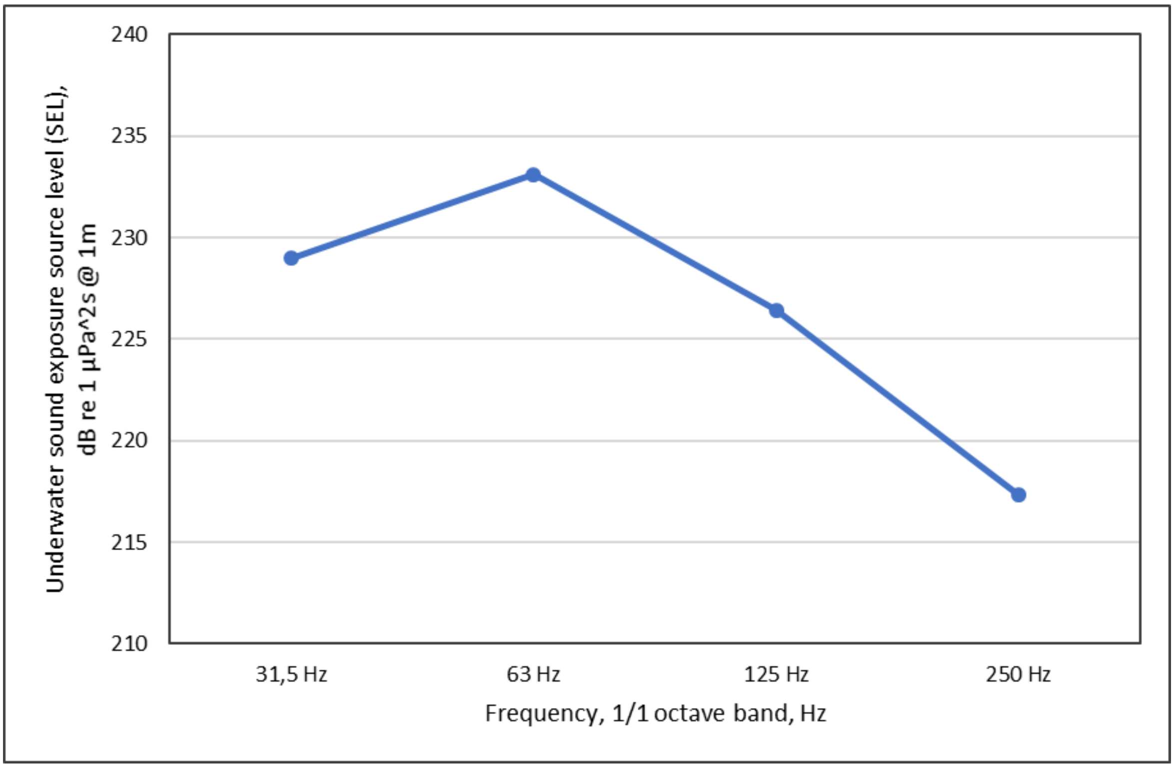


Figure 5-9 Munitions clearance sound source spectrum for a charge weight of 340 kg TNT.

The munitions clearance sound source spectrum for a charge weight of 30 kg TNT applied in the underwater noise propagation calculations has been adjusted according to the sound source exposure level.

Bathymetry

The geometry of the seabed is a significant parameter when calculating underwater noise propagation. The outline of the surface is described with a submarine topography or bathymetry. For the underwater noise propagation modelling, detailed bathymetric data with a sufficient extent for the entire study have been retrieved from EMODnet Bathymetry Viewing and Download Service (EMODnet, 2018). The bathymetry of the project area is thoroughly reviewed in Section 9.1.

Geoacoustic properties

Information regarding the upper layers of the seabed has been gathered from Vibrocore geotechnical drillings along the pipeline alignment. In the area southwest of Bornholm, the Vibrocore data are not fully adequate and have therefore been supplied with information from the HELCOM Map and Data Service (HELCOM, 2018c). Information concerning the bedrock level has been obtained via a publication from the Danish EPA containing altitude maps of the pre-Quaternary surface (Miljøstyrelsen, 2001). The conditions of the seabed vary but are based on the average layer in each area and are considered to be conservative in relation to underwater sound propagation. The layers applied in the underwater noise propagation modelling and the main geoacoustical parameters of the layers at the two selected locations in Danish waters are specified in Table 5-6, based on Jensen *et al.* (2011).

Table 5-6 Overview of the seabed geoacoustic profile used for the modelling of the position in Faxe Bugt and off Bornholm, based on Jensen *et al.* (2011). The geoacoustic properties are described as C_p = compressed wave speed, α = compressional attenuation.

Position	Seabed layer	Material	Geoacoustic property
Faxe Bugt	0 – 25 m	Sand	C_p = 1.650 m/s and α = 0,8 dB/λ
	> 25 m	Bedrock	C_p = 5.250 m/s and α = 0.1 dB/λ
Bornholm	0 – 5 m	Sand	C_p = 1.650 m/s and α = 0,8 dB/λ
	5 – 10 m	Mud	C_p = 1.700 m/s and α = 1 dB/λ
	> 10 m	Bedrock	C_p = 5.250 m/s and α = 0.1 dB/λ

Sound speed profiles

The sound speed profiles are calculated on the basis of water column data consisting of hydrographic measurements of salinity and temperature at descending depths. The water column data have been obtained from the HELCOM/ICES monitoring programme (ICES, 2018a). Water column data have been gathered for representative measurements near the two locations that are being examined.

The hydrographic data are thoroughly reviewed in Section 9.2. The sound speed profiles utilized in the underwater sound propagation modelling are depicted in Table 5-7. The underwater sound propagation characteristics vary throughout the seasons of the year. Predictions have been carried out for both winter (December-March) and summer (July-September) water column conditions.

The speed of sound profiles for the location in faxe Bugt only contains data to a depth of 20 m due to the shallow water in the assessed impact area. The available water colomn data for the location off Bornholm is to some extend deficient. Available water colomn data for calculating the speed of sound profile only contain data to a depth of 20 m for the winter period and to a depth of 57.5 m for the summer period. The majority of measurements of water colomn data for the summer period is present in depths down to 45 m. For further depths applicable for both winter and summer periods data has been extrapolated to prolong the speed of sound profiles to a sufficient depth.

Table 5-7 Water column data (speed of sound profile) for the locations in Faxe Bugt and off Bornholm.

Depth	Position: Faxe Bugt		Position: Bornholm	
	Winter, Speed of sound [m/s]	Summer, Speed of sound [m/s]	Winter, Speed of sound [m/s]	Summer, Speed of sound [m/s]
0 m	1,432	1,483	1.432	1.477
5 m	1,434	1,482	1.433	1.476
10 m	1,435	1,481	1.433	1.475
15 m	1,444	1,479	1.434	1.474
20 m	-	-	1.436	1.473
25 m	-	-	1,440	1,472
30 m	-	-	1,445	1,471
35 m	-	-	1,450	1,470
40 m	-	-	1,454	1,469
45 m	-	-	1,457	1,468
50 m	-	-	1,461	1,467
55 m	-	-	1,463	1,466
60 m	-	-	1,464	1,466

Results of underwater noise modelling

The underwater sound propagation from unplanned events (munitions clearance) has been calculated at two locations in Danish waters, with the source levels and environmental parameterisation described in the previous sections. Figure 5-10 is an example of a vertical cross section plot of the underwater sound propagation for munitions clearance at the location off Bornholm. The figure shows the variation in the levels from the surface to the seabed. The distances predicted to the various threshold limits represent the maximum at any depth down to the bottom. The plot is disproportionate, as the depth is 60 m and the width is 70 km.

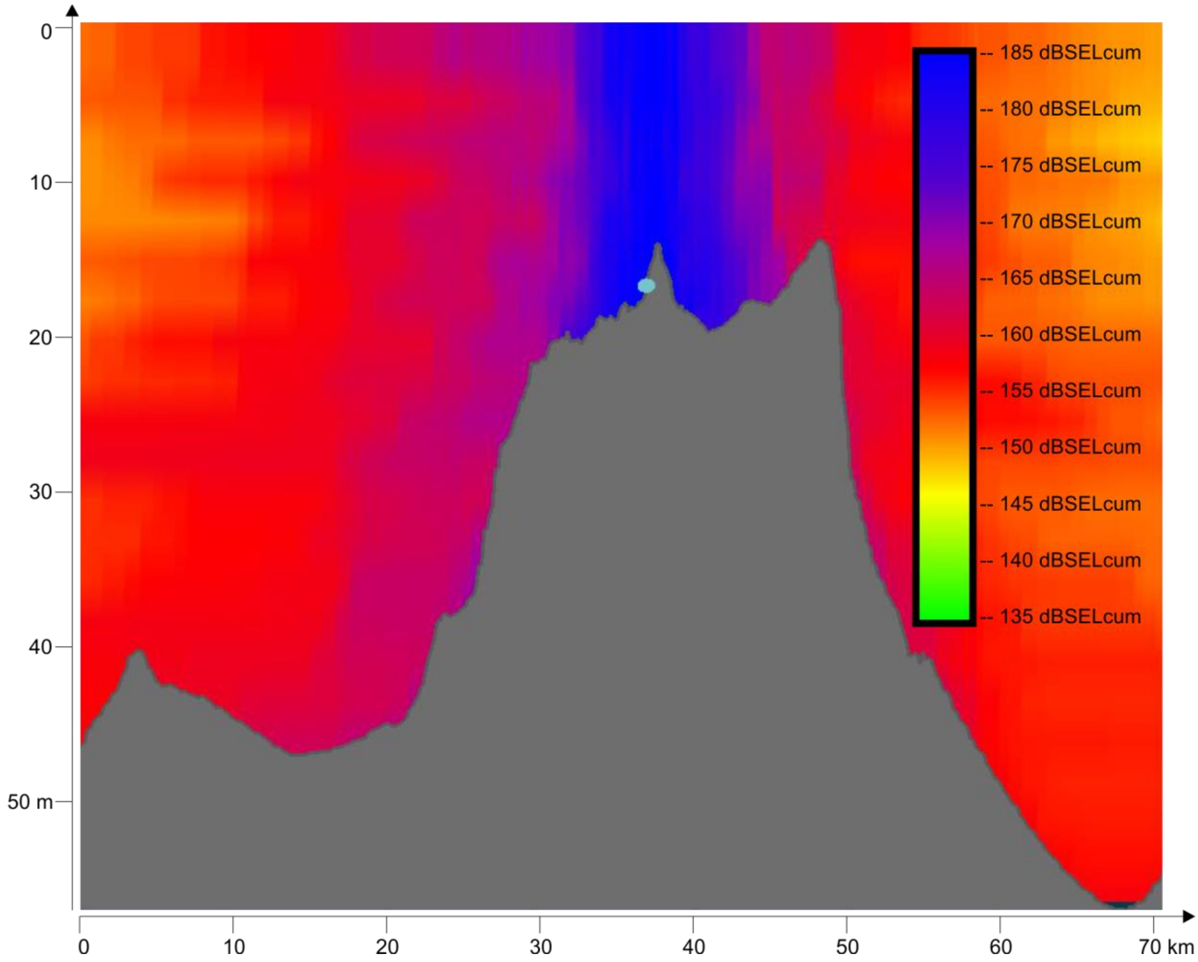


Figure 5-10 Example of vertical plot of munitions clearance sound propagation. The Y axis depicts the depth (60 m) and the X axis represents the distance (70 km); the plot is thus disproportionate. The current underwater sound propagation was calculated for charge weight of 340 kg off Bornholm. The sound source from munition clearance is indicated by the blue dot on the figure.

The subsequent tables (Table 5-8 through Table 5-11) summarize the results of the underwater noise propagation modelling in terms of the distances to applicable assessment threshold level limits indicated in Sections 9.12 (Fish) and 9.13 (Marine mammals). The assessment distances have been calculated for both summer and winter conditions for the specified charge weights at each location.

Table 5-8 Munitions clearance (maximum) distances to the assessment level limit thresholds at the location in Faxe Bugt.

Munitions Clearance (maximum) in Faxe Bugt		Threshold value	30 kg TNT		340 kg TNT	
			Summer	Winter	Summer	Winter
Receptors	Effect	SEL(Cum*) [dB re 1μPa²s]	[km]	[km]	[km]	[km]
Seals and harbour porpoises	PTS	179 dB	1.3	1.3	2.1	2.8
	TTS	164 dB	3.7	4.4	7.7	8.3
Fish	Mortality (mortal injury)	207 dB (229-234 dB peak)	0.6	0.6	0.7	0.7
	Injury	203 dB	0.7	0.7	0.8	0.8

* Cumulative SEL (one event).

Table 5-9 Munitions clearance (average) distances to the assessment level limit thresholds at the location in Faxe Bugt.

Munitions Clearance (average) in Faxe Bugt		Threshold value	30 kg TNT		340 kg TNT	
			Summer	Winter	Summer	Winter
Receptors	Effect	SEL(Cum*) [dB re 1μPa²s]	[km]	[km]	[km]	[km]
Seals and harbour porpoises	PTS	179 dB	1.0	1.0	2.0	1.8
	TTS	164 dB	3.6	4.1	5.9	6.5
Fish	Mortality (mortal injury)	207 dB (229-234 dB peak)	0.4	0.4	0.5	0.5
	Injury	203 dB	0.5	0.5	0.5	0.5

* Cumulative SEL (one event).

Table 5-10 Munitions clearance (maximum) distances to the assessment level limit thresholds at the location off Bornholm.

Munitions Clearance (maximum) in Faxe Bugt		Threshold value	340 kg TNT	
			Summer	Winter
Receptors	Effect	SEL(Cum*) [dB re 1μPa²s]	[km]	[km]
Seals and harbour porpoises	PTS	179 dB	4.8	5.2
	TTS	164 dB	17.5	16.7
Fish	Mortality (mortal injury)	207 dB (229-234 dB peak)	1.5	1.1
	Injury	203 dB	1.5	1.2

* Cumulative SEL (one event)

Table 5-11 Munitions clearance (average) distances to the assessment level limit thresholds at the location off Bornholm.

Munitions Clearance (average) in Faxe Bugt		Threshold value	340 kg TNT	
			Summer	Winter
Receptors	Effect	SEL(Cum*) [dB re 1μPa²s]	[km]	[km]
Seals and harbour porpoises	PTS	179 dB	3.4	3.8
	TTS	164 dB	11.8	12
Fish	Mortality (mortal injury)	207 dB (229-234 dB peak)	0.5	0.5
	Injury	203 dB	0.5	0.6

* Cumulative SEL (one event)

5.1.6 Physical disturbance above water

Physical disturbance above water mainly relates to the presence and activity of construction vessels, including supply vessels with pipe and food supply (fuel supply is not needed, as the pipe-lay vessel normally carries fuel for the entire campaign). Furthermore, helicopters will be used for crew exchange.

Nearshore at the landfall in Faxe Bugt, the pipe-lay vessel will be at the same spot, approximately 1.7 km from the shore, for about two weeks. Furthermore, other vessels will be performing various activities in Faxe Bugt (i.e. excavation of the exit point from tunnelling, recovery of the tunnel boring machine at exit point, trenching of the pipe and backfilling) for about 14 weeks.

The physical disturbance above water at a specific location will take place over a limited amount of time, according to the respective working speeds of the vessels (see Box 5-3).

After installation of the pipeline, a survey vessel will register the precise location of the pipeline as installed.

The physical disturbance from the presence of different vessels and helicopters will be perceived by birds, marine mammals, and humans in the area, due to the visual appearance, the light and the noise emitted. With a nearshore location for the pipe-lay vessel of approximately 1.7 km from the coast line, the noise impact zone predicted to an assessment level of L_r 40 dB(A) is not expected to reach the shore.

5.1.7 Safety zones

During construction, safety zones will be established around the construction vessels to ensure navigational safety. Experience from other pipeline construction vessels suggest that a construction exclusive zone will be established around the pipe-lay vessel, with a radius of 1,500 m centred around the pipe-lay vessel. Likewise, safety zones with a radius of 500 m will be defined around other vessels carrying out surveys, seabed intervention works, etc. However, supply vessels are not expected to impose safety zones. The extent of the safety zones will be agreed with the applicable national maritime authorities.

No non-project related vessels will be permitted to enter the safety zones, which could potentially have an impact during construction on commercial as well as leisure shipping and fishery.

BOX 5-3: Physical disturbance above water & safety zones

WORKING SPEED, PIPE-LAY VESSEL:
Pipe-lay, > 20 m water depth: 2.5-4 km/day
Pipe-lay, < 20 m water depth: 0.5 km/day
Trenching, approx. 12 m water depth (post-lay ploughing): 100-800 m/hour
Trenching, approx. 12 m water depth (back-hoe dredger): Depending on task, subsoil, etc.

VESSELS OPERATING NEARSHORE AT LANDFALL IN FAXE BUGT:
Pipe-lay vessel: approximately 2 weeks
Other vessels: approximately 14 weeks

SUPPLY VESSELS, CREW CHANGE AND SURVEY VESSEL:
Pipe supply: 2-4 per day at water depths > 20 m / 1 per day at water depths < 20 m
Food supply: 1 per week
Crew change: 2-4 helicopters per week
Survey vessel: 1 vessel operating in 2 days to register the pipeline is as installed

AREA OF INFLUENCE ABOVE WATER:
Anchor handling vessel: Max. 1.5 km around the pipeline
Other vessels: 0.5 km around the pipeline

SAFETY ZONE:
Pipe-lay vessels: 1,000 - 1,500 m radius
Other vessels: 500 m radius

5.1.8 Emissions to air

The combustion of fossil fuel by the vessels used during construction of the Baltic Pipe project will result in the emission of several components. Based on experience from other comparable projects, the following are considered to be the four main air emissions: CO_2 (carbon dioxide), NO_X (nitrogen oxides), SO_X (sulphur oxides), and PM (particulate matter). Furthermore, production of the materials used for the project will generate emissions. These air emissions can potentially have an impact on climate, air quality and human health.

Air emission calculations for the Baltic Pipe project have been undertaken. The following delimitation and basis of the air emission calculations provide a general description for the construction and operation of the offshore part of the proposed pipeline.

Delimitation of air emission calculations

The calculated air emissions relate to the direct activities of construction and operation of the pipeline, which include:

- Seabed preparation;
- Trenching and backfilling;
- Rock installation;
- Pipe-lay;
- Other marine logistics (fuel supply and crew change with helicopter);
- Survey and repair during operation.

CO_2 emissions from production of the main materials (steel and concrete used for pipelines and tunnel elements, see Table 3-5 (inventory of materials) are also included in the calculations, as CO_2 emissions have a transboundary geographical scale. Other emissions from material production are not included, as they mainly have an impact on a local scale and it is not known where production will take place. For the offshore emissions calculations, materials from the whole Danish part of the project are included, which includes materials for the pipeline and the tunnel.

Transporting e.g. materials and ships to and from the shore bases is not included in the assessment, as it is not decided where the production of materials will take place and where the ships will be sailing from.

Basis for emission calculations
The emission calculations are approximate, based on a realistic, worst case approach. As the input for the calculations are based on assumptions and as transport of materials and ships to and from the shore bases is not included in the calculations, an uncertainty factor of 1.3 has been added to emissions from construction offshore to compensate for this. Thus, the results are considered as conservative.

The calculations are based on information about vessels used for construction and operation of the project according to information in Chapter 3, Project description, including operation time of the individual types of vessels and the effect (in kW) of the vessels.

Fuel consumption for vessels is calculated using the following formula:

$$Fuel\ consumption\ [kg] = Effect\ [kW] x\ availability\ [hours]\ x\ factor\ for\ fuel\ consumption\ [\frac{g}{kWh}]$$

The factor for fuel consumption applies to all vessels as an average worst case value, and it is based on the latest Greenhouse Gas Study from the International Maritime Organization (IMO, 2015).

The emissions are calculated using the following formula:

$$Emission\ [tonnes] = Fuel\ consumption\ (kWh)\ \ x\ emission\ factor\ (\frac{g}{kg\ fuel})$$

The emission factors for vessels are based on the annual Danish Informative Inventory report to UNECE, made by Aarhus University (Nielsen *et al.*, 2018).

CO_2 emission factors for materials (steel and concrete) are based on the German Ökobau database (ÖKOBAUDAT, 2018), which is a recognised database used by Danish Life Cycle Assessment practitioners.

Air emissions from offshore construction
The results of the air emission calculations for the offshore construction of the project are presented in Table 5-12. The results are divided into offshore construction activities and material production.

Table 5-12 Air emissions from offshore construction and material production.

	Air emissions [tonnes]					
	CO_2	NO_X	SO_2	PM (TSP)	PM_{10}	$PM_{2.5}$
Construction offshore	125,200	3,400	80	150	150	150
Material production (steel and concrete for the pipeline and tunnel)	181,800	-	-	-	-	-

5.1.9 Non-indigenous species

Non-indigenous species (NIS) are species introduced outside their natural past or present range, which may survive and subsequently reproduce. Shipping and boating are important vectors for the introduction and spread of NIS, since the species are easily transported in ballast water tanks or on ship hulls. Up to this date, around 140 NIS or species with unknown means of arrival (cryptogenic species) have been recorded in the Baltic Sea. Of these, 14 were new introductions to the Baltic Sea in the period 2011–2015 (HELCOM, 2017a).

The Ballast Water Management (BWM) Convention, which entered into force on 8 September 2017, 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 (IMO, 2017). In addition, ballast water is regulated by the Danish marine environmental act (see Section 7.8).

All vessels participating in the Baltic Pipe project will be requested to comply with the BWM Convention and the HELCOM Guide to alien species and ballast water management in the Baltic Sea (HELCOM, 2014a). Therefore, the risk of introducing NIS by Baltic Pipe project activities is considered to be very low.

In addition, the risk of introducing NIS in connection with rock installations is negligible, as rocks will be supplied from onshore sources.

5.1.10 Employment generation

Construction of the offshore part of the Baltic Pipe project is expected to be conducted by a specialised contractor. The personnel will primarily stay on the vessels and are therefore not expected to contribute economically to any noticeable higher sales in the form of accommodation and food in the local area. It is expected that approximately 2,000 man-years will be needed as part of the offshore construction activities for the total project in Denmark, Sweden and Poland.

5.1.11 Discharges to sea

Discharges to sea will take place as part of the pre-commissioning activities. Both water intake before and discharge after pressure testing will take place in Faxe Bugt. Further details are outlined in Section 3.9, Pre-commissioning. The characteristics of the discharges to sea are summarized in Box 5-4.

The discharge of water from pressure testing requires a permit from Danish Envoronmental Protection Agency and the discharge permit is granted on the basis of the Order on discharges of substances and materials for the sea[5]. This order is attached to the consolidated Danish Marine Environmental Act (Section 7.8)

BOX 5-4: Summary of discharges to sea from hydrotesting

FLOODING, CLEANING, GAUGING AND DEWATERING
Maximum total discharge volume: 374,000 m^3 (220% of pipeline volume, contingency for re-flooding if first flooding is unsuccessful)
Duration of discharge: 2 weeks

ADDITIVE FOR PREVENTING CORROSION OF PIPELINE (OXYGEN SCAVENGER)
Chemical usage: 20 tonnes of $NaHSO_3$ per flooding, based on assumed oxygen content of 8 mg/l
Discharge water is assumed to be oxygen-free, as almost all $NaHSO_3$ will have reacted with O_2 before discharge

ADDITIVE FOR PREVENTING HYDRATES FORMATION
Chemical use: 240 m^3 Mono Ethylene Glycol (MEG) used for drying pipeline / avoiding hydrate formation during gas filling
The water slugs with MEG (between the pigs) will be recovered to storage tanks in Poland

5.2 Offshore operation

For operation offshore, the potential impacts are listed in Table 5-13.

Table 5-13 Potential impacts for operation offshore and identification of potential receptor interaction.

Potential impact	Receptor*
Presence of pipeline	Bathymetry; hydrography and water quality; surface sediments and contaminants; bathymetry; benthic habitats, flora and fauna; fish; seabirds and migrating birds; biodiversity; protected areas; shipping and shipping lanes; commercial fisheries; raw material extraction sites and dumping sites military practise areas; cables, pipelines and wind farms
Restriction zone	Commercial fisheries; raw material extraction sites and dumping sites; military practice areas; shipping and shipping lanes

[5] Order on discharges of substances and materials for the sea[5] no 394 of 17/07/1984 (*Bekendtgørelse om udledning i havet af stoffer og materialer fra visse havanlæg).*

Potential impact	Receptor*
Heat from pipeline	Hydrography and water quality; benthic habitats, flora and fauna; fish
Underwater noise from gas flow in the pipeline	Marine mammals
Release of contaminants from anodes	Hydrography and water quality; surface sediments and contaminants; benthic habitats, flora and fauna; fish; protected areas
Physical disturbance above water	Birds; biodiversity; commercial fisheries; tourism and recreational areas; protected areas; shipping and shipping lanes
Emissions to air	Climate and air quality; population and human health
Safety zones	Shipping and shipping lanes; commercial fisheries, raw material extraction sites and dumping sites; military practise areas; environmental monitoring stations; tourism and recreational areas

* Assessments of potential impacts on Natura 2000 sites and Annex IV species follow the methodology of Sections 8.3 and 8.4.

Employment generation will be very limited during operation of the pipeline and will not be dealt with further.

BOX 5-5: Summary of offshore operation in Denmark

OPERATION TIME: Approx. 50 years

DIMENSIONS:

- Pipeline width: Approximately 1 m
- Pipeline length in Danish waters and disputed area: 137.6 km
- Trenched pipeline length (expected): 63.5 km
- Rock installation: Approximately 13 locations

RESTRICTION ZONE: 200 m / each side of pipeline

HEAT FROM PIPELINE: max 0.5 °C, 0.5-1 m from pipeline

MAINTENANCE AND SURVEY TRAFFIC: 1 time/year

5.2.1 Presence of pipeline

The presence of the pipeline may change the seabed conditions and hydrodynamics, resulting in temporary disturbance or permanent loss of habitats for benthic flora and fauna; another potential impact is the introduction of a new substrate i.e. artificial reef.

The pipeline length in Danish waters is 137.6 km, of which a large proportion is laid directly on the seabed and not trenched or supported by rock installations. Rocks are installed as support for the pipeline and/or to cover and protect the pipeline at cable crossings and potentially at shipping lanes. Rock installations placed at numerous locations create new substrate at the seabed.

5.2.2 Restriction zone

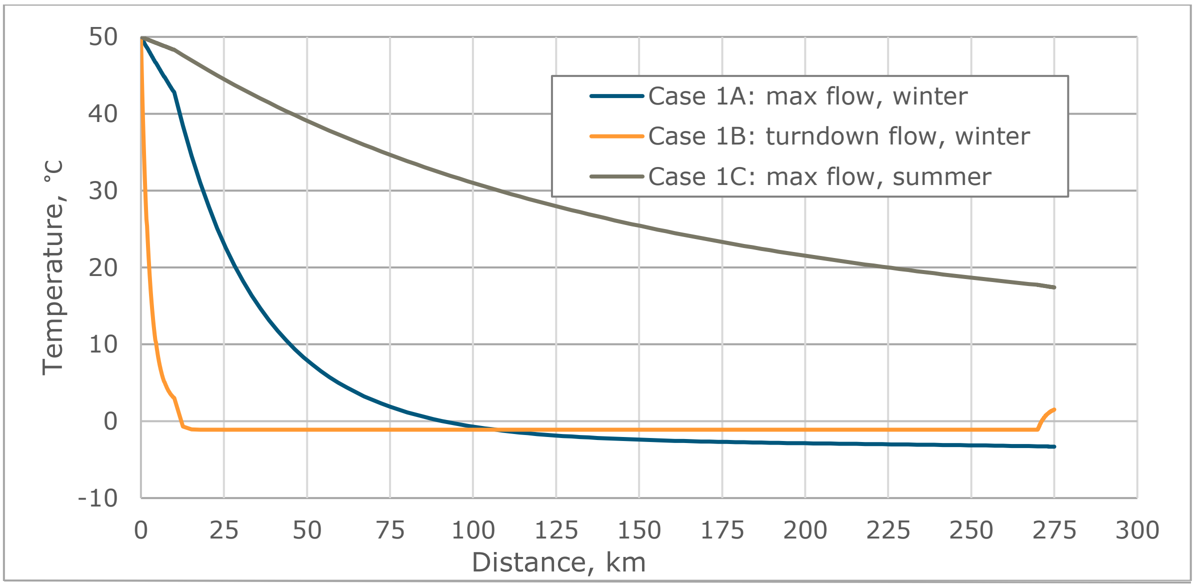
Under the administrative order on protection of submarine cables and submarine pipelines[6], cable or pipeline fields are given a 200 m wide restriction zone along and on each side of the infrastructure. Ships may not, without urgent necessity, anchor in the cable and pipeline fields established for such infrastructure (e.g. pipelines for the transport of hydrocarbons, etc.), which cover the associated restriction zones. In the restriction zones, suction dredging, fishing for stones as well as any use of tools or other gear that is dragged on the seabed is prohibited.

This environmental impact assessment for the Baltic Pipe project is based on the scenario in which the pipeline has a restriction zone as described above. The restriction zone is assessed to have a potential impact on ships and activities in the Baltic Sea (commercial fisheries; raw material extraction sites; military practice areas; shipping and shipping lanes). However, as a part of the further development of the project, it will be clarified if it is possible to eliminate the restriction zone. A scenario with no restriction zone is assessed to have a potential impact on trawling by commercial fisheries.

5.2.3 Heat from pipeline

The temperature of the gas in the pipeline varies, depending on the flow conditions and the temperature of the surrounding seawater and sediments. Figure 5-11 shows the simulated temperature of the gas in the pipeline along the route, for the normal flow situation from Denmark to Poland. The temperature profile for the flow situation from Poland to Denmark is shown in Figure 5-12.

For the situation with gas flow from Denmark to Poland (Figure 5-11), the temperature of the gas at the Danish landfall will be approximately 50˚C. The temperature thereafter drops towards the temperature of the surrounding seawater at a rate determined by the flow conditions and the temperature difference between the gas and the surrounding seawater and seabed surface sediments. The temperature analysis, which includes the cooling caused by the pressure drop (the Joule-Thompson effect), has been used when designing seabed interventions etc. for ensuring that no ice formation takes place at the pipeline surface.



[6]Administrative order no. 939 of 27/11/1992 on protection of submarine cables and submarine pipelines *(bekendtgørelse om beskyttelse af søkabler og undersøiske rørledninger).*

Figure 5-11 Simulated temperature profiles of the gas along the Baltic Pipe pipeline – flow from Denmark to Poland (Rambøll, 2018l).

For the situation with gas flow from Poland to Denmark (Figure 5-12), the temperature along the pipeline is very close to the temperature of the surrounding seawater and seabed surface sediments.

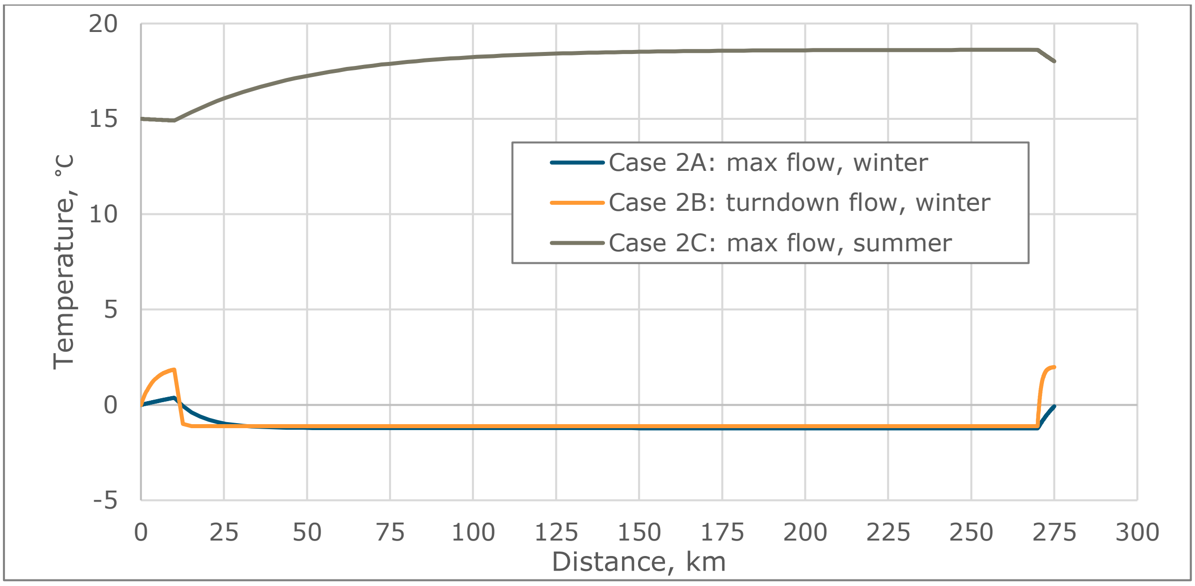


Figure 5-12 Simulated temperature profiles of the gas along the Baltic Pipe pipeline – flow from Poland to Denmark. (Rambøll, 2018l).

The largest temperature difference between the gas in the pipeline and the surrounding seawater and sediments is hence approximately 50˚C, which will occur in winter near the Danish landfall. The temperature difference will cause heat transport from the gas to the surrounding seawater and sediments, which is proportional with the difference in temperature, i.e. largest near the Danish landfall.

Analysis and monitoring from comparable offshore pipeline projects have shown that the temperature impact is small and local. For the Nord Stream pipelines, in the area where the pipelines are exposed with the largest temperature difference (gas temperature: approximately 40˚C), there was a small temperature increase (maximum 0.5˚C) in the water near the seabed and in the water on the downstream side of the pipeline. The temperature change was only detectable at a maximum distance of approximately 0.5-1.0 m from the pipelines. When there was no current, the increase in water temperature was up to 0.1˚C, 5 m vertically above the pipeline (Rambøll / Nord Stream 2 AG, 2017a).

A temperature impact of the same order of magnitude or less is expected from the Baltic Pipe pipeline near the Danish landfall, where the temperature difference between the gas and the surroundings will be the greatest.

5.2.4 Underwater noise from gas flow in the pipeline

Along the alignment through Danish waters, the pipeline will partly be trenched into the seabed and partly be exposed directly on the seabed. At stretches where the pipeline is trenched into the seabed, no underwater noise is expected to be emitted from the operating pipeline to the water above.

During the operational phase, the gas flow will generate low levels of noise at low frequencies. In the literature it is acknowledged that underwater noise from subsea pipeline operation or installation may occur, but the impacts are most likely to be much lower than the noise from commercial ships and will therefore be masked (IISD, 2018). Calculations carried out for a comparable submarine gas pipeline project in the Baltic Sea have shown that noise emitted from the pipeline itself due to the gas flow inside of it is of a very low intensity and only audible to marine mammals very close to the pipeline (Sveegaard *et al.*, 2016).

5.2.5 Release of contaminants from anodes

As outlined in Section 3.3, sacrificial anodes mainly consisting of aluminium will be used as a back-up corrosion protection system in case of damage to the coating of the pipeline. Beyond the immediate vicinity of the anode (i.e. <5 m), the concentrations of metal ions within the water column because of anode degradation during the operational phase will generally be indistinguishable from background concentrations.

Monitoring around the Nord Stream pipeline in the Baltic Sea has shown that concentrations of heavy metals in the water were below the detection limit approximately 1-2 m from the pipelines (Rambøll / Nord Stream 2 AG, 2017a). The same is expected to apply to the sacrificial anodes to be installed on the Baltic Pipe pipeline.

5.2.6 Physical disturbance above water

The physical disturbance above water during operation is mainly related to the presence and activity of survey and maintenance vessels. The physical disturbance is of the same nature as during the construction period (see Section 5.1.6), but with a much lower frequency. The expected frequency of surveys and maintenance is once per year.

5.2.7 Emissions to air

Survey and maintenance vessels will emit emissions to air during operation of the Baltic Pipe Pipeline. The delimitation and basis for air emissions calculations presented in Section 5.1.8 also apply to the offshore air emissions during operation.

Air emissions from offshore operation

The results of the air emissions calculations for operation of the offshore part of the project are presented in Table 5-14. The air emissions are presented as average emissions per year during an estimated operation time of 50 years.

Table 5-14 Air emissions from offshore operation, per year on average during the estimated operation time (50 years).

	Air emissions [tonnes]					
	CO_2	NO_X	SO_2	PM (TSP)	PM_{10}	$PM_{2.5}$
Operation, per year (average)	60	1.5	0	0.1	0.1	0.1

5.2.8 Safety zones

For the vessels carrying out survey and maintenance, exclusion zones will be defined around vessels carrying out the work, corresponding to the safety zone for “other” vessels during operation (500 m radius around the vessels).

The establishment of safety zones results in all ship traffic being requested to avoid these exclusive zones, thus potentially having an impact on both commercial and leisure shipping as well as fishery. The frequency of the survey and maintenance activities are, however, low, i.e. approximately once per year.

5.3 Onshore construction

For construction onshore, the potential impacts are listed in Table 5-15.

Table 5-15 Potential impacts for construction onshore and identification of potential receptor interaction.

Potential impact	Receptor*
Land use change	Population and human health
Physical disturbance	Landscape; geology, groundwater and surface water; protected areas, natural habitats, flora and fauna; annex IV species; biodiversity; population and human health; tourism and recreational areas
Airborne noise	Noise**; population and human health; tourism and recreational areas
Emissions to air	Climate and air quality; population and human health
Employment generation	Population and human health

* Assessments of potential impacts on Natura 2000 sites and Annex IV species follow the methodology of Sections 8.3 and 8.4.

** Noise is not a physical-chemical receptor as such but is related to the existing noise level in the landfall area and the impact on this from the project.

BOX 5-6: Summary of onshore construction in Denmark

DIMENSIONS:
- Work site: 9,000 m^2
- Launch shaft for tunnelling: l:10 m, w: 5 m, d: 10 m

DISTANCE FROM LAUNCH SHAFT TO COAST:
- Perpendicular to the coast: 250 m
- Length of tunnel: 400 m

DURATION:
- Construction period onshore: Approximately 11 months
- Pre-commissioning period: 2 months
- Occupation of work site: 1½-2 years

TRAFFIC TO/FROM SITE:
- Average: About 1,180 trucks during the whole construction period – approximately 6 trucks / day
- Intensive periods: approximately 18 trucks / day for three weeks and 15 trucks / day for another six weeks

5.3.1 Land use change

As outlined in Section 3.4, the construction works will require clearing of a work site with an area of approximately 9,000 m^2, from where the onshore construction activities will take place. The work site will be used for the project both during construction and pre-commissioning and the site will be occupied by the project for about 1½-2 years. Furthermore, an access road to the work site will be established across the field, but its precise location is not yet clarified.

5.3.2 Physical disturbance

Physical disturbance from the construction activities is mainly related to the presence and activities of construction machines at the work site (9,000 m^2) and the associated access road (its precise location is not yet clarified). As part of the work, a launch shaft will be excavated for tunnelling.

The physical disturbance at the landfall includes visual disturbance, traffic to/from the work site, a potential lowering of the near surface groundwater when excavating the launch shaft for tunnelling and a risk of spillage from construction equipment.

Visual disturbance

Visual disturbance from construction machines, trucks and other equipment may result, as the landfall area is an open field with few visual barriers. The work site will be fenced. The visual disturbance will include light at the work site. The tunnelling activities will take approximately 11 months, while pre-commissioning will take approximately two months. However, there will be breaks between the two phases, and it is expected that the work site will be occupied by the project for about 1½-2 years.

Visual disturbance can affect neighbours of the work site and recreational users of the surrounding area. Furthermore, terrestrial fauna may be affected.

Traffic to/from work site

The construction activities will result in traffic to/from the work site, with trucks transporting equipment, materials, and soil etc. On average, 6 trucks (resulting in 12 transports) are expected per day. Additionally, personnel travelling to and from the work site will also generate traffic. Most of the traffic is expected to enter or exit via the motorway exit at Rønnede (motorway exit no. 37).

The majority of the trucks will be needed for transport of excavated soil from the tunnel away from the site. During the most intensive period of construction, when the pre-fabricated tunnel elements will also be transported to the work site, there will be a need for approximately 18 trucks per day for three weeks and 15 trucks per day for another six weeks, resulting in approximately 36 and 30 transports in total each day, respectively.

Lowering of near-surface groundwater

New borings performed at the landfall area show that there may be 1-2 m thick sand lenses saturated with near-surface groundwater in the depth of the launch shaft. As a result, it may be necessary to drain smaller amounts of near-surface groundwater with a pump when establishing the launch shaft, which potentially can have an impact on surface water (i.e. nearby ponds). The launch shaft will be established with sheet piles, thereby cutting off the potential groundwater flow to the shaft. The amount of groundwater that will need to be handled is thus excepted to be low.

Spillage from construction equipment

During construction, there is a risk of spill at the work site from the construction equipment, including mobile fuel tanks, which may potentially impact the groundwater.

5.3.3 Airborne noise

The construction activities will generate airborne noise of varying frequencies and intensities from the work site. Furthermore, there will be noise from the construction related traffic to and from the work site (see further description in Section 5.3.2). The noise may impact the closest surroundings, including neighbours and the users of nearby recreational areas and activities. The following description is related to noise from the work site.

Noise sources

The noise from machines and activities at the landfall is calculated based on the noise source power (sound power, L_{WA} in dB(A)). Source power is an expression of how much noise energy the source of noise emits to the environment and is not indicative of the noise level measured at the noise source. The noise calculations use the source power to calculate the noise level in the surroundings. The noise level around a noise source will always have significantly lower values than the source strength, and it will be lower with increased distance.

The source powers for the noisy machines applied in the study of noise from construction work are shown in Table 5-16. The noisy machinery may be subject to change during the construction phase if the contractors decide on alternative equipment, but the identified noisy machines are assessed as representative for assessing noise from the onshore construction activities.

Table 5-16 Overview of the noisy machinery expected to be used during construction at the landfall. The construction work is divided into five main construction phases. Several types of machinery will be used, but the types listed are the noisiest and will be decisive for the noise caused by construction activities. The source strengths do not include any additions for clearly audible impulses.

Construction phase	Type of machinery	Energy [kW]	Sound power L_{WA} [dB(A)]	Reference
Phase 1 Clearing of work site	Dredger	29	97	(Defra, 2006)
	Dozer	93	109	(Defra, 2006)
	Truck	254	101	(Jacobsen & Kragh, 1986)
Phase 2 Sheet piling and excavation (launch shaft)	Sheet piling	250	125	(Vejdirektoratet, 2016)
	Dredger	385	108	(Defra, 2006)
	Dredger	29	97	(Defra, 2006)
Phase 3 Tunneling	Generator for machines used during tunneling	1519	106	(Defra, 2006)
	Crane for lifting tunnel elements	254	101	(Jacobsen & Kragh, 1986)
Phase 4 Pre-commissioning	Flooding pumps	522	110	(Defra, 2006)
Phase 5 Restoration of launch shaft and work site	Dredger	385	108	(Defra, 2006)
	Compression	11	103	(Vejdirektoratet, 2016)

The individual machinery will be used alone or in combination with other equipment for carrying out the construction activities that are part of the overall construction project. There may be other activities, but these selected activities are considered the noisiest. The individual activities can also be performed differently, which may result in a different number of machinery (e.g. the number of trucks involved in soil works) or different machinery not being in operation all the time.

The individual machine will not normally be in constant operation without interruptions. During the night period, the noise is assessed for the ½ hour in which the most noise occurs. Therefore, if night work occurs, it is not unrealistic that each machine is in continuous operation for the worst ½ hour. It is therefore assumed as a worst-case consideration that most machines are in constant operation.

When sheets are to be brought into the soil, it is assumed that it will be done by piling, which is the noisiest method, and this will be used as a conservative premise for noise calculations. It is possible to vibrate the sheets into the soil, and this method is less noisy than regular sheet piling; however, use of this method will depend on the local soil conditions.

It should be noted that this noise study of the construction work involves several activities that may cause noise above the applied guiding limit values at dwellings (see the following paragraph and Section 9.9). There will be other noisy construction activities that will be part of the overall noise picture, but this noise will be less important and subordinate to the construction activities studied.

Calculation of noise from construction works

Noise that will occur in the future cannot be measured but must be calculated. The basis for calculating noise from the construction activities at the landfall is the information about the type of machinery expected to be used, the noise that the machinery is expected to cause and extensive experience from other major construction projects. For certain noise sources, typical standard data are applied (e.g. for trucks). In addition, a worst-case consideration has been applied in selecting noise data. The basis for noise calculations also includes the preliminary plans for construction work, as they are known at present. It should be noted that the subsequent detailed planning of the construction activities may lead to changes in the assumptions that have been applied. For example, the contractor may choose to use other types of equipment and methods than currently anticipated.

The calculations in this EIA study will, however, be a guide to the noise impact of construction work. In addition, the contractor must report noisy construction work to Faxe Municipality prior to initiation with information on how it will be carried out and information about the impact on dwellings from noise and vibration.

The noise sources will be used to calculate the noise from the work site. The noise will be calculated in a grid net and illustrated as a noise map displaying which surrounding areas can be exposed to noise above the following two noise levels:

- 70 dB(A): The guiding limit value used for construction works within regular working hours; and
- 40 dB(A): The guiding limit value used for construction works outside regular working hours if construction work exceptionally is to be carried out outside normal working hours.

Details regarding the guiding limit values applied for the assessments of this project are elaborated in Section 9.9.

The information on the noise emissions of the various sources (their sound power levels, operating times and the noise frequency composition) has been used to calculate how far away the noise will fall to the two guiding limit values for noise from construction work (70 dB(A) during regular working hours and 40 dB(A) during other periods). These calculations were performed in accordance with the Danish Environmental Protection Agency's guidance on the calculation of noise from companies (Miljøstyrelsen, 1993). However, a few simplifications and assumptions have been applied to the calculations:

- It is assumed that the terrain is acoustically soft everywhere;
- It is assumed that the noise sources are located 2 m above ground (apart from sheet piling, for which the noise source is located 6 m above ground) and the receiver is located 1.5 m above ground.

As previously discussed, audible impulses are likely to occur in the noise from activities involving sheet piling if the distance to the piling work is less than a few hundred meters. At greater distances, the probability of audible impulses may be reduced because other noises can mask how clearly the impulses can be heard. The calculations of noise from sheet piling contain an underlying precautionary measure by including an additional 5 dB both when illustrating the 70 dB(A) and the 40 dB(A) curve.

For the other construction activities, it is less likely that audible impulses or tones will occur within the noise, regardless of distance. Therefore, an additional 5 dB is not included in the calculation of the other construction activities.

Noise modelling results

In Section 9.9, five construction phases for the onshore construction activities have been identified as the noisiest phases. The construction noise from these five phases at the landfall area has been calculated and compared to the applied guiding limit values of 70 dB(A) and 40 dB(A). Table 5-17 provides an overview of the approximate distances from the acoustical centre of the construction work at the work site to the noise impact zones for 70 dB(A) and 40 dB(A), respectively.

Table 5-17 Distances calculated from the acoustical centre of the construction work within each of the five construction phases to the extent of the noise impact zones, respectively within and outside regular working hours.

Construction phase	Noise impact zone	Distances
Phase 1 Clearing of work site	70 dB(A)	60 m
	40 dB(A)	800 - 900 m
Phase 2 Sheet piling and excavation (launch shaft)	70 dB(A)	140 - 150 m
	40 dB(A)	1,600 – 2,600 m
Phase 3 Tunnelling	70 dB(A)	25 m
	40 dB(A)	400 - 550 m
Phase 4 Pre-commissioning	70 dB(A)	70 m
	40 dB(A)	1,000 – 1,500 m
Phase 5 Restoration of launch shaft and work site	70 dB(A)	30 m
	40 dB(A)	500 - 600 m

5.3.4 Emissions to air

Air emissions from onshore construction mainly relate to the tunnelling activities and trucks driving with equipment and soil to/from the landfall area. The various equipment used for tunnelling will be powered by electricity provided by a diesel-driven generator. Furthermore, emissions will arise from pre-commissioning, which involves pumps for flooding, cleaning, and gauging as well as compressors for dewatering and drying.

Delimitation of air emission calculations

Construction of the proposed pipeline at the Danish landfall, Faxe S, will also have an impact on climate and air quality. As was the case with the offshore part of the project, the air emissions assessed relate to the direct activities of construction and operation of the pipeline, which include:

- Contractor machinery preparing the work site;
- Contractor machinery preparing the launch shaft for tunnelling;

- Transportation of equipment for tunnelling and soil to/from work site by truck (assumption: 50 km on average each way);
- Generators used for running the tunnelling equipment;
- Contractor machinery restoring the launch shaft and work site;
- Pumps and compressors used for pre-commissioning activities.

Emissions from the production of the tunnel elements used for tunnelling are not included, as these were already included in the calculation of emissions associated with offshore construction activities.

Basis for emission calculations
The emission calculations are approximate, based on a realistic, worst case approach. Furthermore, an uncertainty factor of 1.2 have been added to the input for the estimates of power consumption during tunnelling, which is one of the main contributors to emissions for the onshore part of the project. Thus, the results are considered as conservative.

The calculations are based on the information about construction machinery presented in Section 3.4.3, including operation time of the individual type of equipment and the effect (in kW) of the equipment.

The emission factors from construction machinery are based on Euro standards. It is assumed that construction machinery will be able to comply with emission factors in Euro standard stage IIIA (which went into force in 2006-2008). The emission factors are taken from the administrative order on limiting air pollution from mobile non-road machines[7].

Emissions factors for pumps, generators and compressors are based on the national Danish emissions inventories, made by Aarhus University for stationary combustion (Aarhus University, 2018a).

Air emissions from onshore construction
In Table 5-18, the air emissions from onshore construction are shown.

Table 5-18 Air emissions from onshore construction, including pre-commissioning.

	Air emissions [tonnes]					
	CO_2	NO_x	SO_2	PM (TSP)	PM_{10}	$PM_{2.5}$
Onshore construction	540	9	22*	0.1	0.6*	0.4*

* It has only been possible to estimate SO_2, PM_{10} and $PM_{2.5}$ emissions from the generator used for tunnelling and from trucks driving to and from the work site. Thus, emissions from other contractor machinery are not included for these polluting components.

Modelling of air quality
The impact on the surrounding air quality as a result of the onshore construction activities has been modelled using the OML model, version 6.2. The OML model is an atmospheric dispersion model developed and maintained by the Danish Centre for Environment and Energy (DCE), Aarhus University.

The onshore construction activities are divided in different phases, where the most energy-consuming phase is related to tunnelling. OML modelling has only been performed for this phase

[7] Administrative order no. 1458 of 07/12/2015 on limiting air pollution from mobile non-road machines *(bekendtgørelse om begrænsning af luftforurening fra mobile ikke-vejgående maskiner mv.)*.

of the project as a representation of the time during construction with the greatest impact on air quality.

The tunnel boring machine and supplementary equipment require electricity from a diesel generator. As the basis for the modelling, a 1650 kVA diesel generator from Perkins has been used as a reference (Perkins, no date), and information from the datasheet about fuel consumption and dimensions has been applied. It is assumed that the generator will be using 75% work load on average during the entire tunnelling process. It has not been possible to determine the temperature of the exhaust gas from the generator. Test modelling shows that 200 degrees is a conservative estimate, which has been applied. The generator is registered as a point source in the OML model. Furthermore, a crane for lifting the tunnel elements will be in use simultaneously with the generator. The crane is registered as an area source in the OML model, as it can be used at the entire work site.

The modelling results are showed in Table 5-19 for NO_2, SO_2, PM_{10} and $PM_{2.5}$ for averaging periods related to the limit values according to the Air Quality Directive (see Section 9.4.1).

Table 5-19 OML modelling results of the impact on air quality in the surrounding area during tunnelling (the results do not include the background levels of the air quality).

Distance from construction site	NO_x (µg/m³)		SO_2 (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)
	1 hour*	Calendar year	1 hour**	24 hours ***	24 hours ****	Calendar year	Calendar year
50 m	594	105	1,460	749	7	2	1
100 m	559	88	538	291	3	1	1
175 m	156	17	214	110	1	0	0
250 m	64	7	118	59	1	0	0
500 m	27	2	53	19	0	0	0
1,000 m	12	1	27	9	0	0	0
1,500 m	8	0	17	5	0	0	0

* The 19th greatest average concentration in an hour.

** The 25th greatest average concentration in an hour.

*** The 4th greatest average concentration in 24 hours.

**** The 36th greatest average concentration in 24 hours.

5.3.5 Employment generation

The onshore construction activities, which are mainly related to tunnelling and pre-commissioning, will generate work for a limited number of personnel during approximately 13 months in total. As the tunnelling work is very specialised, it is expected that a contractor specialised in tunnelling will be engaged, likely from outside the local area. A local contractor may be engaged to prepare the work site and launch shaft and to restore these areas after construction. These activities may result in minor increased employment and turnover in the local area in relation to accommodation, food, etc. It is expected that approximately 12 people will be working with the tunnelling activities.

6. ALTERNATIVES

6.1 The zero alternative

The no-action (or zero) alternative means not implementing the project at all, i.e. all activities connected with project would not take place. The zero-alternative describes the situation in 2022 (end of the construction period), if the project is not realised.

If the zero-alternative is chosen, there is expected no impact on the physical-chemical (e.g. water level, water quality etc.) and biological (e.g. benthic flora and fauna, marine mammals, Natura 2000 etc.), which will not happen naturally in connections with the dynamic conditions in Faxe Bugt and Arkona Basin. Socio-economic environments (commercial fisheries, ship traffic etc.) will, however, develop independently of the Baltic Pipe project, as the project then will not form any potential (minor) barrier for commercial fisheries, ship traffic, and further off shore infrastructural development.

If the project is not implemented, it can lead to a continued need for exploitation of fossil fuels (coal), especially in Poland. In addition, the situation of not implementing the project can contribute to a prolonged transition period in Denmark in changing of energy towards the full implementation of green energy according to the overall Danish energy strategy (Chapter 1). Please consult the sub-report of the project "Introduction and overall conclusion" for more details on the subject.

The zero alternative represents therefore the baseline environmental conditions, which will be described in-depth in the EIA, as will the impacts of implementing the project.

6.2 Considered route alternatives

The proposed pipeline route from Denmark to Poland, which crosses Danish territorial waters and within the Danish EEZ, is the basis for this EIA, as outlined in Chapter 1, Introduction. This proposed route has been selected based on analysis and evaluation of different route alternatives (Figure 6-1).

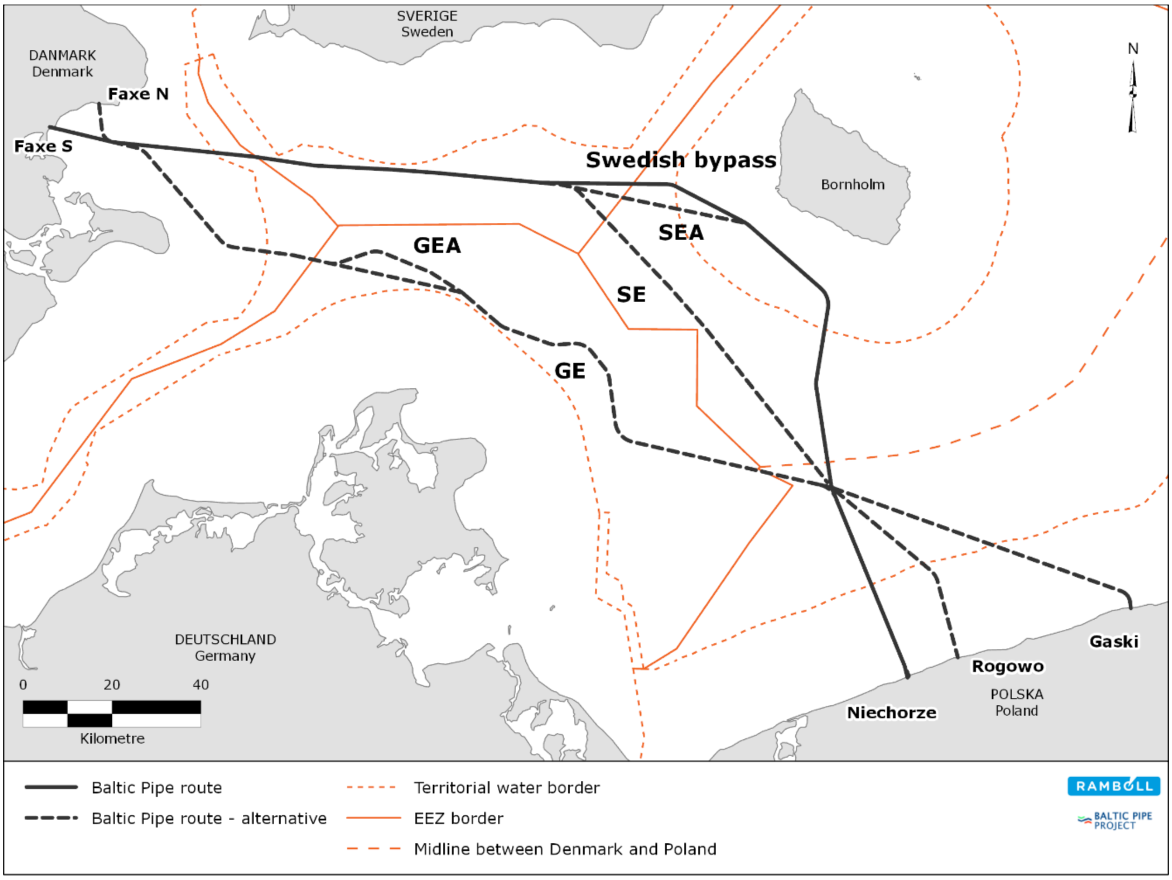


Figure 6-1 Route alternatives trough German EEZ and Swedish EEZ along with Polish and Danish landfalls (Rambøll, 2018n). The abbreviations are explained in the text.

The lengths of the various route alternatives are shown in Table 5-1.

Table 6-1 Lengths of the various route alternatives.

Area	Route Section	Length (km)
Danish landfalls	Faxe North (Faxe N)	9.7
	Faxe South (Faxe S)	14.1
Offshore routes	Swedish bypass route	213.4
	Swedish base case route (SE)	192.9
	Swedish alternative route (SEA)	211.4
	German base case route (GE)	191.8
	German alternative route (GEA)	193.8
Polish landfalls	Niechorze	46.2
	Rogowo	50.1
	Gaski	74.2

6.2.1 Landfall and offshore alternatives

The following alternatives were considered in Danish waters (Figure 6-1):

- Landfall routes in Denmark:
  - Faxe North (Faxe N);
  - Faxe South (Faxe S).

- Offshore routes:
  - Swedish bypass route (preferred alternative);
  - Swedish base case route (SE);
  - Swedish alternative route (SEA);
  - German base case route (GE);
  - German alternative route (GEA).

- Landfall routes in Poland:
  - Niechorze;
  - Rogowo;
  - Gaski.

Legal basis

According to the provisions of the EU Directive on the assessment of the effects of certain public and private projects on the environment[8], which has been implemented in Danish legislation through the Danish legal order on environmental assessment of plans and programmes and of actual projects[9], the following shall be documented in the EIA report in regard to design and route alternatives:

- A description of the reasonable alternatives (for example in terms of project design, technology, location, size, and scale) studied by the developer, which are relevant to the proposed project and its specific characteristics, and an indication of the main reasons for selecting the chosen option, including a comparison of the environmental effects.

Methodology for route selection

Various route alternatives have been studied during preceding feasibility and concept studies and during the initial phase of the present project phase. The optimisation of route alternatives has been complex, as the southern Baltic Sea has many restricted areas, shipping lanes, existing installations, and service lines. The development of the preferred route is the result of an iterative process in which a variety of authorities and stakeholders have been involved in commenting and a detailed analysis of the various alternatives has been undertaken with consideration of the following themes:

- Standard industry criteria for offshore pipeline design;
- Possibility of obtaining construction permit;
- Environmental concerns;
- Compatibility with the project time schedule;
- Cost.

The two landfall route alternatives and the four offshore route alternatives presented to the authorities and stakeholders were all selected with due regard to industry standard for safety of the public and personnel, protection of the environment, and the probability of damage to the pipeline or other facilities. Factors taken into consideration included the following, taken from the DNVGL guidance on pipeline design (DNVGL-ST-F101, 2017):

- **Environment:** Archaeological sites, exposure to environmental loads, areas of natural conservation interest such as oyster beds and coral reefs, marine parks, turbidity flows.

[8] Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment.

[9] Consolidated Act no. 1225 of 25/10/2018 on environmental assessment of plans and programmes and specific projects (EIA) *(bekendtgørelse af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM))*.

- **Seabed characteristics:** Uneven seabed, unstable seabed, seabed geotechnical properties (hard spots, soft sediment, and sediment transport), subsidence, seismic activity.
- **Facilities:** Offshore installations, subsea structures and well heads, existing pipelines and cables, obstructions, coastal protection works.
- **Third-party activities:** Ship traffic, fishing activity, dumping areas for waste, ammunition, etc., mining activities, military exercise areas.
- **Shore crossing:** Local constraints, third-party requirements, environmentally sensitive areas, vicinity to people, limited construction period.

Due to the iterative nature of the route selection process, the final decision on the preferred route deviates slightly from the route presented during the first public hearing to the Danish EIA, in order to satisfy the wishes and requirements of the relevant authorities.

6.2.2 Landfall routes in Denmark

Both landfall routes in Denmark (i.e. Faxe N and Faxe S) were designed to avoid the raw material extraction sites and the Natura 2000 site "Havet og Kysten mellem Præstø Fjord og Grønsund" in Faxe Bugt (Figure 6-2).

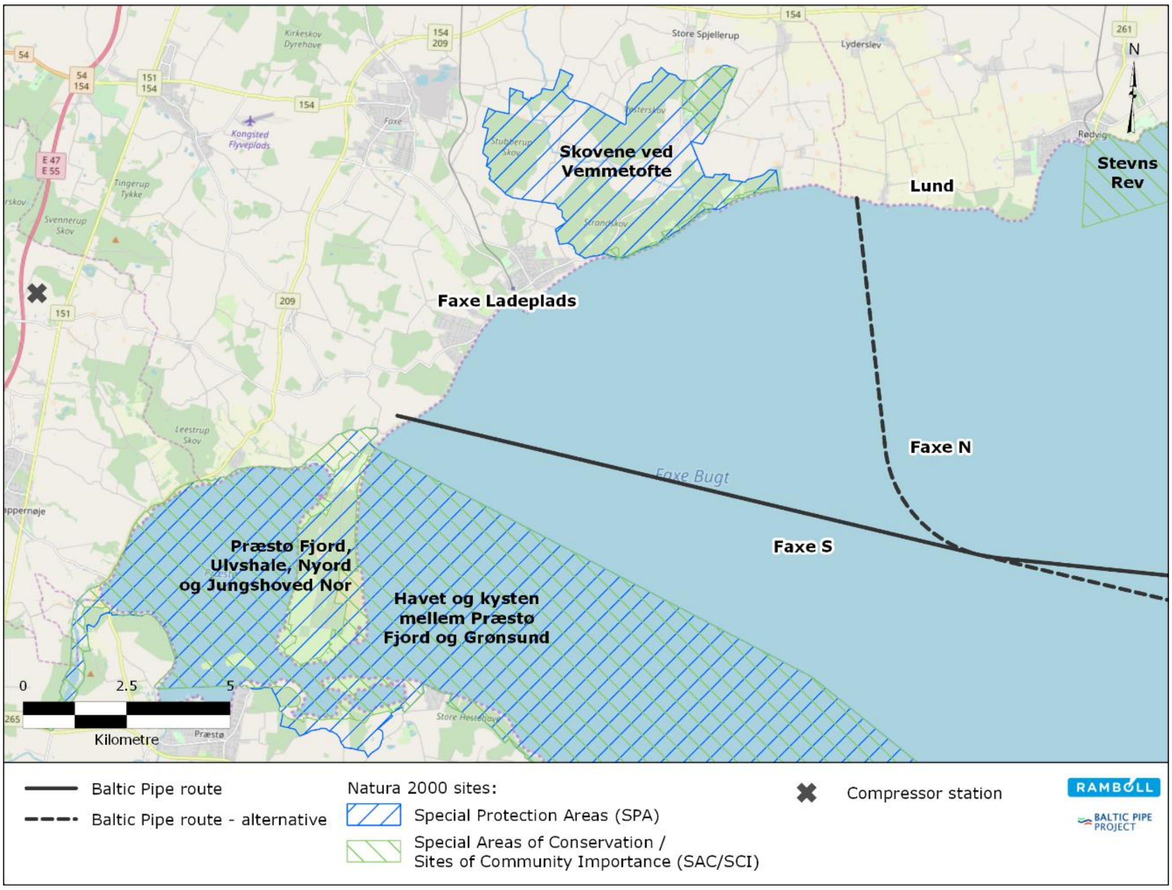


Figure 6-2 Landfall alternatives in Denmark.

The shore crossing at the Faxe N landfall route is located west of the village of Lund (Figure 6-2). As the pipeline would be located only about 500 m from the village, some impact from construction activities could be expected. The pipeline is then routed northwest around the Natura 2000 site "Skove ved Vemmeltofte". South of the Natura 2000 site, the pipeline is extended to the compressor station. As can be seen in Figure 6-2, this section from the landfall to the compressor station is considerably longer than the Faxe S landfall route.

At the Faxe S landfall, the shore crossing is located about 3 km south of Faxe Ladeplads. This landfall is associated with some biological and geological concerns due to the presence of the protected bird species sand martin, which nests in the cliff at the landfall site, and the cliff itself, which is registered as of geological interest. These concerns can, however, be mitigated by using tunnelling instead of an open trench (see Chapter 3, Project description). As there are only few dwellings in the area and no impact is expected on the preserved archaeological site "Skansen ved Strandegård" (about 300 m from the landfall routing), the only socio-economic concern associated with the landfall Faxe S is related to farming activities. Therefore, Faxe S is the preferred landfall site, as the route from the shore crossing to the compressor station is shorter, fewer dwellings are negatively affected and the concerns related to biological impacts at Faxe S landfall can be mitigated.

6.2.3 Offshore route alternatives

Two main offshore routes were considered; a Swedish base case route (SE) and a German base case route (GE). In addition to these, alternative alignments for parts of each route were considered (marked with dotted lines in Figure 6-3); these are referred to as the Swedish alternative route (SEA) and the German alternative route (GEA), respectively. Each of these proposed offshore alternatives are described in turn in the following sections. Some of the most influential receptors in the process of considering route alternatives have been military areas and Natura 2000; these areas are presented in Figure 6-3 and Figure 6-4.

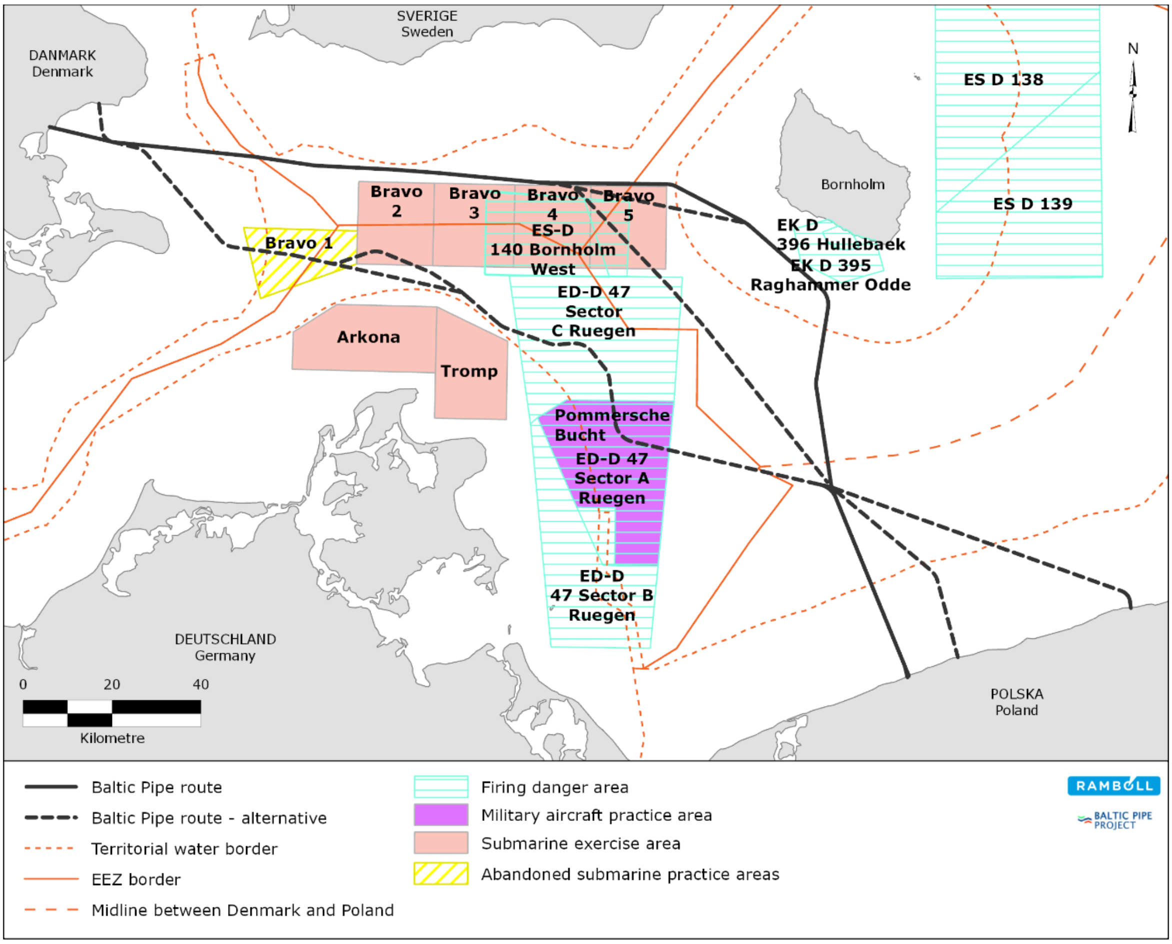


Figure 6-3 Military areas.

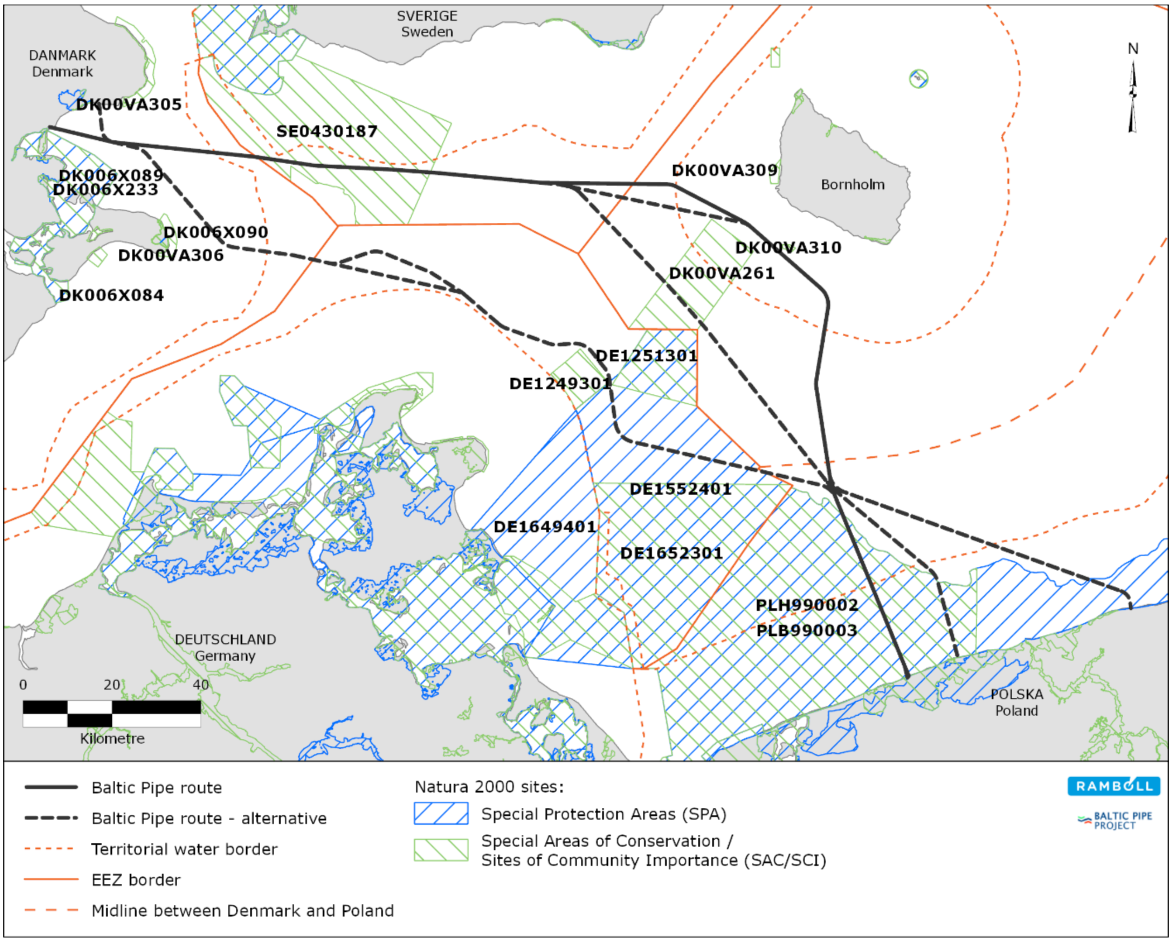


Figure 6-4 Natura 2000 areas.

German offshore routes

The German base case route and alternative routes follow the same 70 km alignment within Danish waters from the landfall site to the German EEZ (Figure 6-1). Within the German EEZ, the two route options follow largely the same course, but they diverge close to the Swedish and Danish EEZ borders, which results in reduced impacts on one receptor and increased impacts on another. Specifically, the German alternative is routed further northwest so as to cross a major shipping lane at a more perpendicular angle, which will lead to a lower impact on maritime traffic. However, the German alternative route crosses into the NATO submarine exercise area, Bravo 2, which is avoided by the German base case route.

After the two German route options merges again, the remainder of the route crosses other major shipping routes as close to perpendicularly as possible, and no other submarine exercise areas are crossed. However, other types of military practice areas are crossed by the German route, including a research area and a firing danger area. The German route options pass through 47 km of one Natura 2000 site in the German EEZ.

In addition to maritime traffic and military practice areas, several other socio-economic and biological considerations taken into account in the development of the German route have included offshore infrastructure, extraction sites, commercial fishery and protected areas.

With respect to infrastructure, the German route has been designed to avoid existing and planned wind farms, including those currently under construction. However, the route does cross

25 cables and the Nord Stream Pipeline (NSP) is crossed at the shallow depth of 21.7 m. Crossing of NSP in such shallow waters would be technically difficult, due to the risk of grounding of ships above the rock installation required for the pipeline crossing.

Impacts on other socio-economic receptors has also been minimised, as the route avoids raw material extraction sites and trenching of the pipeline in the areas with the highest commercial fishery catches will reduce the risk of snagging of fishing gear on the pipeline.

In addition, no Special Areas of Conservation (SACs) are crossed by the route, and although routing through Special Protection Areas (SPAs) has been minimised to the extent possible, the route does inter the SPA Pommersche Bucht. However, no biological impacts which cannot be mitigated have been identified during the evaluation of the German route options.

Through dialogue with the German Defence Forces during the scoping process, it became evident that the presence of a pipeline would be incompatible with the military activities ongoing in the NATO submarine exercise areas and the firing danger area Pommersche Bucht. Therefore, the German offshore routes were assessed not to be feasible (Rambøll, 2018n).

Swedish offshore routes

From the landfall site, the Swedish base case route and the Swedish alternative route follow the same alignment, which runs between the raw materials extraction sites in Faxe Bugt, north of the Krieger's Flak wind farm and into the Swedish EEZ. Before re-entering the Danish EEZ to the southwest of Bornholm, the route options split into two main alternatives: the base case route, which follows a more south-westerly path within the Danish EEZ before crossing the disputed area and entering Polish waters; and the Swedish alternative route, which enters Danish territorial waters southwest of Bornholm prior to crossing the disputed area further east of the Swedish base case route. The most significant difference between the two main Swedish route options is that the Swedish alternative route avoids crossing the Natura 2000 site "Adler Grund og Rønne Banke", which is crossed by the Swedish base case route.

Both route options cross the major international, bi-directional shipping lanes running along the border between the Swedish and Danish EEZs. The Swedish base case route crosses the TSS Bornholmsgat, the most heavily trafficked shipping lane in the Baltic Sea, at a more perpendicular angle than the Swedish alternative.

With respect to military practice areas, near the Danish EEZ border, the route crosses the northern edge of the Bravo 4 submarine exercise area and from here, the Swedish alternative route splits from the Swedish base case route. Both routes pass inside the submarine exercise area Bravo 5, and the Swedish base case route, having re-entered Danish waters, subsequently crosses the corner of the military firing danger area Ruegen (sector C). The section of the Swedish alternative which runs along the coast of Bornholm is routed southwest of the firing danger area Raghammer Odde. The Swedish route options pass through 39 km, designated as a Natura 2000 site within the Swedish EEZ. In addition, the Swedish alternative route passes through 13 km of designated Natura 2000 site in the Danish EEZ.

Concerning offshore infrastructure, the both Swedish routes have been designed to avoid existing and planned wind farms, including those currently under construction. Both route options cross 13 cables, considerably fewer than the German route options, as well as the NSP pipelines. The NSP pipelines are crossed at a water depth of 45.7 m, which is much deeper than for the German route and represents a safer option with respect to the risk of ship grounding.

Both Swedish route options avoid currently active raw material extraction sites and potential future sites of resource extraction were avoided to the extent possible.

Both routes cross a mine belt from World War II as well as the British minefield, Pollack, near the coast of Bornholm. The alternative crosses through the centre of the minefield, whereas the base case route crosses only the extended minefield area. This poses a risk of encountering CWA and UXO. However, local re-routing can be implemented if UXO or CWA are identified along the route.

Biological considerations were also important in the route design process, and protected areas were avoided where possible. The Swedish route option crosses into the Swedish EEZ within the Natura 2000 site "Sydvästskånes Utsjøïvatten", but the route avoids the designated habitat type reef. The route options split close to the Danish EEZ border, and after entering Danish waters, the Swedish base case route crosses the Natura 2000 site "Adler Grund og Rønne Banke", where crossing the designated habitat type reef cannot be avoided. The Swedish alternative route is designed to avoid crossing this Natura 2000 site i.a., as the reef most likely will be destructed due to construction or presence of pipeline.

Summary

On the basis of the above considerations and dialogue with the authorities, military practice areas and Natura 2000 sites were regarded as the most important topics in the selection of the preferred route. The German Defence Forces were contacted regarding the crossing of the submarine exercise areas Bravo 4 and Bravo 5. While re-routing of the German routes was not feasible, bypassing these exercise areas by re-routing to the north was possible for the Swedish alternative. This led to the development of the Swedish bypass route, a variation of the Swedish alternative, which runs 550 m north of the Bravo areas. On this basis, the Swedish alternative route, with the bypass variant, is selected as the preferred offshore route, as it avoids military areas and the Natura 2000 site "Adler Grund og Rønne Banke" in Danish waters.

6.2.4 Polish landfall routes

Three landfall routes were assessed in Poland as part of the route selection process: Niechorze, Rogowo and Gaski. Due to a negative opinion from the National Polish Defense, the Gaski variant was considered no longer feasible and was deselected. Niechorze was chosen as the preferred landfall in Poland due to technical issues, primarily of geological character, and Rogowo will be assessed as an alternative as part of the permitting process in Poland.

7. LEGAL FRAMEWORK

As a transboundary project, the Baltic Pipe project must comply with numerous international conventions and directives/laws on the EU and national levels. This chapter provides an overview of the legal framework that applies to the project.

First, relevant parts of the Continental Shelf Act are described, as it provides the legal basis for construction of the Baltic Pipe project. Subsequently, an overview of the EIA legislation and process is provided, followed by a description of the most project-relevant legislation. In addition, it will be noted throughout the EIA report when a specific convention, law or similar should be complied with, as relevant.

7.1 The Continental Shelf Act

According to sections 3(a) and 4 in the Continental Shelf Act[10], construction of pipelines for transporting hydrocarbons in Danish territorial waters and on the Danish continental shelf requires a construction permit from the Minister of Energy, Utilities, and Climate. A prerequisite for the construction permit in territorial waters, is an assessment from the Foreign Minister that the project is compatible with Danish foreign policy, security policy, and defense policy.

Requirements and terms for the permitting process for pipelines for the transportation of hydrocarbons over the Danish continental shelf and Danish territorial waters between two foreign states are regulated by Administrative Order on Pipeline Installations[11].

7.2 Environmental Impact Assessment (EIA)

This section describes the EU directive and Danish legislation on Environmental Impact Assessment (EIA).

7.2.1 EIA Directive

The principle of the EIA Directive[12] is to ensure that projects likely to have significant effects on the environment are made subject to an environmental assessment, prior to their approval or authorisation. Public participation is a central element of the EIA procedure. Projects covered by the EIA Directive are listed in Annexes I and II; an EIA is mandatory for projects listed in Annex I whereas projects listed in Annex II must go through a screening procedure, after which the relevant national authorities decide whether an EIA is required.

The Baltic Pipe project is covered by Annex I, section 16(a): *Pipelines with a diameter of more than 800 mm and a length of more than 40 km for the transport of gas, oil, chemicals*. Thus, an EIA is mandatory.

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[10] Consolidated Act no. 1101 of 18/11/2005 on the Continental Shelf *(bekendtgørelse af lov om kontinentalsoklen)* with amendments, including LOV no. 1401 of 05/12/2017.

[11] Administrative Order no. 1520 of 15/12/2017 on Pipeline Installations *(bekendtgørelse om visse rørledningsanlæg på søterritoriet og kontinentalsoklen).*

[12] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment. Amended in 2014 it became Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment.

7.2.2 Danish EIA legislation

The EIA Directive is implemented in Danish legislation by the Consolidated Act on Environmental Assessment[13] and the Administrative Order on Environmental Assessment[14]. The Consolidated Act follows the structure of the EIA Directive, where projects in Annexes I and II are included in the Act and an EIA is mandatory for Annex I projects. Thus, the Baltic Pipe project is also covered by Annex I, section 16(a) of the Consolidated Act on Environmental Assessment, and an EIA is mandatory.

The Danish Energy Agency (DEA), as an agency within the Ministry of Energy, Utilities, and Climate, is the authority overseeing the EIA process for projects listed on Annex 1, section 16(a).

As the project is included in the current list of Projects of Common Interest (PCI) (see Section 1.1), the DEA can act as one-stop-shop, coordinating and facilitating the permit granting process in Denmark. The DEA may coordinate the permit granting process in cooperation with the Danish Environmental Protection Agency as the competent authority for the onshore part of the Baltic Pipe project in Denmark.

7.2.3 EIA procedure and public participation

The Danish EIA procedure is described in the following.

Notification

In accordance with section 18 of the Consolidated Act on Environmental Assessment, the project has been notified to the DEA. The notification contained a definition and a short description of the project and was submitted jointly with the notification by Energinet on November 8th, 2017.

As the project is included in Annex I of the EIA Directive and the Consolidated Act on Environmental Assessment, an EIA is mandatory.

Scoping

There is no statutory requirement in the Danish EIA legislation for a scoping phase for offshore projects. However, GAZ-SYSTEM S.A. decided in agreement with the authorities to conduct a national scoping process for the Baltic Pipe project to inform of the expected level of baseline studies and the content of the EIA.

Thus, an environmental programme scoping document has been prepared after the notification, which considered the environmental assessment approach, or scope. The DEA is the responsible authority and will, as the coordinating authority, ensure that all relevant authorities are consulted and have the possibility of commenting on the scope. This will result in requirements from the authorities regarding the content and focus of the environmental impact assessment. The consultations will give a certain degree of security for the authority consent in the further development of the project.

EIA report

The purpose of the EIA procedure is to ensure that the likely significant environmental impacts of the proposed project are assessed systematically prior to project implementation. The EIA report identifies, describes, and assesses the likely significant impacts (direct and indirect) from the

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[13] Consolidated Act no. 1225 of 25/10/2018 on environmental assessment of plans and programmes and specific projects (EIA) *(bekendtgørelse af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM))*

[14] Administrative Order no. 1470 of 12/12/2017 on environmental assessment *(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))*.

project on receptors for the three environments: physical-chemical, biological, and socioeconomic.

The following key stages are included in the EIA report:

- Baseline studies: identification of existing environmental conditions through review of existing information and field studies, to provide a basis for the assessments of potential impacts;
- Potential impacts: identification of potential impacts specific to the proposed project;
- Assessment of impacts: identification and assessment of likely significant impacts on the environment from the proposed project;
- Mitigation: identification of measures to avoid, reduce or compensate for impacts;
- Residual impacts: identification of residual impacts after mitigation.

Public participation
The EIA process involves two rounds of public participation.

The first public hearing takes place as a part of the scoping phase. Together with the Danish Environmental Protection Agency, the DEA has called for ideas and proposals for the scoping of the onshore and offshore EIAs in Denmark via their website (www.ens.dk). The public hearing took place from December 21st, 2017 to January 22nd, 2018. For compliance with PCI regulations, public meetings were arranged, taking place in six Danish cities in January 2018[15]. The incoming comments from the first public hearing have been used as input for the EIA.

The second public hearing is expected to take place from February 15th, 2019 and will be notified on the DEA website (www.ens.dk). As part of the second public hearing, the DEA may also decide to arrange public meetings or distribute information on the project by other means to members of the public who have an interest. The comments from the second public hearing will be gathered in a so-called white paper, where they will be assessed and commented on by the DEA.

Approval
Based on a thorough inspection of the delivered project documents, including the results of the second public hearing (the white paper), the DEA will assess if an permit can be granted for the Baltic Pipe project. The DEA will, as a part of a potential permit, formulate conditions and requirements for the implementation of the project.

7.3 The Espoo Convention

The UNECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) has been ratified by Denmark and applies to the proposed project, as it is a project with potential transboundary impacts.

Appendix I of the Convention provides a list of activities covered by the convention. The Baltic Pipe project is covered by Appendix I, section 8 *Large-diameter pipelines for the transport of oil, gas or chemicals*.

An Espoo procedure for the Baltic Pipe project takes place as a separate process, which includes, *inter alia,* an Espoo report, public hearings etc. The following countries are part of the Espoo procedure: Poland, Sweden, and Denmark, as both Parties of Origin and Affected Parties, and with Germany also as an Affected Party.

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[15] Kolding and Slagelse: January 8th 2018, Middelfart: January 9th 2018, Varde and Årslev: January 10th 2018, Næstved: January 11th 2018.

7.4 The Habitats and Birds Directives

The Habitats Directive[16] aims to promote the maintenance of biodiversity, taking account of economic, social, cultural, and regional requirements. Annex IV of the Habitats Directive contains a list of species that are strictly protected across their entire natural range within the EU, both within and outside Natura 2000 sites. The Birds Directive[17] aims to protect all 500 wild bird species naturally occurring in the European Union.

The main implementation of the Habitats and Birds Directives in Danish legislation is through the Act on Environmental Goals[18] and the Habitats Order[19], but the directives are also implemented in other parts of Danish legislation, including the Offshore Impact Assessment Order[20].

7.4.1 Natura 2000 and Annex IV species

Together, the Habitats and Birds Directives form the cornerstone of the legislative framework for protecting and conserving wildlife and habitats in the EU and establish the EU-wide Natura 2000 ecological network of protected areas to be safeguarded against potentially damaging developments. The aim of the network is to ensure favourable conservation status for the species and habitats which form the designation basis for the habitats and bird protection sites, across their natural range.

The Natura 2000 network comprises;

- *Birds sites (Special Protection Areas (SPA))*: sites designated for the protection of rare and vulnerable bird species listed in Annex I of the Birds Directive, as well as of regularly occurring migratory bird species. Sites are also known as bird protection sites. Ramsar sites[21] are also included as protected wetland areas with special importance for birds;
- *Habitat sites (Special Areas of Conservation (SAC)/Sites of Community Interest (SCI))*: sites designated under the Habitats Directive for natural habitats and species.

In addition, the Administrative Order on Offshore Appropriate Assessments[22] applies to the project for the assessment of the potential for significant impacts on Natura 2000 sites as well as on the strictly protected Annex IV species.

In Sections 9.19 and 9.23, the impacts of the proposed project on Natura 2000 sites are assessed, and in Sections 9.16 and 9.22, the impacts on Annex IV species are assessed.

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[16] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.

[17] Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds. Amended in 2009 to become Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.

[18] Consolidated Act no. 119 of 26/01/2017 on environmental goals for international nature protection sites *(bekendtgørelse af lov om miljømål m.v. for internationale naturbeskyttelsesområder (Miljømålsloven)*.

[19] Administrative Order no. 1240 of 24/10/2018 on appointment and administration of international nature protection sites and protection of certain species *(bekendtgørelse om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter)*.

[20] Administrative Order no. 434 of 02/05/2017 on impact assessment of international nature protection sites and protection of certain species at preliminary studies, investigation and extraction of hydrocarbon, storage in the underground, pipelines, etc. 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).*

[21] Ramsar sites are identified as part of the UN Convention of the Wetlands of International Importance, especially as Waterfowl Habitat (also known as the Ramsar Convention). In the EU, all Ramsar sites are included in the network of Special Protection Areas (SPAs) under the Birds Directive.

[22] Administrative Order no. 434 of 02/05/2017 on offshore appropriate assessments *(bekendtgørelse om konsekvensvurdering vedrørende internationale naturbeskyttelsesområder og beskyttelse af visse arter ved forundersøgelser, efterforskning og indvinding af kulbrinter, lagring i undergrunden, rørledninger, mv. offshore)*.

7.5 Marine Strategy Framework Directive

The Marine Strategy Framework Directive[23] (MSFD) aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The Commission has also produced a set of detailed criteria and methodological standards[24] to help Member States implement the MSFD. To achieve GES by 2020, each Member State is required to develop a strategy for its marine waters (Marine Strategy).

The MSFD is implemented in Danish legislation through Consolidated Act on Marine Strategy[25]. The purpose of the act is to establish the framework for achieving GES in Danish waters. The central instrument in achieving this is the Marine Strategy, covering all Danish marine waters, including the Danish waters of the Baltic Sea.

The project is assessed in relation to the MSFD in Chapter 10.

7.6 Water Framework Directive

The Water Framework Directive[26] (WFD) is the legislative framework for the protection of water in the EU (rivers, lakes, groundwater, inland waters, surface water and coastal waters). The Directive sets a new approach for water management and protection by river basins – the natural geographical and hydrological unit – instead of according to administrative or political boundaries. The overall objective of the Directive is that all waters must achieve "good status". Good status is achieved when both the ecological and chemical status is good. The Directive covers coastal waters up to 1 nm off the coast for ecological status and 12 nm for chemical status.

The main implementation of the WFD by Danish legislation is through the Consolidated Act on Water Planning[27] and associated administrative orders. A central element of implementing the WFD is the river basin management plans, which contain information about how river basins are affected, monitoring, assessment of status, environmental targets and measures to achieve the targets. With the river basin management plans being an informative tool for communicating the Danish implementation of the WFD, administrative orders have been issued as legal bindings of the environmental targets and programs. Annex 2 of administrative order on environmental targets for surface water and groundwater[28] contains the targets for river basin Sjælland and administrative order on programs for river management districts[29] determines the programs for the river basin districts, where Annex 2 specifically applies for Sjælland.

The project is assessed in relation to the WFD in Chapter 10.

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[23] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

[24] Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment and repealing Decision 2010/477/EU.

[25] Consolidated Act no. 117 of 26/01/2017 on marine strategy *(bekendtgørelse af lov om havstrategi)*.

[26] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

[27] Consolidated Act no. 126 of 26/01/2017 on water planning *(bekendtgørelse af lov om vandplanlægning)*.

[28] Administrative Order no. 1522 of 15/12/2017 on environmental targets for surface water and groundwater *(bekendtgørelse om miljømål for overfladevandområder og grundvandsforekomster)*.

[29] Administrative order no. 1521 of 15/12/2017 on programmes for river management districts *(bekendtgørelse om indsatsprogrammer for vandområdedistrikter)*.

7.7 Helsinki Convention

The Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention) covers the whole of the Baltic Sea area. Measures are also taken in the whole catchment area of the Baltic Sea to reduce land-based pollution.

The governing body of the Convention is the Helsinki Commission - Baltic Marine Environment Protection Commission - also known as HELCOM. The present Contracting Parties to HELCOM are Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, and Sweden. One of the most important duties of HELCOM is to make Recommendations on measures to address certain pollution sources or areas of concern. These Recommendations are to be implemented by the Contracting Parties through their national legislation.

The HELCOM Baltic Sea Action Plan, which was adopted in 2007 (and updated regularly), provides a concrete basis for HELCOM work. Its overall objective is to restore the good ecological status of the Baltic marine environment by 2021, and it sets goals and objectives for eutrophication, biodiversity, hazardous substances, and maritime activities.

7.8 Danish marine environmental law

The Danish Marine Environmental Act[30] (Law on protection of the marine environment) is based on the international convention prevention of pollution from ships of 1973/78 (MARPOL Convention) and it implements parts of the Helsinki Convention on the Protection of the marine environment in the Baltic Sea (see Section 7.7).

The Danish Marine Environmental Act establishes a number of prohibitions on discharges of, inter alia, oil, liquid substances transported in bulk, sewage, waste, and prohibition of dumping of substances and materials into the sea. Limiting sulfur content in ship's fuel is also part of the law. In addition, the law regulates the discharges of ballast water.

The Danish Marine Environmental Act is a framework law that authorises the Minister for the Environment to regulate pollution from shipping.

To document that the pipeline and all joints are intact, the Baltic pipeline is pressure tested as part of the precommissioning activities. There may be a need to add an antioxidant to counteract corrosion and algal formation on the inside of the pipeline. In addition, another chemical must be added to dry the inside of the pipe when the pressure test is done. The water used for pressure testing will be taken from and discharged from Faxe Bugt. The discharge of water from pressure testing requires a permit from the Danish Environmental Protection Agency and the discharge permit is granted on the basis of the Order on discharges of substances and materials for the sea[31]. This order is attached to the consolidated Danish Marine Environmental Act.

The impacts from the intake and discharge of water for pressure testing is assessed in Section 5.1.11 and ballast water in Section 5.1.9.

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[30] Consolidated act on the protection of the marine environment no. 1033 of 04/09/2017 (*Bekendtgørelse af lov om beskyttelse af havmiljøet*).

[31] Order on discharges of substances and materials for the sea[31] no 394 of 17/07/1984 (*Bekendtgørelse om udledning i havet af stoffer og materialer fra visse havanlæg).*

8. METHODOLOGY

The methodology chapter covers a description of the basis for the baseline, field surveys, impact assessment methodology, and assessment methodologies for Natura 2000 (after the Habitats Directive), Water Framework Directive and Marine Strategy Framework Directive.

8.1 Baseline

The baseline is a description of the existing environmental conditions of the project area, in this case the southern Baltic Sea, the Arkona Basin. Special focus is given to the Danish part of the project area onshore and offshore. The baseline forms the foundation for the assessments of the project impacts.

A scoping procedure has identified the relevant environmental receptors for the project in the Danish part of the project area. As a result of this procedure, a scoping report has been prepared and submitted to the Danish authorities (Danish Energy Agency), and subjects from the complementary consultation round have been included to ensure that all relevant and important environmental aspects are covered. The scoping process has also identified whether some receptors should be given special attention in the EIA.

The baseline has been prepared using desktop studies of scientific literature, technical reports of available data covering the project area, together with field surveys (Section 3.2, Field surveys), where results add new information and/or can confirm already existing information.

The baseline covers the three environments: the physical-chemical, the biological and the socio-economic.

8.1.1 Scoping

A scoping report have been prepared and presented for the Danish Energy Agency (DEA). Scoping decision, which covers the entire project in Denmark from the DEA have been sent to project owners the 28 September 2018 (Energistyrelsen, 2018). In the scoping decision, a list of expected content to the EIA was presented. In addition to the DEA expectations to the EIA content, responses from the scoping hearing, where e.g. the Swedish and Polish authorities have responded, where summarised in the draft scoping decision. Overall summary of the responses is listed below:

- Suggestion for an alternative route around Denmark, so land is avoided in Denmark;
- Wish that the German route in the Baltic Sea will be chosen;
- Hearing responses related to chemical ammunition;
- An emphasis on movement patterns for harbour porpoises (Belt Sea population and Baltic Sea population) and the impacts, especially during construction work, must be covered in the EIA;
- Comments on the content of the EIA, including modeling of sediment dispersion, commercial fishery, description of mitigation measures in relation to noise, noise modeling, description of various construction methods, cumulative impact, impact on nature conservation areas, analysis of accidents and emergencies, impact on fauna and flora, impact on birds etc.;
- Hearing responses in relation to traffic separation systems in the area;
- Hearing responses with comments in relation to commercial fisheries;
- Recommendation to complete an UXO survey along the route before construction;
- Recommendation of that underwater cultural heritage is ensured and protected;
- Recommendation of an assessment of the transboundary environmental impacts;
- Comments regarding crossing of other infrastructure;

- Comments that ship traffic must be taken into consideration;
- Comments on the impact on oxygen and salt levels in the Baltic Sea;
- Recommendation for a risk assessment in relation to ship traffic and proposed mitigation measures;
- Notice that the route goes through a military practice area (Pomeranian Bay).

Subjects of all comments have been replied to in the scoping decision by the DEA and have been dealt with in the EIA.

DEA has in general accepted the level and focus in the scoping for the EIA in the Danish part of the Baltic Sea.

8.2 EIA assessment methodology

The impact assessment will address the potential environmental and social impact of all parts of the project life cycle – construction, operation, and decommissioning - on the relevant environmental and social receptors.

The assessment methodology is based on the EIA Directive[32] and Danish EIA law[33]. The assessment will cover a description of the probability of the impact, taking the direct and indirect, cumulative, and transboundary, permanent, and temporary, positive, and negative impacts of the project into consideration. Furthermore, the assessment will consider the objectives defined at the EU (e.g., Marine Strategy Framework Directive (MSFD)) and national levels.

Qualitative and/or quantitative methods and national guidelines and threshold values will be used in the assessment.

Impacts will be evaluated based on their nature and scale and in relation to the receptor (social and environmental). The impact assessment will distinguish between the sensitivity of the receptor (social and environmental) and the magnitude of the impact to predict the significance of the impact.

The proposed methodology used for assessment of impacts includes the following criteria for categorising environmental and social impacts:

- Sensitivity of the receptor;
- Nature, type, and reversibility of the impact;
- Intensity, scale, and duration of the impact;
- Overall significance of the impact.

The impact assessment methodology serves to provide the means of characterising identified impacts and their overall severity.

8.2.1 Sensitivity of receptor

The overall significance of the impacts is evaluated based on the evaluation of the single impact variables, as described above, and on the sensitivity of the receptor affected.

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[32] Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment.

[33] Consolidated Act no. 1225 of 25/10/2018 on environmental assessment of plans and programmes and specific projects (EIA) *(bekendtgørelse af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM))*.

It is imperative to place some form of value on the sensitivity (low, medium, or high) of a receptor that could potentially be affected by project activities. Such a value may be regarded as subjective to some extent.

However, expert judgement and stakeholder consultation ensure a reasonable degree of consensus on the intrinsic value of a receptor. The allocation of a value to a receptor allows for the assessment of a receptor's sensitivity to change (impact). Various criteria are used to determine value/sensitivity, including, among others, resistance to change, adaptability, rarity, diversity, value to other receptors, naturalness, fragility and whether a receptor is actually present during a project activity. These determining criteria are elaborated upon in Table 8-1.

Receptors protected under the Habitats and Birds Directives are dealt with according to the Directives. See also Section 8.3 and Section 8.4.

Table 8-1 Criteria used to evaluate the sensitivity of a receptor.

Sensitivity	
Low	A receptor that is not important to the functions/services of the wider ecosystem or that is important but resistant to change (in the context of project activities) and will naturally and rapidly revert to pre-impact status once activities cease.
Medium	A receptor that is important to the functions/services of the wider ecosystem. It may not be resistant to change, but it can be actively restored to pre-impact status or will revert naturally over time.
High	A receptor that is critical to ecosystem functions/services, not resistant to change and cannot be restored to pre-impact status.

8.2.2 Nature, type, and reversibility of impacts

Impacts are initially *described* and classified according to their nature (either negative or positive), their type and their degree of reversibility. Type refers to whether an impact is direct, indirect, secondary, or cumulative (intra-specific within project or existing pressures, or cumulative with other projects and plans, the latter is dealt with in Chapter 11). The degree of reversibility refers to the capacity of the impacted environmental or social receptor to return to its pre-impact state.

Nature, type, and reversibility are elaborated upon in Table 8-2.

Table 8-2 Classification of impacts: Nature, type, and reversibility of impacts.

Nature of impact	
Negative	An impact that is considered to represent an adverse change from the baseline (current condition) or to introduce a new, undesirable factor.
Positive	An impact that is considered to represent an improvement to the baseline or to introduce a new, desirable factor.
Type of impact	
Direct	An impact that results from a direct interaction between a planned project activity and the receiving environment.
Indirect	An impact that results from other activities that are assessed to happen as a consequence of the project.
Secondary	An impact that arises following direct or indirect impacts as a result of subsequent interactions within the environment.
Additive	Combined impacts of project-related activities.
Cumulative	An impact that may occur in combination with other plans or projects that are currently under consideration, or any existing or proposed projects and plans, Chapter 11.
Transboundary	An impact that occurs across borders.
Degree of reversibility	
Reversible	An impact on receptors that ceases to be evident, either immediately or following an acceptable period of time, after termination of a project activity.
Irreversible	An impact on receptors that is evident following termination of a project activity and that remains for an extended period of time. An impact that cannot be reversed by the implementation of mitigation measures.

8.2.3 Intensity, scale, and duration of impacts

The predicted *impact magnitude* is defined and assessed in terms of a number of variables, primarily the intensity, scale and duration of an impact. Ascribing values to the variables is, for the most part, objective. However, awarding a value to certain variables may be subjective in that the extent, and even direction, of change often is difficult to define.

An explanation of the classifications and values applied in the EIA is presented in Table 8-3.

Table 8-3 Classification of impacts in terms of intensity, scale, and duration. The classification is adapted for each of the three environments.

Intensity of impacts	
No impact	No impacts on the structure or function of the receptor within the affected area.
Minor impact	Minor impacts on the structure or function of the receptor within the affected area, but basic structure and function remain unaffected.
Medium impact	There will be partial impacts on the structure or function inside the affected area. Structure/function of the receptor will be partially lost.
Large impact	The structure and function of the receptor are altered completely. Structure/function loss is apparent inside the affected area.
Geographical extent of impacts	
Local impacts	Impacts are restricted to the project area (1 km on each side of route)
Regional impacts	There will be impacts outside the immediate vicinity of the project area (local impacts).
National impacts	Impacts will be restricted to the national sector.
Transboundary impacts	Impacts will be experienced outside of the Danish/German/Swedish/Polish sector. Impacts can also be across a national border within the Parties of Origin, see Chapter 12.
Duration of impacts	
Immediate	Impacts during and immediately after the project activity; however, the impacts stop shortly after the activity is stopped.
Short-term	Impacts throughout the project activity and up to one year after.
Medium-term	Impacts that continue over an extended period, between one and ten years after the project activity has ended.
Long-term	Impacts that continue over an extended period, more than ten years after the project activity.

8.2.4 Overall significance of impacts

The severity of the impact is then defined by comparing the impact magnitude of the project and the sensitivity of the environmental receptors (Figure 8-1). It is classified according to a scale which ranges from "negligible" to "major", defined as presented in Table 8-4, where the distinction between a significant/not significant impact is also specified.

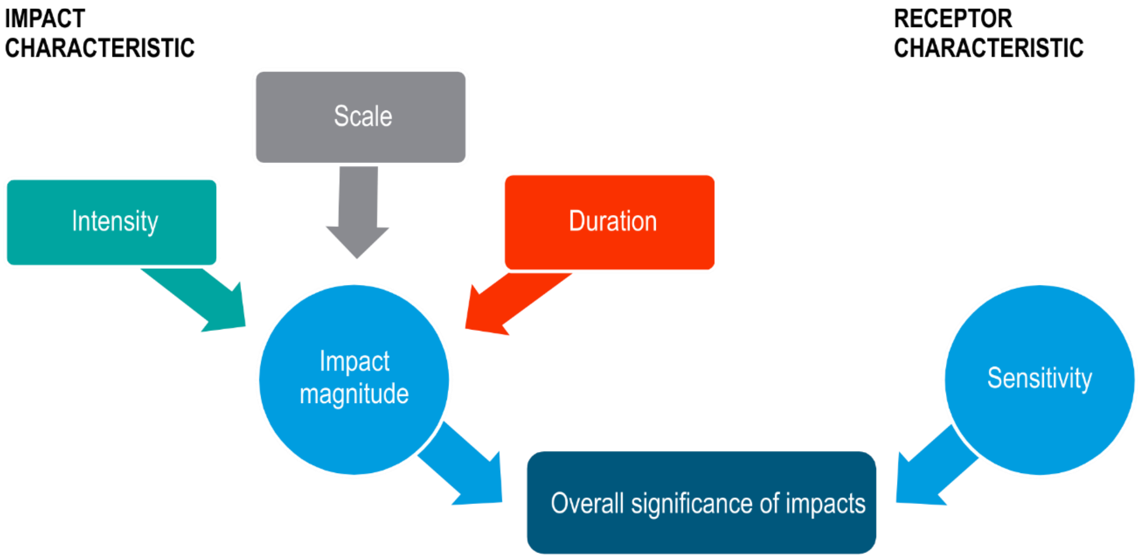

Figure 8-1 Impact assessment methodology.

Table 8-4 Criteria for evaluation of the significance of an impact (a combination of impact magnitude and sensitivity).

Impact significance	Impact severity	
Not significant	Negligible	There will be no or negligible impact on the environment.
Not significant	Minor	Minor adverse changes that might be noticeable but fall within the range of normal variation. Impacts are short-term and natural recovery takes place in the short term.
Not significant / Significant	Moderate	Moderate adverse changes in an ecosystem. Changes may exceed the range of natural variation. Potential for natural recovery in the medium-term is good. However, it is recognised that a low level of impact may remain. Impact may or may not be significant depending on the impact type. Mitigation measures may be applied to reduce the impact.
Significant	Major	The structure or function in the area will be changed, and the impact will also have impact outside the project area. Mitigation measures will be considered to reduce the impact.

Positive impacts are shown with a "+" in the comprehensive tables for the potential impacts.

Mitigation measures

The impact assessments will be performed taking a two-step approach.

1. The assessment of impact significance will be performed based on the optimised project description without mitigation measures and conclusions will be presented. Only mitigation measures, or preferably, project optimisations, will be included in the initial assessments.
2. If residual significant impacts occur, mitigation measures will be included in the assessment of impact significance and new assessment results will be presented.

8.3 Natura 2000 assessments

In accordance with Articles 6(3) and (4) of the Habitats Directive, it is required to perform an assessment of whether a project may result in significant impacts on Natura 2000 sites. In the

EIA, an assessment of potential impacts on Natura 2000 sites in relation to the Baltic Pipe project will be performed.

The methodology for Natura 2000 assessments is a four step-process comprising:

- Screening;
- Appropriate assessment;
- Assessment of alternative solutions; and
- Assessment where no alternative solutions exist and where adverse impacts remain (assessment of imperative reasons of overriding public interest (IROPI)).

Screening: In the Natura 2000 screening, the potential impacts of a project upon a Natura 2000 site(s), either alone or in combination with other projects or plans are assessed. The assessment identifies whether these impacts are *likely to be significant*.

Appropriate assessment: If the competent authority (the Danish Energy Agency) concludes that the project can significantly affect a Natura 2000 site, a more detailed assessment of the impact of the project on the Natura 2000 site should be made, a so-called appropriate assessment. In the appropriate assessment, the impact on the site’s structure, function and conservation objectives (the integrity) will be assessed. If the assessment shows that the project will *adversely impact* the integrity of the Natura 2000 site, no permit, dispensation or approval may be granted to the applicant.

A significant impact is thus defined as a possible harmful effect on the Natura 2000 site and its conservation objectives. It can be more accurately formulated as an effect that prevents favorable conservation status or other objectives from being maintained or achieved. The assessment is based on the local state, vulnerability and background load.

Assessment of alternative solutions: If the appropriate assessment has concluded that adverse effects on the integrity of a Natura 2000 site are likely, an assessment of alternative solutions for achieving the objectives of the project should take place.

Assessment of imperative reasons of overriding public interest (IROPI): If no alternative solutions are present and adverse impacts remain, an IROPI test will be made and an assessment of compensatory measures will be assessed.

For the proposed project, a Natura 2000 screening has been conducted and submitted to the DEA. In Sections 9.19 and 9.23 the results of the screening are summarised. In Sections 9.16 and 9.22, Annex IV species are assessed.

8.4 Articles 12 and 13 assessments (Annex IV species)

Article 12 of the Habitats Directive aims at the establishment and implementation of a strict protection regime for animal species listed in Annex IV(a) of the Habitats Directive within the whole territory of Member States.

In accordance with the Directive, the following is prohibited for strictly protected species:

- All forms of deliberate capture and keeping and deliberate killing;
- Deliberate damage to or destruction of breeding or resting sites;
- 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;

- Deliberate destruction or taking of eggs from the wild or keeping these eggs even if empty;
- 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.

Article 13 of the Habitats Directive ensures that Member States take the requisite measures to establish a system of strict protection for the plant species listed in Annex IV, prohibiting:

- The deliberate picking, collecting, cutting, uprooting or destruction of such plants in their natural range in the wild;
- The keeping, transport and sale or exchange and offering for sale or exchange of specimens of such species taken in the wild, except for those taken legally before this Directive is implemented.

The assessments of the *ecological functionality* of present Annex IV species will be included in the EIA.

If ecological functionality cannot be guaranteed, it may happen that a given species cannot maintain the favorable conservation status of the population. This means that the project can only be implemented in accordance with special derogation provisions of the Habitats Directive, section 11 which, *inter alia*, includes the opinion of Danish Environmental Agency and the orientation of the European Commission.

8.5 Water Framework Directive and Marine Strategy Framework Directive

With respect to the targets set in the WFD, the potential impact from the Baltic Pipe will be assessed to see if the project will affect the ability of reaching good environmental status (GES) for the relevant indicators (chlorophyll-*a* concentration, benthic fauna index, depth limit of eel grass etc.). With respect to the targets set in the MSFD, the potential impact on the 11 descriptors set in the Directive will be assessed.

9. ENVIRONMENTAL BASELINE AND IMPACT ASSESSMENT

The following chapter constitutes the environmental baseline and impact assessment for construction and operation of the proposed project. The chapter is divided in the three overall environments; The physical-chemical, the biological and the socioeconomic environment. The overall environments are divided into an offshore and onshore part.

The receptors described and assessed are shown in Table 9-1.

Table 9-1 Environmental receptors relevant for the Baltic Pipe project.

Physical-chemical environment	Biological environment	Socioeconomic environment
Offshore		
• Bathymetry • Hydrography and water quality • Surface sediments and contaminants • Climate and air quality • Underwater noise	• Plankton • Benthic habitats, flora and fauna • Fish • Marine mammals • Seabirds and migrating birds • Migrating bats • Annex IV species • Biodiversity • Protected areas • Natura 2000	• Shipping and shipping lanes • Commercial fisheries • Archaeology and cultural heritage • Cables, pipelines and windfarms • Raw material extraction sites and dumping sites • Military practice areas • Environmental monitoring stations
Onshore		
• Landscape • Geology, groundwater and surface water • Climate and air quality • Noise*	• Protected areas, natural habitats, flora, and fauna • Annex IV species • Natura 2000	• Archaeology and cultural heritage • Population and human health • Tourism and recreational areas

* Noise is not a physical-chemical receptor as such but is related to the existing noise level in the landfall area and the impact on this from the project.

PHYSICAL-CHEMICAL ENVIRONMENT - OFFSHORE

9.1 Bathymetry

In this section, the baseline for the bathymetry is described and the impacts from the project are assessed.

9.1.1 Baseline

The Baltic Sea is a semi-enclosed sea and one of the world's largest brackish water bodies (Snoeijs-Leijonmalm and Andrén, 2017). It separates the Scandinavian Peninsula from the rest of continental Europe and is connected to the North Sea through the narrow Danish Straits; Lillebælt, Storebælt and Øresund (Mohrholz *et al.*, 2015). The total area of the Baltic Sea is approximately 369,000 km^2 with an estimated volume of approximately 21,000 km^3 (Snoeijs-Leijonmalm and Andrén, 2017).

The Baltic Sea is divided into a number of sub-basins, and the pipeline route in Danish waters crosses the Arkona Basin and the Bornholm Basin (Figure 9-1).

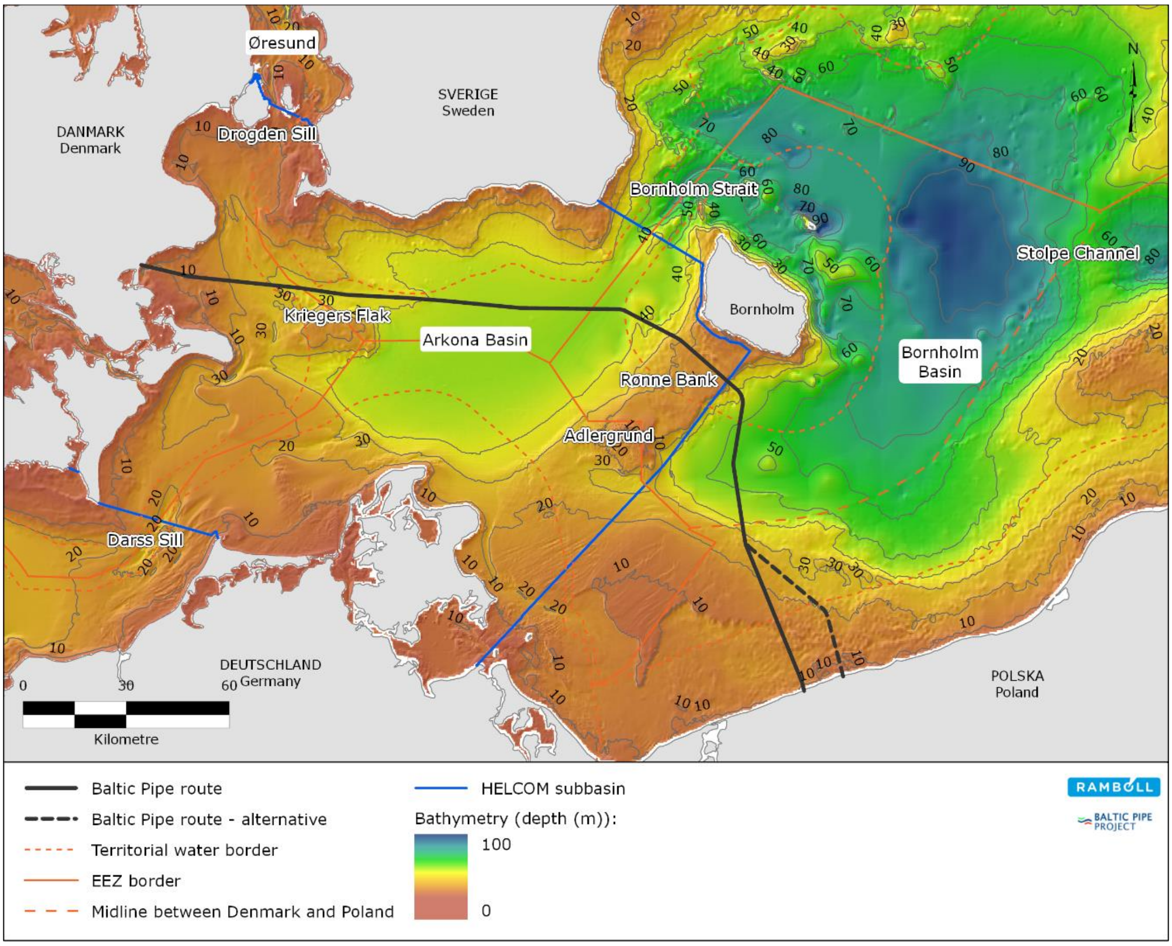

Figure 9-1 Bathymetry in the Danish waters of the Baltic Sea.

The water transport (inflow and outflow) in the Baltic Sea is restricted by the bathymetry. The inflow of saline and oxygen-rich water to the Arkona Basin is restricted by the sills Drogden Sill (in Øresund) to the north and Darss Sill (in Femern Belt) to the west. The basin is divided from the Bornholm Basin by the glacial morphological structures of Adlergrund and Rønne Bank, which create shallow banks and reef structures (Zettler *et al.*, 2006). The Bornholm Strait does not separate the Bornholm Basin from the Arkona Basin by a distinct shallow sill, but the water depth is, however, still critical for the flow between the two basins (Krauss and Brügge, 1991). The outflow from the Bornholm Basin to the Gotland Deep is controlled by the Stolpe Channel.

The average water depth of the Arkona Basin is 23 m, with a maximum depth of 53 m (Snoeijs-Leijonmalm and Andrén, 2017). Only the marginal zones of the basin and Krieger's Flak are shallower than 20 m.

The bathymetry along the route (Figure 9-2) shows that the seabed within the western part of the Danish section of the project area slopes almost uniformly downward from the landfall to the deepest part at 33 m at the EEZ border to Swedish waters. Within the eastern part of the Danish sector of the project area, the depth is 50 m, and the water depth decreases to 15-20 m at the crossing of Rønne Bank.

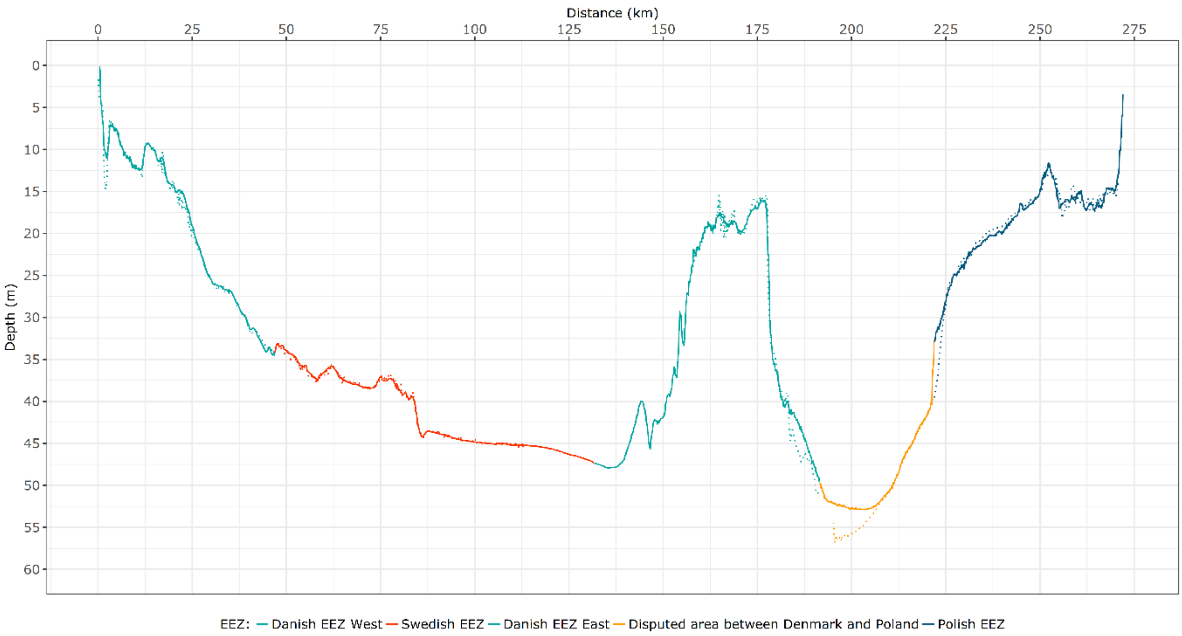

Figure 9-2 Water depth along the route.

9.1.2 Impact assessment

Relating to the construction and operation of the Baltic Pipe, two potential impacts have been identified (Table 9-2).

Table 9-2 Potential impacts on bathymetry.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Presence of pipeline		X

The following source of impact has been screened out:

- **Sedimentation (construction):** Sedimentation of suspended sediments released from intervention works during construction can be screened out due to the small amount of increased sedimentation (see Section 5.1.2). The changes in bathymetry caused by increased sedimentation are not of a magnitude that will cause any changes in the basic physical conditions for life.

Physical disturbance of seabed

During the construction phase, physical disturbance of the seabed will occur due to seabed intervention works such as tunnelling, trenching and pipe-lay.

Dredged material from the exit point and the associated transition zone will be transported to a temporary disposal area on the seabed (see Section 5.1.1). After the tunnel boring machine has been removed and pipe-lay nearshore has taken place, the hole will be backfilled, and the seabed will be re-established to pre-impact status.

Trenching is expected to be carried out in five sections within Danish waters, with an approximate length of 63.5 km. Where the pipeline is trenched into the seabed, the seabed height around the trench may vary from the surrounding seabed due to spoil heaps. However, artificial and natural backfilling will subsequently smoothen out the seabed bathymetry along the trenched pipeline sections.

Pipe-lay can also cause local physical disturbance of the seabed, either from DPS with powerful thrusters or anchors that keep the lay vessel in position (see Section 5.1.1). DPS can cause turbulence from the operation of the thrusters and may locally impact the seabed surface, depending on the size of thrusters, the water depth and the seabed condition (i.e. presence of stones, size of stones, grain size of sediment etc.), but it will not impact the bathymetry. DPS will only be used when the water depth is > 20 m.

If anchors are used, the anchors and the anchor chains will impact the seabed surface where they are in contact with the seabed.

The impact from DPS and anchors is assessed to be local and does not impact the general bathymetry of the Baltic Sea.

The sensitivity of the receptor is assessed to be medium as it is important to the functioning of the wider ecosystem, but it can be actively restored to pre-impact status or it will revert naturally over time. The intensity of the impact is classified as minor and the spatial scale as local. The duration is considered immediate, as there will be no disturbance once the construction work ends. Hence, the severity of the impact is negligible, and the impact is not significant (Table 9-3).

Table 9-3 Impact significance on bathymetry from the physical disturbance of seabed.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance of seabed	Medium	Minor	Local	Immediate	Negligible	Not significant

Presence of pipeline

The bathymetry will be permanently affected by the presence of the pipeline and the duration is therefore classified as long-term (Table 9-4). The presence of the pipeline and support structures such as rock placement will result in a local reduction of the water depth. Only insignificant impacts on sediments and hydrography are expected (Section 9.2.1 and 9.3.1), and the spatial scale is assessed to be local to the footprint of the pipeline. The intensity is minor as there will be no alteration of the general bathymetry and only insignificant, secondary impacts on sediments and hydrography. Thus, the severity of the impact is negligible and not significant.

Table 9-4 Impact significance on bathymetry from the presence of pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Presence of pipeline	Medium	Minor	Local	Long-term	Negligible	Not significant

9.1.3 Conclusion

The potential impacts on bathymetry resulting from the construction and operation of the proposed pipeline in Danish waters are summarised in Table 9-5.

Table 9-5 Overall impact significance for bathymetry.

Potential impact	Severity of impact	Significance	Transboundary
Physical disturbance of seabed	Negligible	Not significant	No
Presence of pipeline	Negligible	Not significant	No

9.2 Hydrography and water quality

This section describes the baseline of the hydrographic and water quality conditions in the Danish part of the project area. In addition, an assessment of the potential impacts on the hydrography and water quality due to the construction and operation of the pipeline project is outlined.

9.2.1 Baseline

Salinity, water temperature and stratification

The Baltic Sea is characterized by its natural formation as an enclosed estuary with high freshwater input and restricted exchange of water through the Danish straits with the more saline North Sea water. The shallow-water thresholds Drogden Sill and Darss Sill (see Figure 9-3) constitute “bottlenecks” which control the inflow to the Baltic Sea.

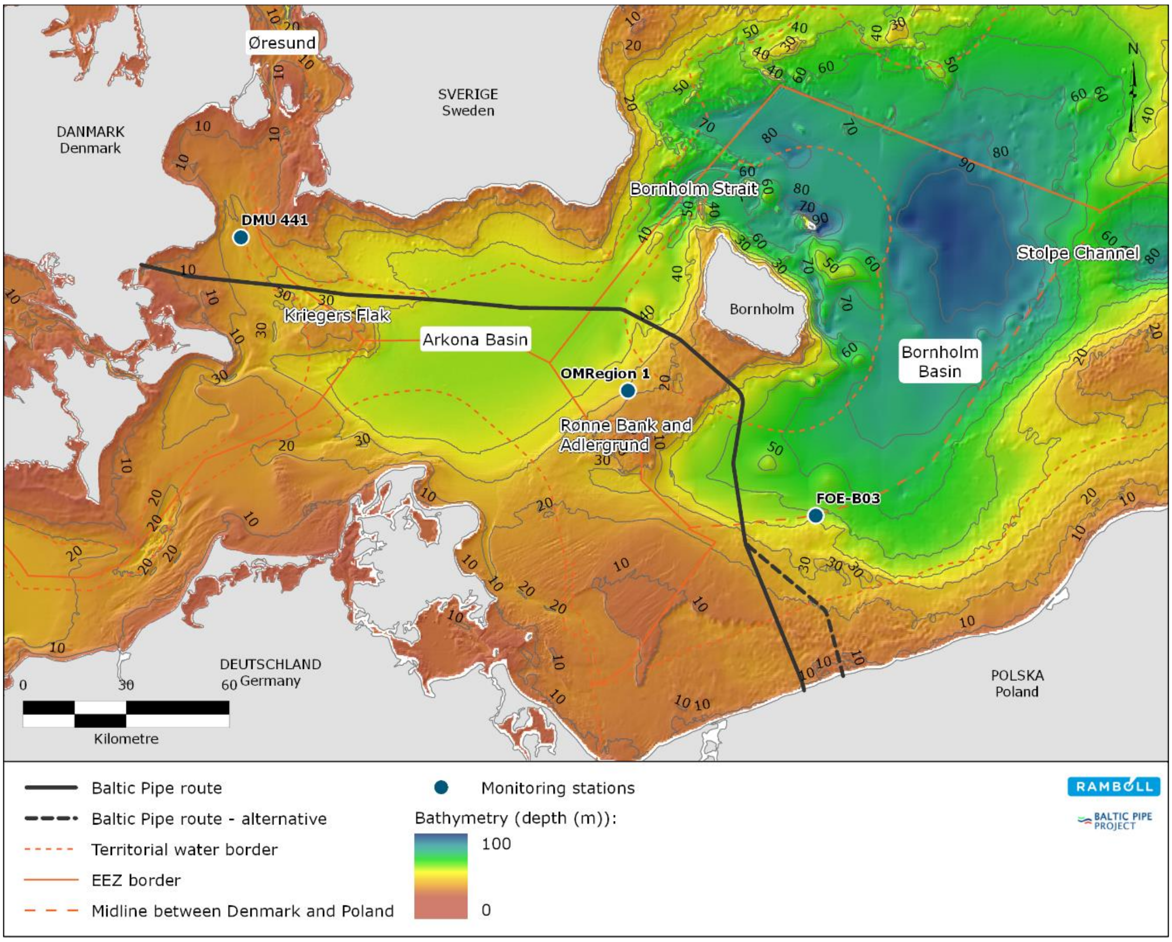

Figure 9-3 Locations of the three HELCOM/ICES stations from which profile data have been used (DMU_441, OMREGION_1 and FOE-B03).

River runoff and precipitation/evaporation are responsible for balancing the inflow of saline water through the Danish straits. The mean annual runoff into the Baltic Sea during the period 1950-2014 has been approximately 14,381 m^3/s (HELCOM, 2015a), with the greatest runoff occurring in May and June (up to 25,000 m^3/s) due to ice and snow melting. The lowest runoff occurs in January and February (Jacobsen, 1993). The total volume of water in the Baltic Sea is approximately 21,721 km^3 (Al-Hamdani & Reker, 2007).

The water quality in the deeper parts of the Baltic Sea depends on the rare inflow events caused by low pressure in the Baltic Sea region and strong winds from west. During these inflows, saline, oxygen-rich water flows from the Skagerrak/North Sea through the Danish straits into the deeper parts of the western Baltic Sea. These inflow events are important for maintaining the stratification of the water column and for the fauna of the Baltic Sea, i.e. for successful cod spawning in the Baltic Proper. The boundary between the upper, less saline and the deeper, more saline water masses, known as the halocline, is a layer of water where salinity levels change rapidly. Like a lid, the halocline limits the vertical mixing of water (see Figure 9-4).

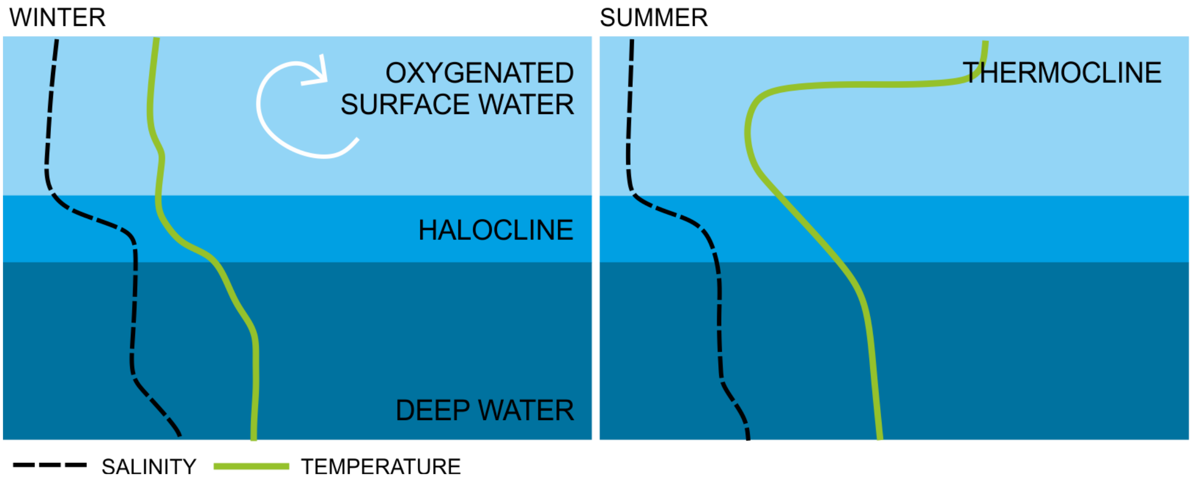

Figure 9-4 General summer and winter variations in salinity and temperature in the Baltic Sea. The depths shown are examples; the depths of the halocline and thermocline vary depending on the location in the Baltic Sea.

A number of water quality parameters are measured as profiles at various locations in the Baltic Sea as part of the HELCOM/ICES monitoring programme. Measuring results from the three stations considered representative for the Baltic Pipe alignment shown in Figure 9-3 and are presented in the following.

Measured profiles of salinity and water temperature from the three HELCOM/ICES stations are shown in Figure 9-5, Figure 9-6 and Figure 9-7, as averages for the period 2000-2016 in summer (June-August) and winter (December-February) situations, respectively. The measurements were not carried out at exactly the same time each year, and the measurement positions could deviate 10-20 km from the position shown in Figure 9-3. Moreover, the depths at which the measurements were taken were not the same in all the years. Therefore, some of the profiles are not completely smooth; this is particularly the case for the salinity measurements from OMREGION_1.

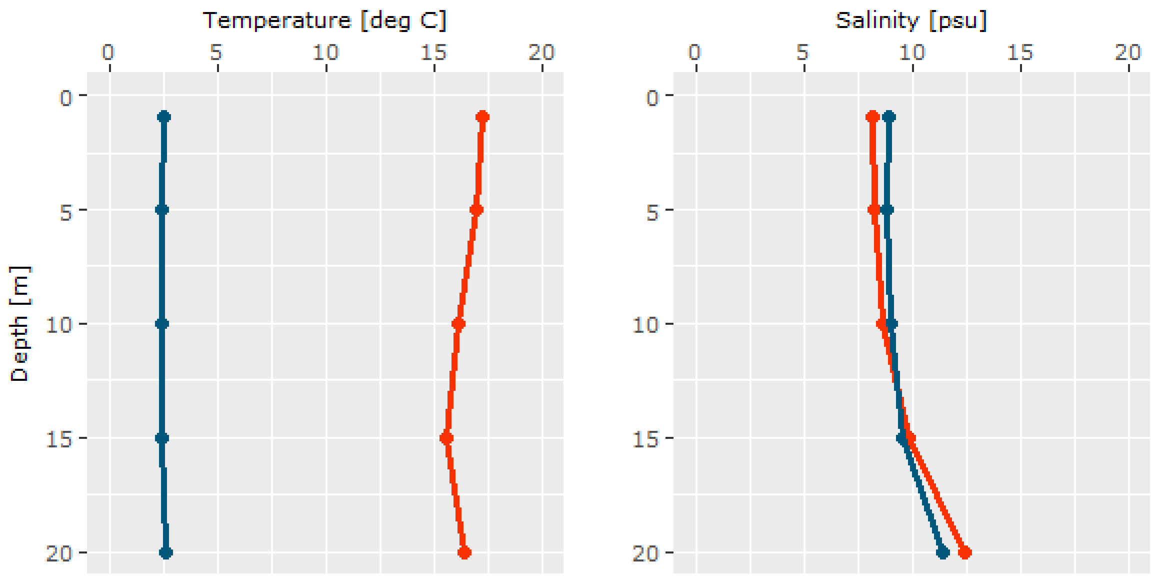

Figure 9-5 Profiles of average summer (red) winter (blue) water temperature (left) and salinity (right), for the period 2000-2016 at HELCOM/ICES station DMU_441.

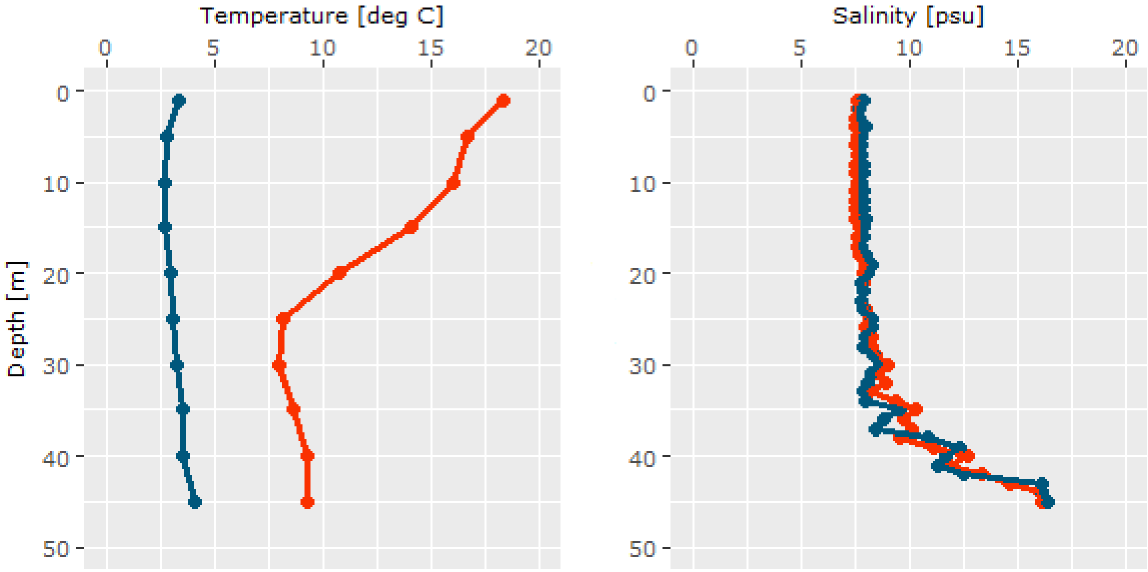

Figure 9-6 Profiles of average summer (red) winter (blue) water temperature (left) and salinity (right), for the period 2000-2016 at HELCOM/ICES station OMREGION_1.

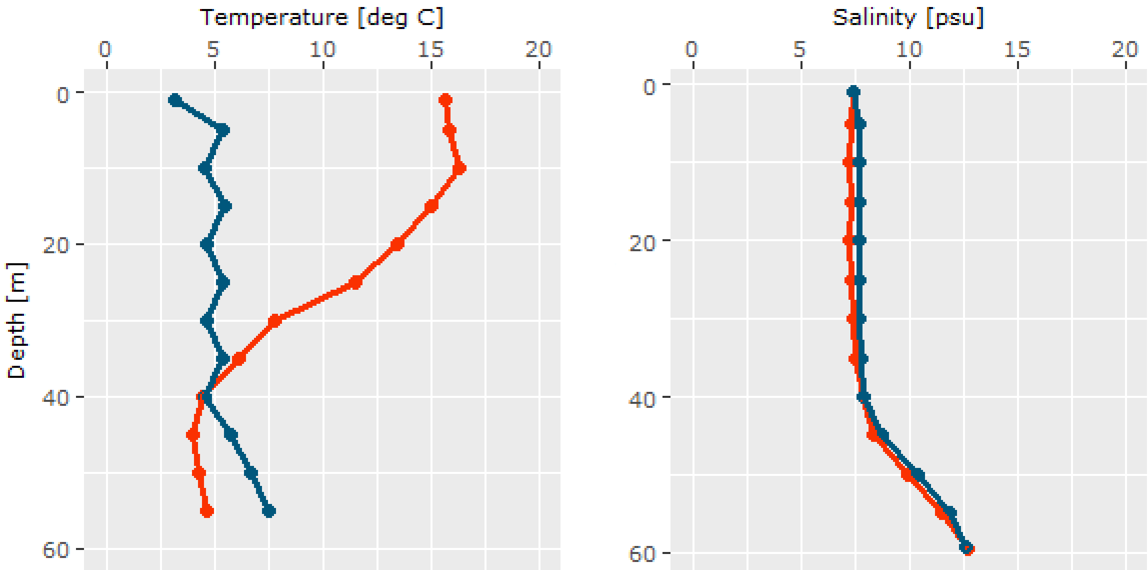

Figure 9-7 Profiles of average summer (red) winter (blue) water temperature (left) and salinity (right), for the period 2000-2016 at HELCOM/ICES station FOE_B03.

The summer and winter salinity profiles are relatively similar, with a tendency towards a slightly higher surface salinity in winter compared to in summer. The surface salinities vary from approximately 8-9 psu at DMU_441 to 7-8 psu at OMREGION_1 and FOE-B03 (Table 9-6). The salinity increases slightly towards the seabed. A layer with a strong vertical salinity gradient (a halocline) exists 35-45 m below the water surface at OMREGION_1, where the salinity increases from approximately 9 to 16 psu, and at a depth below surface of 40-60 m at FOE-B03, where the salinity increases from approximately 8 to 13 psu.

Table 9-6 Salinity parameters for the Arkona Basin (Leppäranta and Myrberg, 2009). The table includes a salinity profile for the measuring stations DMU_441, Omregion_1 and FOE_B03.

Basin / Station	Salinity [‰] Upper layer	Salinity [‰] Lower layer	Halocline depth [m]
Arkona Basin	7.5 – 8.5	10 – 15	20 – 30
DMU_441	8 – 9	11 – 12	N/A
Omregion_1	7 – 8	16 – 17	35 – 45
FOE_B03	7 – 8	12 – 13	40 – 60

The average surface water temperatures at the three measuring stations were found to be approximately 17-18^{0}C in summer and 2-3^{0}C in winter. At DMU_441, the water temperature is relatively constant with depth both in summer and in winter (down to 20 m water depth), whereas the water temperature in summer decreases with depth until approximately 25 m below water surface at OMREGION_1 and approximately 40 m below water surface at FOE_B03. In winter, the water temperature increases slightly towards the seabed.

The profiles shown in the above figures indicate that the water column at DMU_441, which represents the area near the Danish landfall down to 20 m water depth, is not stratified. At OMREGION_1 in the middle, the water column is permanently stratified with a marked halocline 35-45 m below the water surface. In addition, the large vertical temperature gradients in summer in the uppermost 25 m contribute to stabilization of the water column. At FOE_B03, which is the station near the midline between Denmark and Poland, the water column is permanently stratified by a marked halocline 40-60 m below the water surface. In addition, the large vertical temperature gradients in summer in the uppermost 10-40 m contribute to stabilization of the water column.

The profiles shown in Figure 9-5, Figure 9-6 and Figure 9-7 correspond well with the conceptual figure shown in Figure 9-4, where the upper limitation of the halocline is present at a depth of 35-40 m below the sea surface and with no "deep water" part in the project area.

The permanent stratification in the Baltic Sea is maintained by temperature differences in the water column as well as the large annual input of freshwater from the many rivers in the region combined with occasional influx of denser, more saline water from the Skagerrak/North Sea over the thresholds in the Danish straits. The weaker temporal stratification occurring in shallow waters (20-30 m depth) normally collapses due to storm events during the autumn and winter mixing of the water column (Al-Hamdani & Reker, 2007).

The bottom current of inflowing saline water is driven by gravity. As the saline water passes the narrow cross-sections at the sills (Darss Sill, with a water depth of approximately 17 m, and Drogden Sill, with a water depth of approximately 8 m), the water flows down the sloping seabed towards the Bornholm Basin (see Figure 9-8). Consequently, the water exchange is highly sensitive to physical changes in the transition area and not very sensitive to the bathymetric conditions in the open basins. However, increased flow resistance or other obstacles may lead to increased vertical mixing of the water masses.

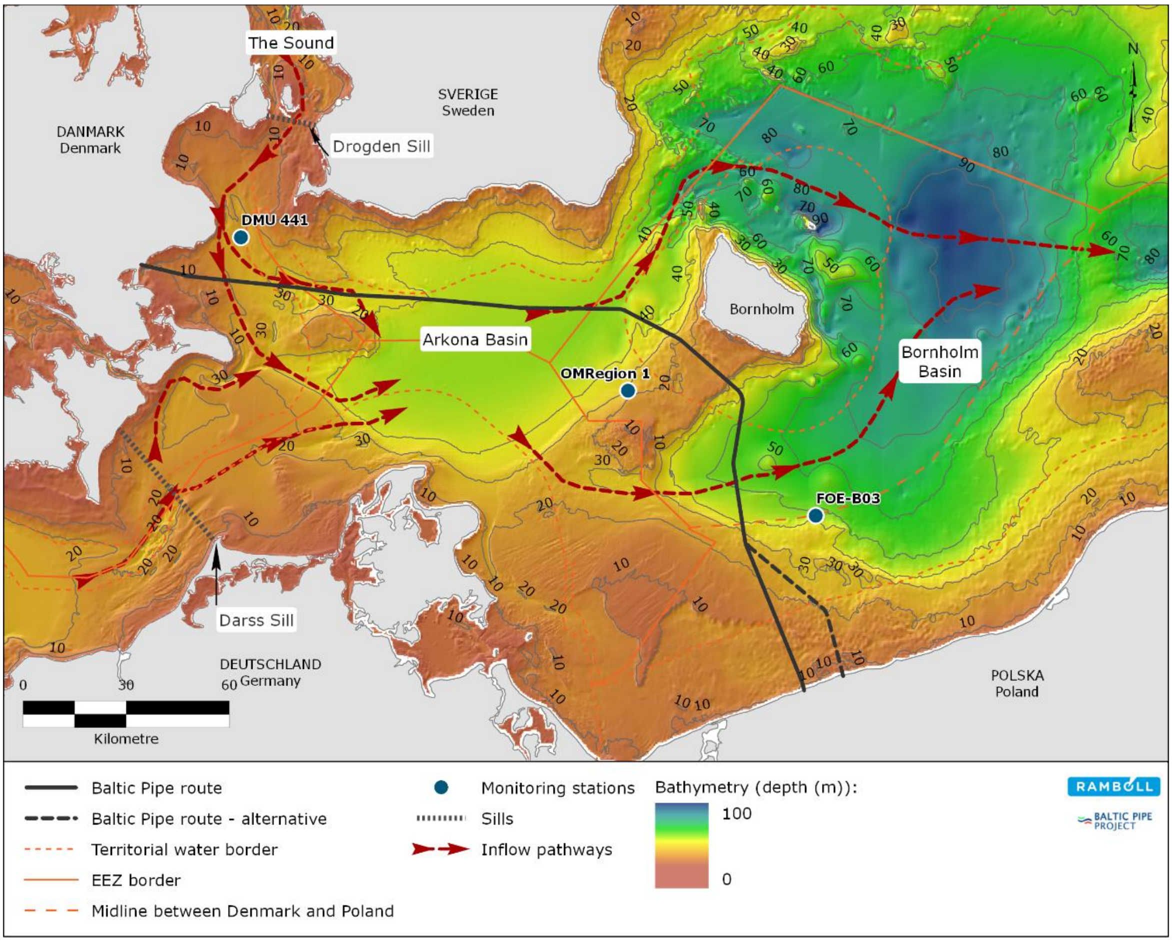

Figure 9-8 Bathymetric map of the southwestern Baltic Sea, showing the inflow pathways for saline water indicated by dashed bold arrows (after Mohrholz *et al.*, 2015).

Before 1980, such major Baltic inflow (MBI) events were relatively frequent and could be observed on average once per year. However, since this time, they have become less frequent and take place during strong storms in the late autumn or winter months. In recent times, MBIs have occurred in 1993 and 2003. After nearly a decade without an MBI, a relatively large inflow was detected in the western Baltic Sea in the winter of 2011-2012. This inflow, which could be traced until the southern part of the eastern Gotland Basin, ventilated the Bornholm Basin but did not renew the deep water (Bernes, 2005). MBIs account for approximately 30% of the total salt influx, whilst the remaining 70% of the salt influx is due to weaker inflow events (Møller & Hansen, 1994).

A weak MBI occurred in March 2014. Previously, two smaller inflow events in November 2013 and February 2014 has reached the Bornholm Basin. In December 2014, a strong MBI brought large amounts of saline and well-oxygenated water into the Baltic Sea. Based on observations and numerical modelling, the inflow was classified as one of the rare, very strong events. The inflow volume and the amount of salt transported into the Baltic Sea were estimated at 198 km^3 and 4 Gt, respectively. The strength of the MBI considerably exceeded the 2003 event. Of the MBIs since 1880 (Matthäus, 2006), the 2014 inflow is the third strongest event, together with the MBI in 1913 (Mohrholz *et al.*, 2015).

These inflows create clear salinity gradients geographically, temporally and vertically.

Climate changes

During the lifetime of the pipeline, the climate is expected to change due to global warming. Warming air temperature in the Baltic Sea region has already been verified, but the increase is seasonally and regionally different. Simulations of the development until the year 2100 indicate a possible rise in surface temperatures of approximately two degrees Celsius for Baltic Sea waters. This milder climate would lead to a possible decrease in Baltic Sea ice cover by 50 – 80%. A general increase in precipitation is expected, particularly in winter, and a decrease of up to 40% could occur on the southern coasts in summer. This will potentially both cause the salinity of the Baltic Sea to decrease and the input of nutrients from river runoff to increase. With respect to winds, simulation results diverge, and it is not possible to estimate whether there will be a general increase or decrease in wind speed in the future (Bolle *et al.*, 2015).

The sea level rise in the Baltic Sea is closely coupled to the global sea level. This means a possible rise of approximately 0.3 – 0.8 m is predicted in the Baltic Sea region by the end of the century. However, this rise is superimposed by geological subsidence and uplift processes. The potential local sea level rise is partly compensated by vertical land movement, which varies between 0 m per century in Denmark and roughly 0.8 m per century in the Bothnian Bay (Bolle *et al.*, 2015). This means that there will be virtually no compensation caused by uplift processes in the Baltic Pipe project area.

Suspended sediments

Suspended sediments comprise particulate matter (organic and/or inorganic) in the water column. Suspended particulate matter can originate from production in the water column (autochthonous sediments), it can be provided advectively (allochthonous sediments), or it can be provided from re-suspension of seabed sediments. Sediment production in the water column can arise either from chemical precipitation or biological activity, e.g. algae growth. Advectively supplied sediments have been provided laterally by the currents and can originate from e.g. riverine inflow or coastal erosion. Re-suspended sediments have been provided vertically from the mobilisation of seabed sediments, either due to man-made activity (e.g. bottom trawling or trenching) or due to natural processes, e.g. the impacts on the seabed caused by currents, waves or biological activity.

The natural concentration of suspended sediments in the water column depends on the balance between the supply of sediments from the above mechanisms and the settling of sediments to the seabed.

In Christiansen *et al.* (2002) the natural sediment transport was studied at four stations in a transect from shallow (16 m) to deep (47 m) water depth (the Arkona Basin) in the southern Baltic Sea (between Germany, Poland, and Bornholm) in 1996-1998. Water column average suspended sediment concentrations in the depth profile generally ranged between 2 and 12 mg/l. At all stations, the amount of suspended materials increased towards the seabed.

Measurements in Øresund prior to construction of the Øresund Fixed Link showed surface SSCs under calm weather conditions with out-flowing brackish Baltic Sea water in the range of 0-1 mg/l. The SSC in the saline bottom layer was 1-2 mg/l. During stormy periods in winter, the regional SSC level in the entire water column was up to 5-15 mg/l, and the local SSC level was up to 20-40 mg/l (Valeur *et al.*, 1996). These measurements were also carried out in relatively shallow waters and are expected to be comparable with the conditions near the Danish landfall.

Femern Belt A/S has carried out continuous turbidity monitoring at three positions at water depths of 20-29 m during the period March 2009 to January 2010. The mean SSC at all three stations ranged from between 1 to 2 mg/l at the surface and in the mid-water column, whereas it ranged from 1 to 4 mg/l near the seabed (FEHY, 2013b).

Continuous measurements of SSC carried out at four monitoring stations at Hoburgs Bank and Norra Midsjöbanken in the Swedish EEZ at water depths of 28-43 m in the period November 2010 to August 2011 showed, in general, very low SSC; most of the time, SSC was approximately 1 mg/l, and only in very short periods was it above 2 mg/l (*Valeur et al.*, 2012).

The above investigations were carried out during periods representing all seasons of the year and should therefore be considered representative for the various hydrographic conditions prevailing in the areas where they were carried out, except for the more extreme situations.

Suspended sediments will eventually settle to the seabed and be transported to areas of net accumulation of fine-grained sediments. The primary sedimentation might take place in areas where the seabed is more exposed to the action of waves and currents. From there it will be resuspended in rough weather, until it ends up in the sheltered and deep net accumulation areas of the Baltic Sea. The seabed in such areas is typically classified as "fine-grained sediment (clay/silt)", as shown in Figure 9-20 in Section 9.3.

The net accumulation rates have been estimated from dating of the sediment layers using radioactive tracers. These studies show that the net accumulation rate in accumulation areas in the southern Baltic Sea is in the range of 0.5-2 $mm \cdot yr^{-1}$ (Mattila *et al.*, 2006; Szmytkiewicz & Zalewska, 2014).

Water transparency and turbidity
Water transparency mainly depends on the concentration and type of suspended particulate matter and on the amount of coloured dissolved organic matter. Water transparency is an important physical parameter which is important to marine life. Reducing the incoming sunlight has a negative impact on the photosynthesis of phytoplankton and benthic flora and can subsequently negatively impact migrating and foraging fauna.

Turbidity is an optical property of the water that causes light to be scattered or absorbed instead of being transmitted. Increased concentrations of suspended sediments in the water column causes the turbidity to increase, i.e. it reduces the water transparency. The increase in turbidity not only depends on the increase in SSC, but also on the characteristics of the suspended sediments, in particular the grain size distribution and the type and shape of particles. For a given SSC, the turbidity is several times larger for fine-grained sediments (e.g. silt and clay) than it would be if the suspended sediments constituted coarse-grained sediments (e.g. sand).

A decrease in summertime water transparency has been observed in all Baltic Sea sub-regions over the last 100 years. The decrease is most pronounced in the northern Baltic Proper and in the Gulf of Finland. The primary cause for decreased summertime water transparency in the Baltic Proper is the increase in phytoplankton biomass and cyanobacterial blooms due to progressing eutrophication (Laamanen *et al.*, 2005).

Nutrients, eutrophication and oxygen conditions
Eutrophication has a range of effects on the Baltic Sea ecosystem, such as increased water turbidity, increased blooms of cyanobacteria, deterioration of underwater seagrass meadows, changes in fish species composition, and oxygen deficiency in bottom sediments (Ahtiainen *et al.*, 2014). In Figure 9-9, the effects of eutrophication in the Baltic Sea are outlined.

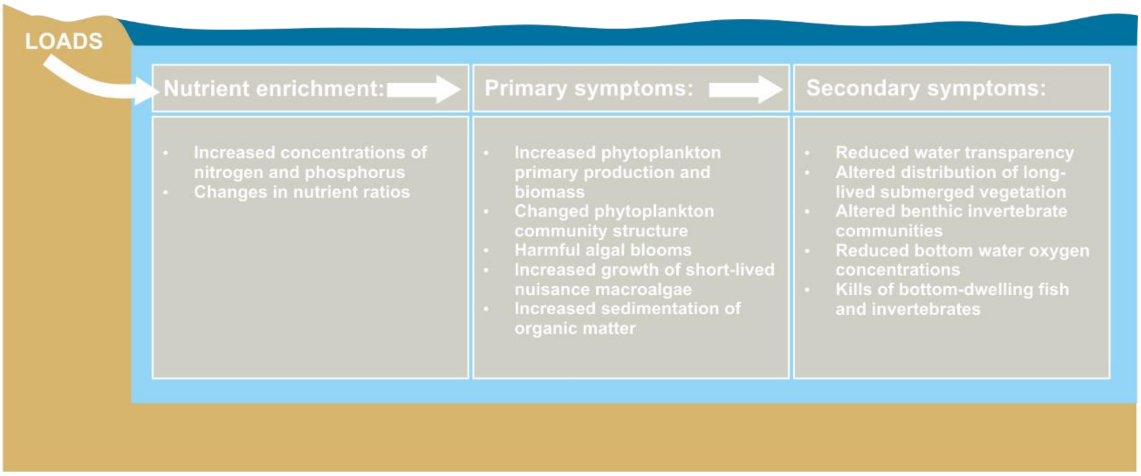

Figure 9-9 A simple conceptual model of eutrophication symptoms in the Baltic Sea (HELCOM, 2009a).

Nutrient inputs take place as deposition to the water surface, inputs from the surrounding land areas (via rivers and from the coast – from point sources and diffuse sources) and through water exchange via the Danish straits. In addition, nutrients are released to the water column when organic matter, e.g. dead algae, degrades. Also, phosphorus reserves accumulated in the sediments of the seabed ("internal load") are released back into the water under anoxic conditions (HELCOM, 2005).

The average yearly inputs of nitrogen and phosphorus to the Baltic Sea have been calculated based on the period 2010-2012. Normalized inputs were used for the riverine and atmospheric inputs to reduce the impact of inter-annual variability in the inputs caused by weather conditions. The calculations showed a total yearly input to the Baltic Sea of approximately 825,000 tonnes of nitrogen and approximately 32,000 tonnes of phosphorus. Trend analysis has shown that total inputs to the Baltic Sea from 1995 to 2012 have decreased by approximately 18% with respect to nitrogen and by approximately 23% with respect to phosphorus (Svendsen *et al.*, 2015).

As a follow-up to the Baltic Sea Action Plan from 2007 (see Chapter 10, MSFD & WFD), a revised HELCOM nutrient reduction scheme was adopted in the 2013 HELCOM Ministerial Declaration, in which reduction requirements for nitrogen inputs to the Baltic Sea were set. The HELCOM nutrient reduction scheme defines maximum allowable inputs (MAI) of nutrients, which indicate the maximum level of inputs of water- and airborne nitrogen and phosphorus to Baltic Sea sub-basins that can be allowed in order to obtain good environmental status (GES) in terms of eutrophication (Svendsen *et al.*, 2015).

Measured profiles of the concentrations of nitrate (NO_3^-) and phosphate (PO_4^{3-}) phosphorous (P) from the stations DMU_441 and OMREGION_1 are shown in Figure 9-10, and profiles of total P from the station OMREGION_1 are shown in Figure 9-11. The measurements represent averages for the available data during the period 2000-2016, as summer (June-August) and winter (December-February) situations (locations of measuring stations are shown in Figure 9-3).

Nitrate and phosphate represent the majority of the dissolved (bioavailable) nitrogen (N) and P in the Baltic Sea. In winter, the concentrations of both are significantly higher than in summer, because the majority of the N and P in the water column in summer exists incorporated in algae and other organic matter. The fact that the concentration of nitrate, in contrast to the concentration of phosphate, is close to zero in the uppermost 10-20 m of the water column shows that the algae growth in summer is limited by the supply of dissolved N, not of dissolved P.

The winter, the average concentrations at the two stations in the surface waters are approximately $[NO_3^-]$ = 2-4 μmol/l and $[PO_4^{3-}]$ = 0.6-0-7 μmol/l.

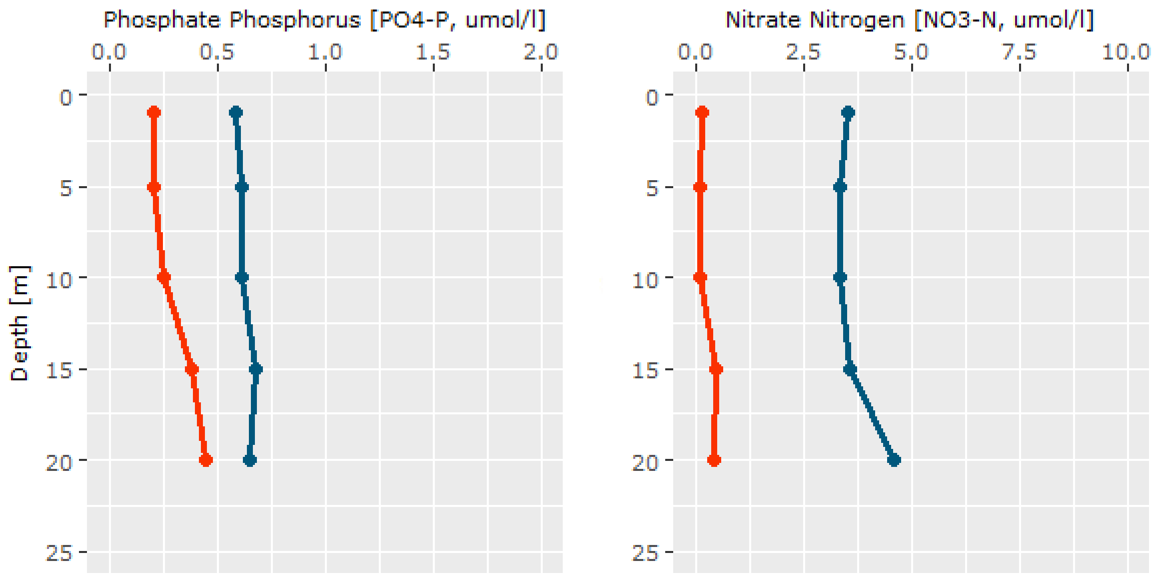

Figure 9-10 Profiles of average summer (red) winter (blue) dissolved phosphate and nitrate, respectively, for the period 2000-2016 at HELCOM/ICES station DMU_441. Data were only available for some of the years in the period 2000-2016.

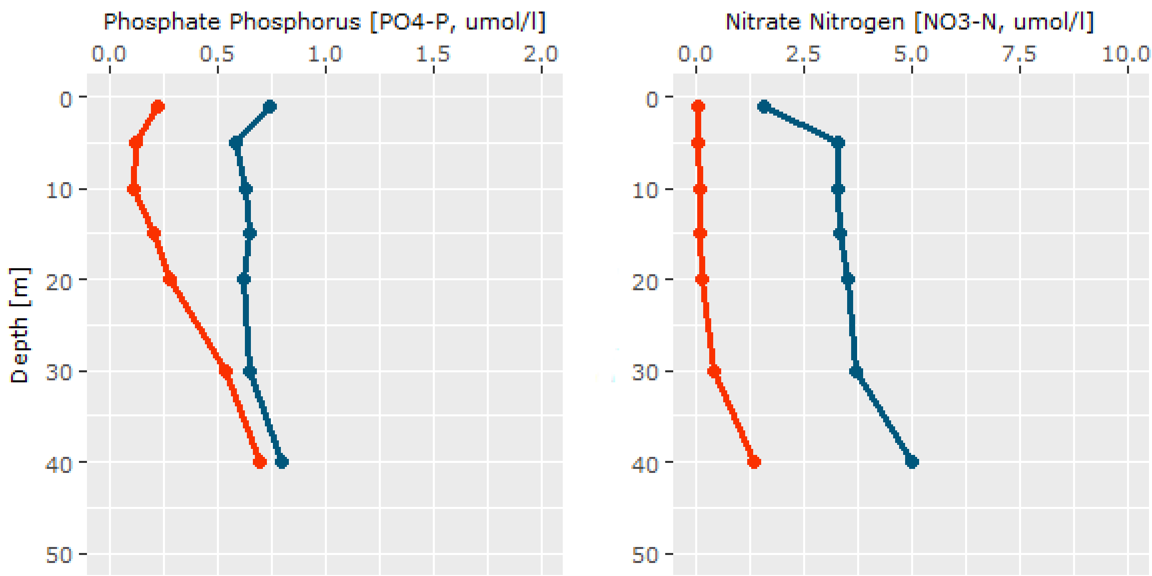

Figure 9-11 Profiles of average summer (red) winter (blue) dissolved phosphate and nitrate, respectively, for the period 2000-2016 at HELCOM/ICES station OMREGION_1. Data were only available for some of the years in the period 2000-2016.

Nutrient enrichment will generally cause an increase in phytoplankton primary production, which will result in increased turbidity and increased sedimentation of organic matter to the seafloor. This may in turn cause oxygen depletion due to oxygen consumption caused by mineralisation of degrading organic matter, ultimately resulting in hypoxia or anoxia, and loss of higher life forms, including fish and bottom invertebrates (HELCOM, 2009a). Currently, large parts of the Baltic Sea are in a state of so-called repressed recovery, where widespread hypoxia facilitates the release of

P from the sediment and fuels blooms of nitrogen (N_2) fixing blue-green algae that tend to counteract reductions in external P and N loads.

The deeper parts of the Baltic Sea are suffering from oxygen deficiency. The strong vertical stratification of the water column in combination with eutrophication and other factors form the basis for the problematic oxygen conditions that are found in the Baltic Sea. In the Arkona Basin, anoxia is a sparse phenomenon, while in the Bornholm Basin it is a more seasonal feature occurring almost every year (SMHI, 2018).

Anoxic conditions, where no oxygen remains in the water, may occur at very low oxygen concentrations, or in the absence of oxygen, due to the remaining available oxygen being consumed by microbial processes. Under anoxic conditions, hydrogen sulphide (H_2S), which is toxic for all higher marine life, is formed. Hypoxia is a condition that occurs when dissolved oxygen falls below the level needed to sustain most animal life. The concentration at which various animals are affected varies, but generally effects start to appear when oxygen drops below 2.8-3.4 ml/l (4-4.8 mg/l). Acute hypoxia is usually defined at 1.4-2.1 ml/l (2-3 mg/l). For the purposes of this report, hypoxia is defined as oxygen concentrations <2 ml/l.

Yearly monitoring has shown that a distinct regime shift in the oxygen situation in the Baltic Proper occurred around 1999. The situation in 2016 (see Figure 9-12) is representative for the situation in autumn as it has been measured in the years since 1999 (SMHI, 2017).

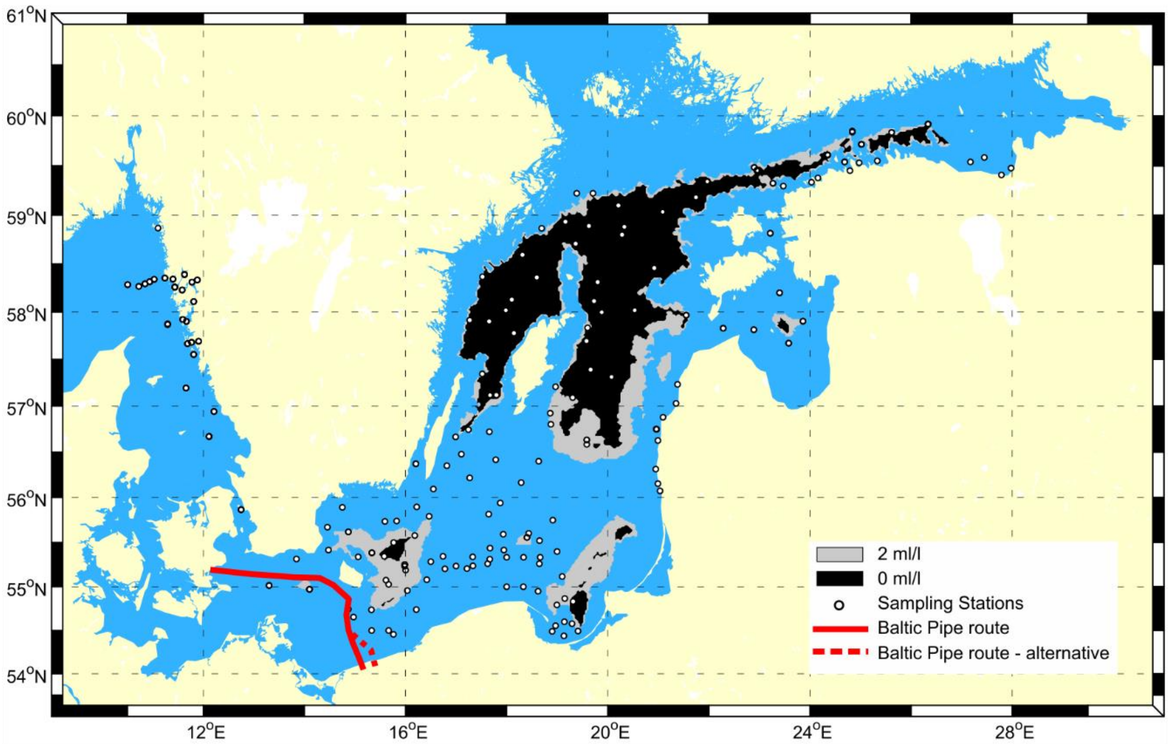

Figure 9-12 Extent of hypoxic and anoxic bottom water in the Baltic Sea, autumn 2016 (modified after SMHI, 2017).

Oxygen depletion was registered both east and west of Bornholm in 2016. The oxygen depletion west of Bornholm typically occurs in a thin layer of dense bottom water which has moved in from the Kattegat. The oxygen depletion west of Bornholm prevailed in August-September and had disappeared by October 2016 (Hansen *et al.*, 2018).

Measured profiles of the concentrations of O_2 from the three stations shown in Figure 9-3 are shown in Figure 9-13 and Figure 9-14, respectively. The measurements represent averages for the period 2000-2016 during summer (June-August) and winter (December-February) situations.

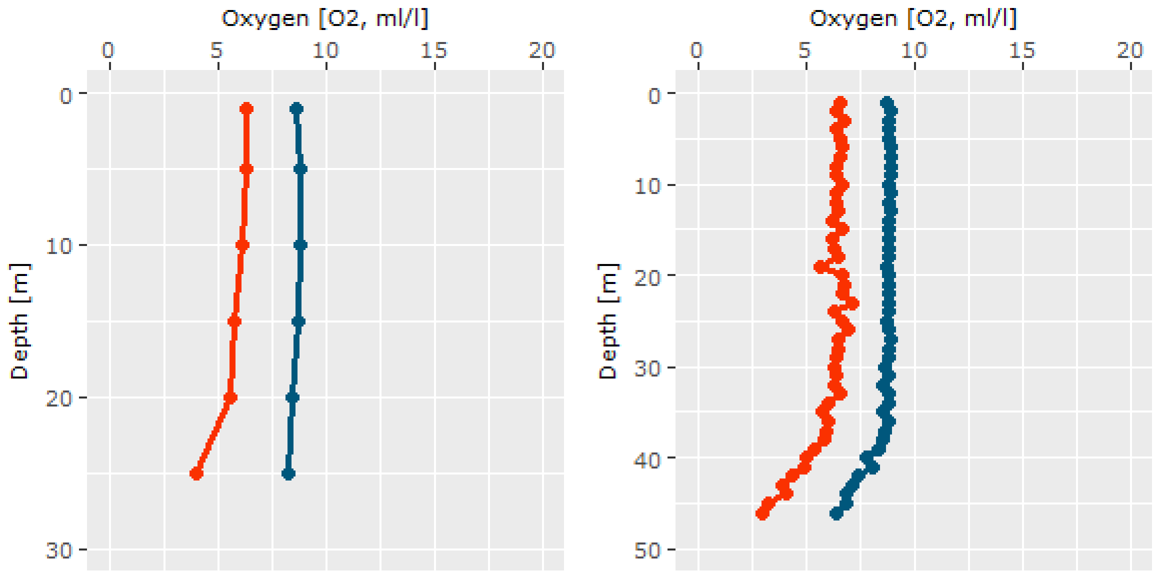

Figure 9-13 Profiles of average summer (red) winter (blue) oxygen concentration for the period 2000-2016 at HELCOM/ICES stations DMU_441 (left) and OMREGION_1 (right).

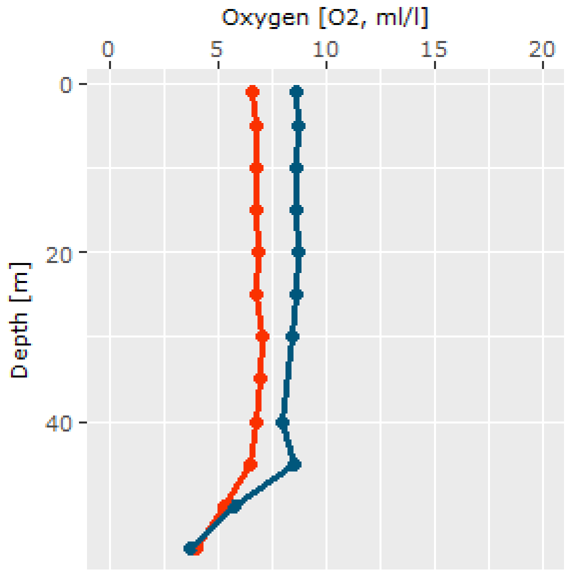

Figure 9-14 Profiles of average summer (red) winter (blue) oxygen concentration for the period 2000-2016 at HELCOM/ICES station FOE-B03.

The solubility of dissolved O_2 depends on the water temperature and, to a lesser degree, on the salinity. With the salinities measured at the three stations, the solubility of O_2 is approximately 9 ml/l at a water temperature of 2^0C, 8 ml/l at 10^0C and 6.5 mg/l at 18^0C.

The oxygen concentration profiles in Figure 9-13 and Figure 9-14 show that in winter, the water column is oxygen-saturated down to approximately 40 m below the water surface. At deeper depths, the oxygen saturation decreases to a level of approximately 3.5 mg/l at 55 m depth below the water surface at station FOE-B03, which corresponds to approximately 45% oxygen saturation. In summer the surface water is oxygen-saturated, and from approximately 10 m below the water surface, the oxygen saturation decreases gradually (an almost constant or decreasing oxygen concentration in water of generally decreasing temperature). At station FOE-B03, the oxygen concentration at 55 m water depth is approximately 3.5 ml/l also in summer, and the oxygen saturation is approximately 40% (due to the *lower* water temperature near the seabed in winter at this station).

The oxygen measurements from the three stations shown in Figure 9-13 and Figure 9-14 indicate that the marine life in the project area do not suffer from hypoxia. It should, however, be noted that the profiles shown are averages for the period 2000-2016; lower oxygen concentrations may therefore occur near the seabed in some years.

Heavy metals and organic pollutants

There has been substantial input of organic contaminants in the Baltic Sea from numerous sources, mainly in the last half of the 20th century. Anthropogenic sources include point sources such as the organochlorines in effluent from pulp and paper mills, run-off from farmland, special paints used on ships and boats, dumped waste and atmospheric deposition. Organic contaminants are usually hydrophilic and quickly adsorb onto fine-grained particles suspended in the water mass, which subsequently are deposited in net accumulation areas in the Baltic Sea (see Section 9.3). The concentrations of organic contaminants in the sediment are therefore generally several orders of magnitude higher than in the overlying water mass (HELCOM, 2001).

Several organic contaminants, such as DDT and technical-grade HCH isomers, have been completely banned since the 1980s. TBT, which belongs to the organotin compounds used as biocides, such as antifouling paints on ships, were banned in 2003 in EU-15 (HELCOM, 2009b). Since the use of TBT was banned, its concentration has been decreasing in the Baltic Sea. TBT compounds are hydrophobic and bind to particles, especially organic matter, and ultimately deposit in sediments (Svavarsson *et al.*, 2001). The available data on concentrations of organic pollutants in the water column are limited and mostly outdated because it has become standard practice to measure organic contaminants and metals in sediment and biota rather than in the water column (Hansen *et al.*, 2018).

The concentration of heavy metals in the Baltic Sea has generally decreased since the 1980s. However, the concentrations are still higher than in Atlantic waters, which are considered less influenced by human activities (Pohl & Hennings, 2009). To compare, the concentrations of dissolved mercury (Hg), cadmium (Cd), lead (Pb), copper (Cu) and zinc in the North Atlantic and in the Baltic Sea is shown in Table 9-7.

Table 9-7 Concentrations of dissolved heavy metals in waters of the North Atlantic and the Baltic Sea measured in the period 1993-2005 (Pohl & Hennings, 2009).

Metal	Concentrations, North Atlantic Ocean [ng/l]	Concentrations, Baltic Sea [ng/l]
Hg	0.15-0.3	0.5-1.5
Cd	4±2	12-16
Pb	7±2	12-20
Cu	75±10	500-700
Zn	10-75	600-1,000

Baseline water quality survey in the project area in 2018

As part of the baseline monitoring for the Baltic Pipe project, water samples for subsequent analysis for chemical parameters have been collected at the 38 sampling positions along the Baltic Pipe route variant shown in Figure 9-15. The distance between the sampling stations did not exceed 20 km.

The monitoring was carried out in Danish waters during the period 24-26 March 2018. Water samples were collected at all stations as surface samples (0.5-1 m below the water surface) and as near bottom samples (up to 2 m from the seabed). In addition, at four sampling stations, water samples were collected at depths of 2.5 m, 5 m, 10 m, 15 m, and thereafter every 10 m from the sea surface to the bottom sample (HCH_04 in Danish waters).

The following parameters were analysed: Salinity, temperature, SSC, transparency, pH, alkalinity, oxygen, 5-day oxygen demand (BOD_5), total organic carbon (TOC), nutrients (N, P), heavy metals (As, Cr, Cd, Pb, Hg and Ni) and organic pollutants (Crude cil derivate hydrocarbons, PAH, PCB) (MEWO S.A. & Maritime Institute in Gdansk, 2017).

In addition to the above results from water sampling and subsequent laboratory analysis, measurements were carried out using a CTD (Conductivity – Temperature – Density), which included sensors for measuring turbidity, oxygen saturation and chlorophyll-*a* (which is a measure of algae concentration).

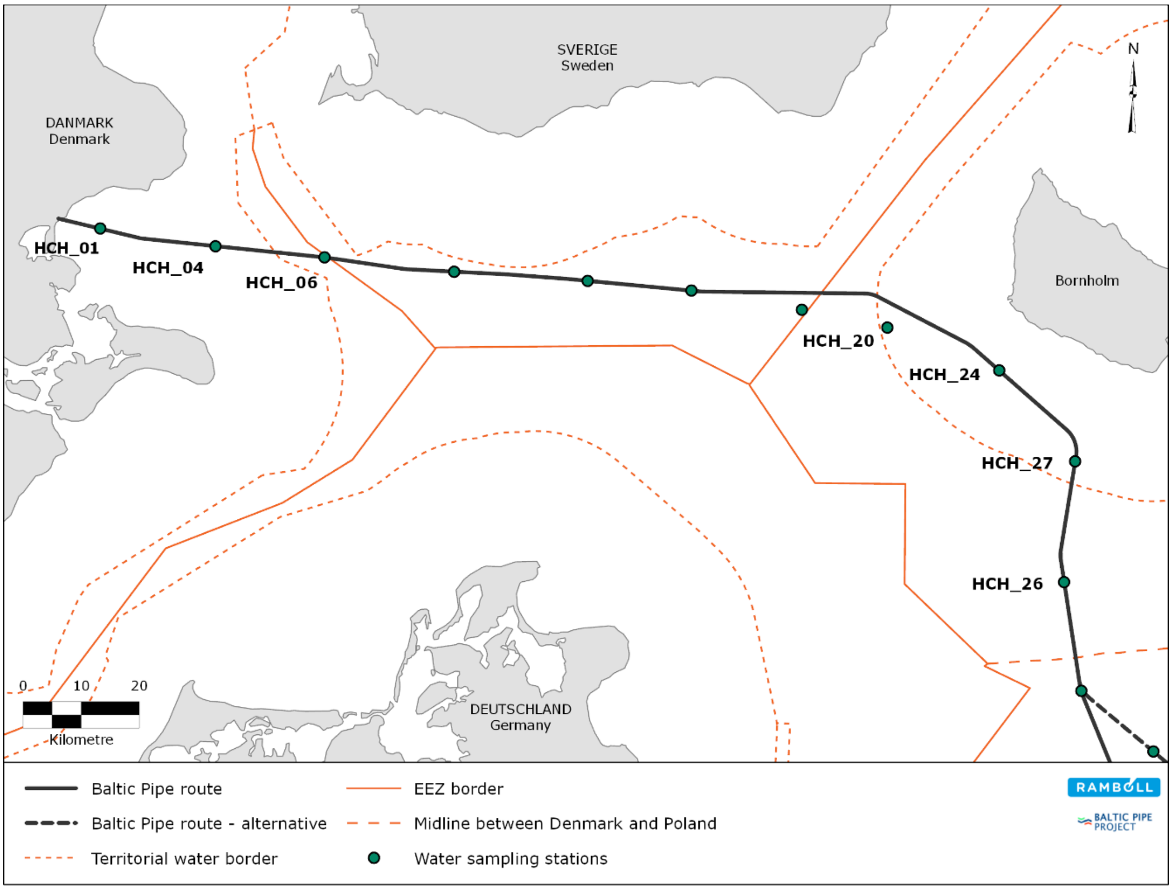

Figure 9-15 Locations of hydro-chemical sampling stations along the Baltic Pipe route variants. Stations in Danish waters are marked with a number.

The monitoring stations in Danish waters include the following (see Figure 9-15): HCH_01, HCH_04, HCH_06, HCH_20, HCH_24 and HCH_27 and HCH_26. The positions and water depths of these stations are shown in Table 9-8. Selected measuring results are presented in Table 9-9. In addition, profiles of water temperature, salinity, turbidity and chlorophyll-*a* are shown in Figure 9-16 to Figure 9-19.

Table 9-8 Coordinates and water depths of water quality monitoring stations in Danish waters. MSL: Mean Sea Level.

Station	UTM 33 [m] (WGS-84 datum)		WGS 84 [DD°MM'SS.SSS"]		Depth [m] (MSL)
HCH_01	323,862	6,117,834	12° 14' 2.445" E	55° 10' 32.488" N	-9.9
HCH_04	343,722	6,114,829	12° 32' 49.937" E	55° 9' 19.405" N	-22.2
HCH_06	362,460	6,112,913	12° 50' 31.132" E	55° 8' 37.463" N	-33.7
HCH_20	459,134	6,100,861	14° 21' 37.102" E	55° 3' 10.322" N	-44.0
HCH_24	478,385	6,093,498	14° 39' 43.923" E	54° 59' 16.479" N	-15.1
HCH_27	491,463	6,077,876	14° 52' 1.341" E	54° 50' 52.507" N	-44.1
HCH_26	489,575	6,057,194	14° 50' 18.210" E	54° 39' 43.262" N	-50.7

Table 9-9 Water quality monitoring results from 24-26 March 2018. The measurements are shown for each station for surface, indicated as S (sampling 0.5-1.0 m below the water surface) and for bottom, indicated as B (less than 2 m from the seabed); the measurements from additional levels are below water surface.

Station-date\ Parameter	Temp ^0C	Salinity psu	SSC mg/l	$N\text{-}NO_3$ mg/l - µmol/l	$P\text{-}PO_4$ mg/l - µmol/l	O_2 mg/l – ml/l
HCH_01 S (26/3)	1.9	7.0	5.0	0.012 / 0.9	0.028 / 0.90	14.0 / 9.8
HCH_01 B (26/3)	1.9	9.8	4.5	0.034 / 2.4	0.015 / 0.48	11.6 / 8.1
HCH_04 S (26/3)	2.3	7.3	< 2	0.035 / 2.5	0.021 / 0.68	13.0 / 9.1
HCH_04 2.5m (26/3)	2.3	7.4	< 2	0.039 / 2.8	0.020 / 0.65	12.6 / 8.8
HCH_04 5m (26/3)	2.5	7.4	< 2	0.037 / 2.6	0.020 / 0.65	12.7 / 8.9
HCH_04 10m (26/3)	2.3	7.6	< 2	0.039 / 2.8	0.021 / 0.68	12.6 / 8.8
HCH_04 15m (26/3)	1.8	8.2	4.7	0.056 / 4.0	0.022 / 0.71	12.5 / 8.8
HCH_04 B (26/3)	2.5	17.4	< 2	0.043 / 3.1	0.015 / 0.48	12.2 / 8.5
HCH_06 S (26/3)	2.4	7.7	< 2	0.025 / 1.8	0.018 / 0.58	13.0 / 9.1
HCH_06 B (26/3)	3.2	21.6	< 2	0.040 / 2.9	0.023 / 0.74	10.6 / 7.4
HCH_20 S (25/3)	2.2	7.9	< 2	0.037 / 2.6	0.021 / 0.68	12.7 / 8.9
HCH_20 B (25/3)	2.2	8.6	< 2	0.061 / 4.4	0.020 / 0.65	12.3 / 8.6
HCH_24 S (25/3)	2.9	7.5	< 2	0.035 / 2.5	0.021 / 0.68	12.8 / 9.0
HCH_24 B (25/3)	2.4	7.8	< 2	0.036 / 2.6	0.020 / 0.65	14.2 / 9.9
HCH_27 S (24/3)	2.9	7.7	< 2	0.009 / 0.6	0.035 / 1.13	12.7 / 8.9
HCH_27 B (24/3)	2.8	7.7	< 2	0.012 / 0.9	0.019 / 0.61	12.8 / 9.0
HCH_26 S (24/3)	2.8	7.5	< 2	0.020 / 1.4	0.028 / 0.90	12.4 / 8.7
HCH_26 B (24/3)	2.7	7.7	< 2	0.018 / 1.3	0.021 / 0.68	12.2 / 8.5

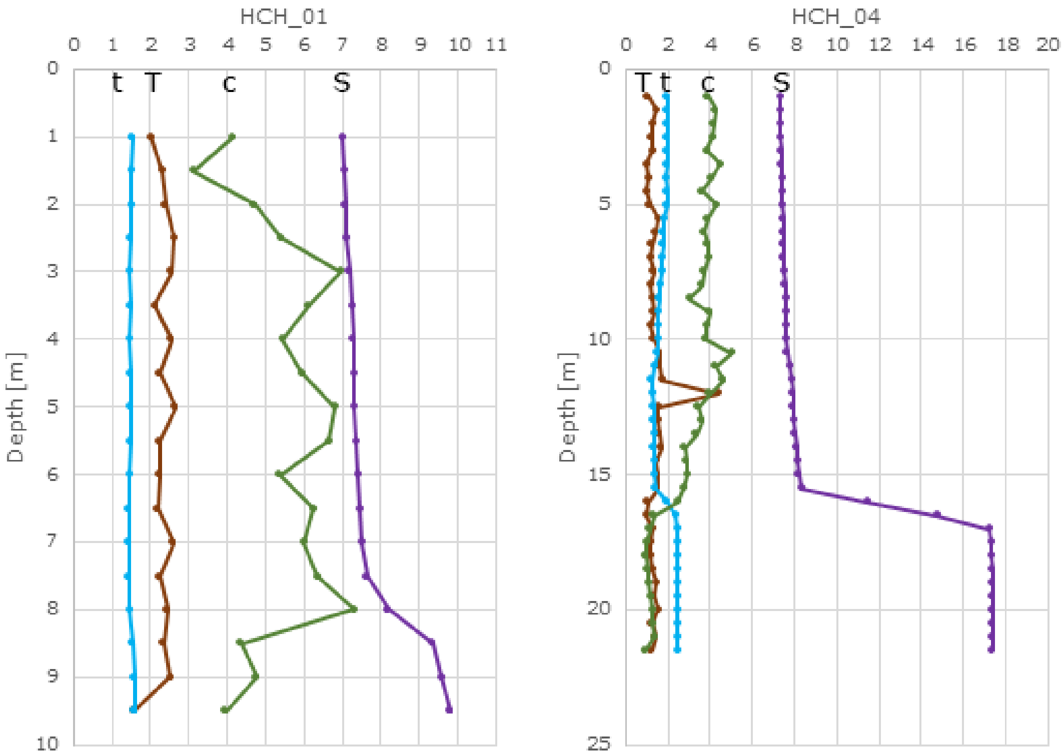

Figure 9-16 HCH_01 (left) and HCH_04 (right): Vertical profile of water temperature (t; ^{0}C), salinity (S; psu), turbidity (T; FTU) and chlorophyll-*a* (c; mg/m^3), measured on 26 March 2018.

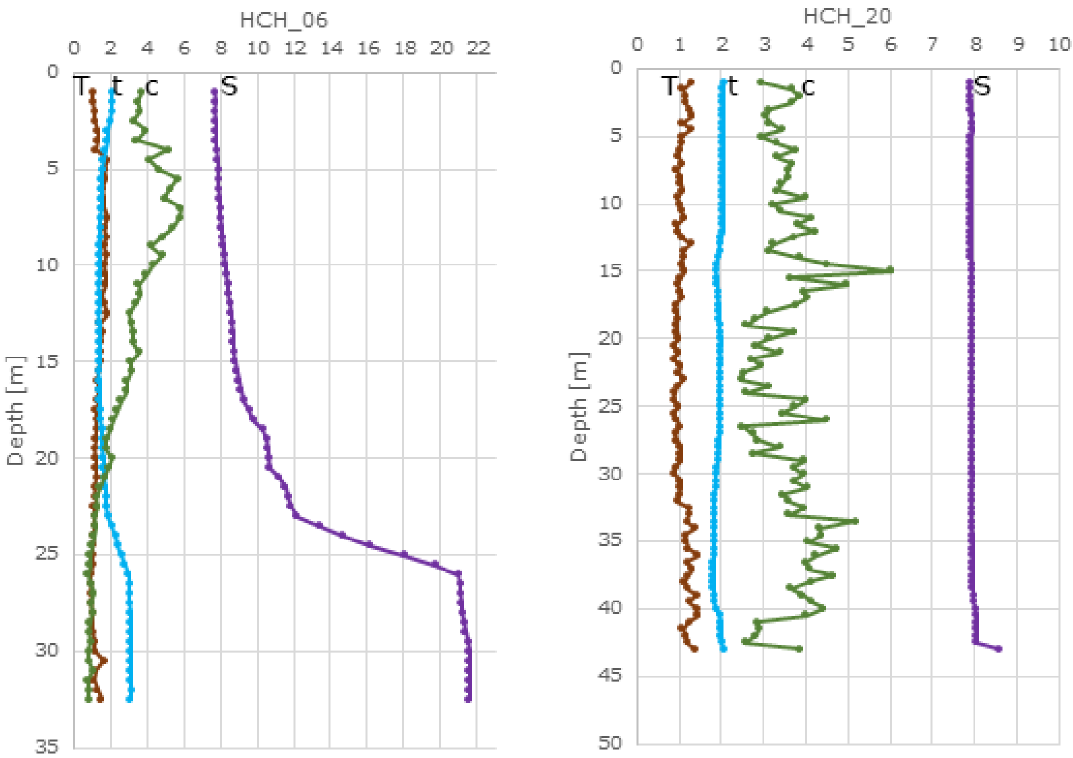

Figure 9-17 HCH_06 (left) and HCH_20 (right): Vertical profile of water temperature (t; ^{0}C), salinity (S; psu), turbidity (T; FTU) and chlorophyll-*a* (c; mg/m^3), measured on 25-26 March 2018.

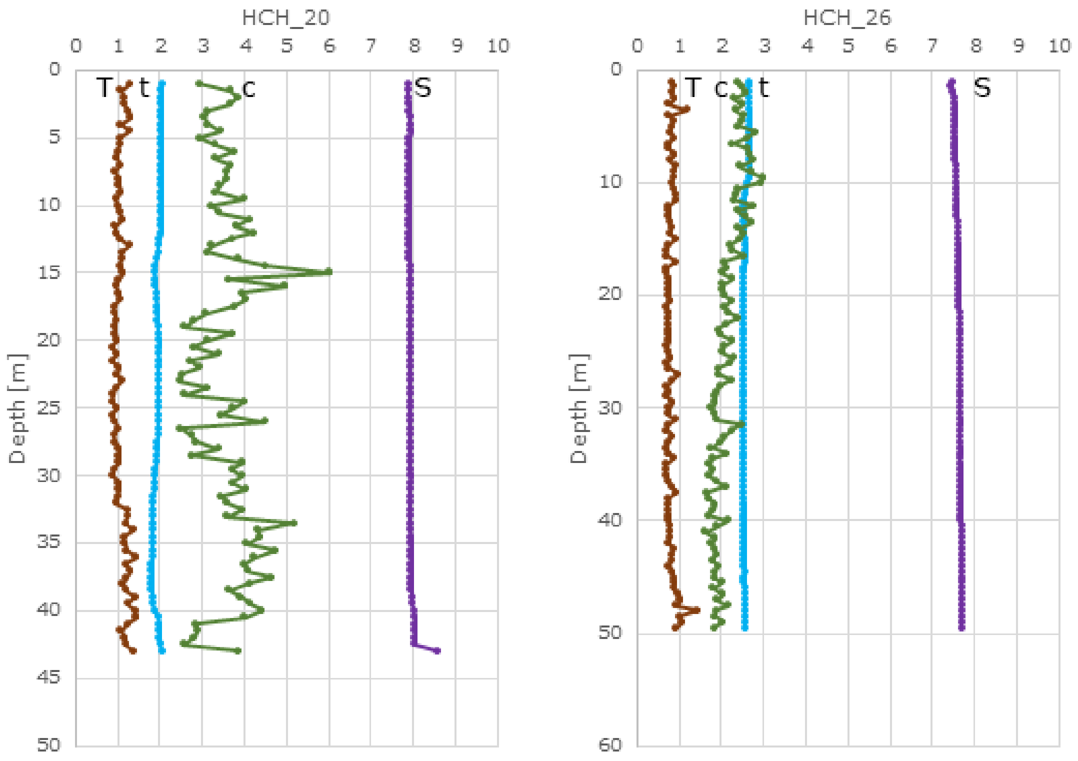

Figure 9-18 HCH_24 (left) and HCH_27 (right): Vertical profile of water temperature (t; ⁰C), salinity (S; psu), turbidity (T; FTU) and chlorophyll-*a* (c; mg/m^3), measured on 24-25 March 2018.

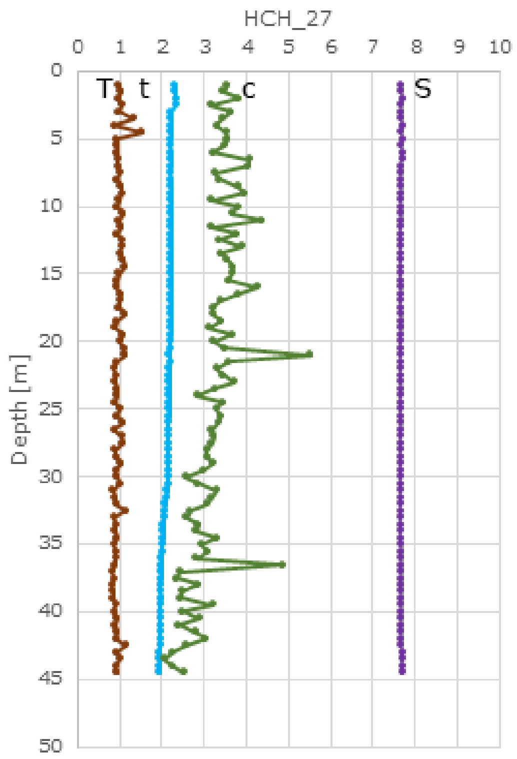

Figure 9-19 HCH_26: Vertical profile of water temperature (t; ⁰C), salinity (S; psu), turbidity (T; FTU) and chlorophyll-*a* (c; mg/m^3), measured on 24 March 2018.

Stratification – water temperature and salinity
The surface salinity measured at all the stations was in the range of 7-8 psu, and the surface water temperatures were in the range of 1.5-2.7^{0}C.

Measurements took place from the most westerly of the stations (HCH_01, HCH_04 and HCH_06) on 26 March 2018. At the station HCH_04 (see Figure 9-16), the salinity increased only slightly from 0 to 16 m below water surface (from 7 to 8 psu), and thereafter a marked halocline existed where the salinity increased from 8 to 17 psu through the depth interval 14-17 m below water surface, below which the salinity was relatively constant down to the seabed 22 m below water surface. The halocline was situated deeper at station HCH_06 (see Figure 9-17), where the salinity increased from 10 to 20 psu through the depth interval 19-26 m below water surface.

Measurements from the stations southwest of Bornholm (HCH_20, HCH_24 and HCH_27 and HCH_26) were carried out on 24-25 March 2018. The surface salinity at all stations was in the range of 7.5-8 psu. The salinities increased only slightly towards the seabed at these stations; at the station HCH_20, the salinity varied from 7.9 psu at the surface to 8.6 psu 43 m below the surface (Figure 9-17), and at HCH_27 (Figure 9-18) and HCH_26 (Figure 9-19) the salinity is even more constant at 7.5-7.7 psu from the surface to the seabed 45 and 50 m below the water surface, respectively.

Comparing with Figure 9-4, the halocline in the area near the landfall (HCH_04, HCH_06) is at a depth of 15-25 m, with the depth to the halocline increasing at the stations located further east. In the area southwest of Bornholm, no halocline was measured at the stations (down to 45-50 m below the water surface).

The surface water temperatures measured at all the stations were in the range of 1.5-2.7^{0}C. At the stations HCH_4 and HCH_6, the temperature of the water above the halocline was in the range of 1.3-2.1^{0}C, and in the range of 2.4-3.1^{0}C below the halocline (see Figure 9-16 and Figure 9-17), i.e. a relatively small vertical difference. At the stations HCH_20, HCH_27 and HCH_26 the temperatures were almost constant with depth; all the measured temperatures at these stations were in the range of 1.8-2.7^{0}C.

The measurements of water temperature and salinity show that a halocline existed at the stations near the Danish landfall, at approximately 15-25 m below the water surface. This corresponds well with the level of the halocline in the Arkona Basin as shown in Figure 9-6 and Table 9-6. At the stations southwest of Bornholm, neither a halocline nor a thermocline existed. When the surface waters warm up during spring-summer, a thermocline will develop, as shown in the right part of Figure 9-4.

Suspended sediments and turbidity
The water sampling carried out 24-26 April 2018 showed that the SSC was below 2 mg/l both near the water surface and near the seabed (see Table 9-9). An exception was the station closest to the coast of Sjælland (HCH_01), where the SSC was 4.5-5.0 mg/l, probably due to the low water depth (10 m) and the closeness to the coast, i.e. sediments suspended from coastal erosion and resuspension of seabed sediments from shallow-water areas influenced the water quality. Another exception was station HCH_04, where SSC was measured at 4.7 mg/l at a depth of 15 m below the water surface. This coincided with the halocline, and the high SSC likely reflected organic / fluffy matter (e.g. dead algae) floating on top of the denser saline water below the halocline.

The turbidity measurements are given in the unit FTU (Formazine Turbidity Unit), which is a unit proportional to the SSC for a given sediment type; conversion from FTU to mg/l is, however, sensitive to the grain size distribution and other characteristics of the suspended sediments. The measurements related to the three water samples with SSC of 4.5-5.0 mg/l showed turbidity values in the range of 2.0-4.5 FTU, indicating that 1 FTU corresponded to approximately 1 mg/l during this measuring campaign.

The turbidity profiles showed the highest values (1.6-2.7 FTU) at the station HCH_01, where the highest SSC was also measured. The increased SSC at the top of the halocline at HCH_04 was also visible in the turbidity profile. Apart from these instances, the turbidity was low, in the range of 1-2 FTU at the stations near the Danish landfall and in the range of 0.7-1.3 FTU at the stations southwest of Bornholm.

The measurements confirm the range of natural background SSC and turbidity in calm weather, as outlined in the section on suspended sediments above.

<u>Nutrients and oxygen conditions</u>
At all the measuring stations, the oxygen saturation was above 95% at all levels during the campaign carried out on 24-26 March 2018. This was expected, as oxygen depletion typically occurs in late summer to early autumn.

The chlorophyll-*a* concentration at the stations near the Danish landfall (HCH_01, HCH_04 and HCH_06) were in the range of 3-7 mg/m^3 above the halocline (see Figure 9-16 and Figure 9-17), down to a depth of approximately 15 m below the water surface. This corresponds to the photic zone in which phytoplankton growth takes place. Below the halocline, the concentration was approximately 1 mg/m^3.

At the stations southwest of Bornholm (HCH_20, HCH_24, HCH_27 and HCH_26; see Figure 9-17, Figure 9-18 and Figure 9-19) the chlorophyll-*a* was more evenly distributed in the water column, with the highest values at HCH_20 and HCH_27 (2-6 mg/m^3), and the lowest values at HCH_24 and HCH_26 (1-3 mg/m^3).

The measurement results for concentrations of PO_4-P and (NO_3-N) are shown in Table 9-9. The concentration of phosphate phosphorus was in the range of 0.5-1.1 µmol/l, which is in line with the typical winter concentrations in the area (see Figure 9-10 and Figure 9-11). The concentration of nitrate nitrogen was in the range of 0.6-4.4 µmol/l, with large differences between the stations. When comparing with Figure 9-10 and Figure 9-11, the values measured in March 2018 are in between the winter and summer profiles. The measurements show that the spring bloom has started, and therefore, part of the pool of dissolved nutrients has been taken up by the algae.

9.2.2 Impact assessment

The construction of the Baltic Pipe pipeline may interfere with the hydrography and water quality within Danish waters during both construction and operation. See Table 9-10 for an overview of the potential impacts.

Table 9-10 Potential impacts on hydrography and water quality.

Potential impact	Construction	Operation
Suspended sediments	X	
Contaminants and nutrients	X	
Discharges to sea	X	
Presence of pipeline		X
Heat from pipeline		X
Release of contaminants from anodes		X

Suspended sediments

As outlined in Section 5.1.2, Suspended sediments and sedimentation, sediments will be spilled to the water column as a consequence of the construction activities. This will temporarily and locally cause the SSC and the turbidity of the water to increase, i.e. a change to the water quality is introduced.

In order to assess the impacts caused by sediment spill, the dispersion of the mobilised sediments has been modelled using the numerical modelling system MIKE 3. The results of the modelling are shown in Section 5.1.2, Suspended sediments and sedimentation. The results presented in Figure 5-2, Figure 5-3 and Figure 5-4 show the duration for which the increase in SSC caused by the construction works exceeds 10 mg/l for various areas along the pipeline route. The value SSC = 10 mg/l corresponds to the level which is naturally exceeded in the area during and shortly after rough weather conditions (see "Suspended sediments" in Section 9.2.1).

The exceedance of the SSC = 10 mg/l value primarily takes place because of trenching using back-hoe dredgers at less than 12 m water depth, as visible in Figure 5-3. This value is only exceeded for more than a few hours in isolated areas close to the pipeline route, and in no location is the value exceeded for more than 4 days.

As outlined in Section 9.2.1, Baseline, the SSC varies naturally with the time of the year and with the hydrographic conditions. The relatively localised and short-term increases in SSC caused by sediment spill as a result of the Baltic Pipe construction activities are comparable to increases that naturally take place in periods of rough weather due to coastal erosion and the resuspension of seabed sediments.

The water quality is only affected temporarily and locally by the increased SSC/turbidity caused by the construction works; the SSC/turbidity conditions will revert naturally and rapidly to pre-impact status once the activities cease. Therefore, the sensitivity is considered low.

The intensity of the impact is classified as minor, and the spatial scale is classified as local/regional (due to the fact that increased SSC can occur up to a few km from the construction site). The duration is considered immediate, i.e. closely linked to the duration of the construction activities. This leads to classifying the severity of the impact as minor and the impact as not significant (see Table 9-11).

Table 9-11 Impact significance on hydrography and water quality from suspended sediment.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Suspended sediments	Low	Minor	Local/regional	Immediate	Minor	Not significant

Contaminants and nutrients
Seabed sediments include varying concentrations of sediment-associated contaminants and nutrients, both associated with the sediment particles themselves (incorporated into the particle or adsorbed to the particle surface) and with the sediment pore water. The concentrations of these substances along the pipeline route are outlined in Section 9.3, Surface sediments and contaminants.

The average concentrations of heavy metals in the seabed sediments along the pipeline route are shown in Table 9-19, where sediment quality criteria are also shown where applicable. In general, the concentrations are below the quality criteria, i.e. they can be considered as unpolluted sediments. At one of the stations, (GCH51), the concentrations of Pb and Cu were approximately 20% above the ERL (Effect Range Low; explained in Section 9.3). The seabed sediments at this station consist entirely of clay and silt, and the concentration of particulate organic matter is several times larger than at any of the other stations (see Section 9.3, Surface sediments and contaminants). Therefore, the adsorption capacity is very high, and a higher concentration of contaminants is therefore expected at this station due to the sediment characteristics. Also, the concentrations of organic contaminants were in line with the general levels in the Baltic Sea; no contaminant "hot spots" were identified along the pipeline route.

The concentrations of the nutrients N and P follow the same pattern, with the highest concentrations in the deep areas where net accumulation of fine-grained sediments with a high organic content takes place.

The average concentrations of contaminants and nutrients are shown in Table 5-3. The total sediment spill from the construction works in Danish waters has been estimated to be 38,000 tonnes (see Table 5-2). The total amounts of the various contaminants and nutrients in the spilled sediments have been calculated, by multiplying the average concentrations with the total spill. These values are also shown in Table 5-3.

Only a fraction of the contaminants and nutrients in the spilled sediments will be released to the water column; the rest will stay associated with the sediment particles and return to the seabed. Moreover, only a part of the released substances will be bioavailable, on the order of magnitude of 10% (see Section 5.1.3, Contaminants and nutrients).

The concentrations of contaminants and nutrients in the seabed sediments along the pipeline route are in general below the various relevant quality criteria, i.e. the concentrations are what is normal for unpolluted areas in the Baltic Sea. Therefore, the release of contaminants and nutrients caused by the sediment spill from the construction activities are comparable with other activities and conditions which cause resuspension of seabed sediments. This includes e.g. bottom trawling and natural re-suspension of seabed sediments during rough weather.

The total mass of nutrients in the spilled sediments have been found to be approximately 59 tonnes N and 18 tonnes P. This can, for comparison, be compared with the yearly input to the Baltic Sea of approximately 825,000 tonnes N and 32,000 tonnes P. Moreover, only a fraction of the nutrients in the spilled sediments will be released to and be bioavailable in the water column.

Based on the above, the water quality can potentially only be affected very locally and temporarily by an increase in the concentrations of contaminants and nutrients caused by the construction works, as the concentrations will revert naturally and rapidly to pre-impact status once the activities cease. The contaminants and nutrients in the spilled sediments will rapidly be diluted, and a large fraction of these will settle to the seabed again, adsorbed to or incorporated into particles. A proportion will, however, contribute to the overall inventory within the Baltic Sea water. Due to the small and temporary increases in concentrations, which will rapidly revert to background conditions once the construction activities cease, the sensitivity is classified as low.

The intensity of the impact is classified as minor, and the spatial scale is classified as local/regional (due to the fact that increased concentrations can occur up to a few km from the construction site). The duration is considered immediate, i.e. closely linked to the duration of the construction activities. This leads to classifying the severity of the impact as minor and the impact as not significant (see Table 9-12).

Table 9-12 Impact significance on hydrography and water quality from contaminants and nutrients.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Contaminants and nutrients	Low	Minor	Local/regional	Immediate	Minor	Not significant

Discharges to sea

The planned scenario for wet pre-commissioning is outlined in Section 3.9, Pre-commissioning and in Section 5.1.11, Discharges to sea. It includes a discharge of a maximum of 374,000 m^3 treated seawater into Faxe Bugt. This maximum will be discharged only if it is necessary to repeat the pressure test. The most likely scenario includes only one flooding; in that case the discharge will be approximately 187,000 m^3.

As noted in Section 3.9, Pre-commissioning, the chemicals that may be used in the pressure test water are classified as PLONOR, i.e. causing little or no harm to the environment. The discharge water will be devoid of oxygen, but when the water is diluted 1-2 times with the receiving seawater, the oxygen content will increase to above 4 mg/l and therefore will not affect marine life (see Section 9.2.1).

The discharge of treated pressure test water to sea will take place with a current velocity within the pipe of 0.5-0.7 m/s, resulting in a discharge to sea of approximately 0.30-0.42 m^3/s through a diffuser. Experience form comparable projects has shown that the dilution of the discharged water will ensure that the oxygen conditions are above 4 mg/l within 10-30 m of the discharge point, depending on the hydrographic conditions (Rambøll / Nord Stream 2 AG, 2017b).

The water quality is only impacted temporarily and locally by the decrease in oxygen concentration caused by the discharge of pressure test water; the concentrations will revert naturally and rapidly to pre-impact status once the activities cease. Therefore, the sensitivity is classified as low.

The intensity of the impact is classified as minor, and the spatial scale is classified as local. The duration is considered immediate, i.e. closely linked to the duration of the discharge of pressure test water (during up to in total approximately 14 days). This leads to classifying the severity of the impact as minor and the impact as not significant (see Table 9-13).

Table 9-13 Impact significance on hydrography and water quality from discharges to sea.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Discharges to sea	Low	Minor	Local	Immediate	Minor	Not significant

Release of contaminants from anodes
As outlined in Section 3.3.3, On-bottom stability and coating design and Section 5.2.5, Release of contaminants from anodes, the anodes provide a backup protection system in case of damage to the pipeline coating. Therefore, only a small proportion of the anode materials is expected to be dissolved during the lifetime of the pipeline. The consumption of anode alloy has been calculated to be a maximum of 495 kg/km, which for the part of the route through Danish waters (137.6 km) corresponds to approximately 68.1 tonnes.

With the distribution of elements shown in Table 3-4, this corresponds to the following amounts of each metal (taking the max in the intervals shown):

Al: 64 tonnes (94.00%)
Zn: 3.9 tonnes (5.75%)
In: 20 kg (0.030%)
Cd: 1.4 kg (0.002%)
Fe: 61 kg (0.090%)
Cu: 2.0 kg (0.003%)
Si: 82 kg (0.12%)

The potential release of 1.4 kg of Cd during the 50-year design life of the pipeline corresponds to 0.028 kg/year. When comparing with the estimated yearly water-borne input to the Baltic Sea of approximately 48 kg (HELCOM, 2011), the potential annual input from the Baltic Pipe is approximately 0.06% of this amount. As mentioned above, this is a theoretical maximum, however, as the sacrificial anodes act as a back-up system only in the rare event of damage to the pipeline coating. The actual release will therefore only be a small fraction of the above-described potential release.

As outlined in Section 5.2.5, Release of contaminants from anodes, monitoring in connection with a comparable pipeline project in the Baltic Sea has shown that the concentrations of heavy metals are below the detection limit within 1-2 m from the pipeline anodes.

The intensity of the impact is classified as minor, and the spatial scale is classified as local. The duration is considered long-term, as it will continue at least during the operational life of the pipeline. This leads to classifying the severity of the impact as minor and the impact as not significant (see Table 9-14).

Table 9-14 Impact significance on hydrography and water quality from the release of contaminants from anodes.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Release of contaminants from anodes	Low	Minor	Local	Long-term	Minor	Not significant

Presence of pipeline
The possible impact of the presence of the Nord Stream pipelines on the inflow of more saline water through the Danish straits has been analysed both for the two Nord Stream pipelines (SMHI, 2009) and for the two Nord Stream 2 pipelines (Stigebrandt, 2016). These pipelines are larger (48'') than the Baltic Pipe pipeline (36''). The existing Nord Stream and the planned Nord Stream 2 pipeline routes are not the same as the Baltic Pipe route, but none of the pipeline routes are situated at any sill crests controlling the inflow to the Baltic Sea.

Even though the location of the Baltic Pipe differs from the location of the Nord Stream pipelines, the mechanisms causing possible impacts are the same. The possible impacts caused by the pipeline on the flow of new deep-water into the Baltic Proper and thereby changes in hydrography are the following (Stigebrandt, 2016):

- Changed vertical mixing in the water column, which would also change volume flow and salinity of deep-water flowing into the Baltic Proper;
- Increased blocking of flow if the pipeline increases the height of topographic crests (sills) that already block the flow; and
- Creation of a local dam, which collects denser water that may possibly stay so long that the water in the dam becomes anoxic, leading to leakage of phosphorus from the seabed.

The analysis for the Nord Stream and Nord Stream 2 pipelines showed increased mixing during inflows to the Baltic Proper in the range of 0.0-0-4%, resulting in an increased bottom current flow of 0-86 m^3/s and a decreased salinity of the bottom water of 0-0.008 psu, and an increased oxygen transport of 0-1 kg/s (Stigebrandt, 2016). Because the Baltic Pipe consists of only one pipeline, with a smaller diameter than the Nord Stream pipelines, the above insignificant (positive) impact on the oxygen conditions is expected to be even smaller for the Baltic Pipe project.

For the four Nord Stream pipelines, the positive effect of increased oxygen supply due to possible increased mixing was found to be counteracted to some extent by the possible increased phosphorus release from the pipeline dam effect at the water depth interval of 40-80 m. The estimated phosphorus flux caused thereby was found to be 0–26 tonnes P per year, which was considered insignificant compared to the ongoing leakage from anoxic bottoms (the internal load) which has been estimated at approximately 90,000 tonnes P per year (Stigebrandt, 2016). The Baltic Pipe consists of only one pipeline, with a smaller diameter than the Nord Stream pipelines, and only a small portion of the route are below 40 m water depth. Therefore, the possible dam impact caused by the Baltic Pipe is expected to be insignificant.

The intensity of the impact is classified as minor, and the spatial scale is classified as local. The duration is considered long-term, as it will continue at least during the operational phase of the pipeline. This leads to classifying the severity of the impact as negligible and the impact as not significant (see Table 9-15).

Table 9-15 Impact significance on hydrography and water quality from change of hydrodynamics.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Presence of pipeline	Low	Minor	Local	Long-term	Negligible	Not significant

Heat from pipeline

The gas temperature within the pipeline will vary along the route. The gas temperature is expected to be approximately 50⁰C at the Danish landfall and close to the ambient water temperature at the Polish landfall (for the normal flow situation; from Denmark to Poland). The difference in temperature between the gas in the pipeline and the surrounding water and sediments will cause the exchange of heat between the gas and the surrounding seabed through the pipeline walls. The magnitude of this impact is outlined in Section 5.2.3, Heat from pipeline.

The intensity of the impact is classified as minor, and the spatial scale is classified as local. The duration is considered long-term, as it will continue at least during the operational phase of the pipeline. This leads to classifying the severity of the impact as negligible and the impact as not significant (see Table 9-16).

Table 9-16 Impact significance on hydrography and water quality from heat from the pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Heat from pipeline	Low	Minor	Local	Long-term	Negligible	Not significant

9.2.3 Conclusion

The potential impacts on hydrography and water quality resulting from the construction and operation of the proposed pipeline in Danish waters are summarised in Table 9-17.

Table 9-17 Overall impact significance for hydrography and water quality.

Potential impact	Severity of impact	Significance	Transboundary
Suspended sediments	Minor	Not significant	No
Contaminants and nutrients	Minor	Not significant	No
Discharges to sea	Minor	Not significant	No
Release of contaminants from anodes	Minor	Not significant	No
Presence of pipeline	Negligible	Not significant	No
Heat from pipeline	Negligible	Not significant	No

9.3 Surface sediments and contaminants

9.3.1 Baseline

Geology

The Baltic Sea is located on the Eurasian continental shelf and is almost completely enclosed by landmasses made up by the European mainland and the Scandinavian peninsula (Snoeijs-Leijonmalm & Andrén, 2017). The crystalline basement is of the Precambrian age, and this is made up of Archean granulite, amphibolites and paleoproterozoic zones of granite and granite-gneisses (Ūsaityté, 2000).

Most of the bottoms of the Baltic Sea are made up of low- or unmetamorphosed sedimentary rocks beneath a cover of Quaternary deposits. While the surrounding bedrock in Sweden and Finland is almost two billion years old, in the Baltic States, Poland, Germany and Denmark, the crystalline bedrock is covered by Phanerozoic sedimentary rocks as are also the bottoms of the Baltic Sea. The magnitude of the seismicity in the Baltic Sea region is generally low, well below M=6 on the Richter scale (Beckholmen & Tirén, 2009).

The Baltic Sea is a relatively young ocean. During the latest glaciation event, the Baltic Sea area was covered by an icecap. As the ice retreated, a dammed-up ice lake was formed in the area west of Bornholm, and then later the Baltic Sea was formed as a brackish ocean with passage to the Great Belt and Kattegat (GEUS, 2002).

The late glacial and post-glacial development that shaped the present Baltic Sea was governed by interaction between eustatic sea level rise and isostatic rebound, i.e. the water level of the oceans, and the post-glacial uplift of Scandia. The latter is the rise of land masses that were depressed by the huge weight of ice sheets during the last ice age. Melting of the Earth’s ice sheets caused a 120-m sea level rise, whereas the isostatic rebound after the heavy load of the ice sheet on Scandinavia is still ongoing, by up to approximately 9 mm per year in the northern part of the Baltic Sea to approximately 0 mm in the southern part (Snoeijs-Leijonmalm & Andrén, 2017).

Characterisation of the seabed
In the southwestern part of the Baltic Sea where the Baltic Pipe will pass through, the seabed is covered with approximately 1 m of quaternary sediment, formed from the latest ice age (GEUS, 2002). Generally, the seabed surface sediments consist of material supplied from erosions of coast or seabed as well as organic matter, shells and other elements originating from production in the ocean (Geocenter Danmark, 2014). In the area of the Baltic Pipe route, the sediment mainly consists of fine and medium-grained sand in the shallow areas, silt in the deeper areas and coarse sand and gravel along the coastline (Bobertz et al, 2005).

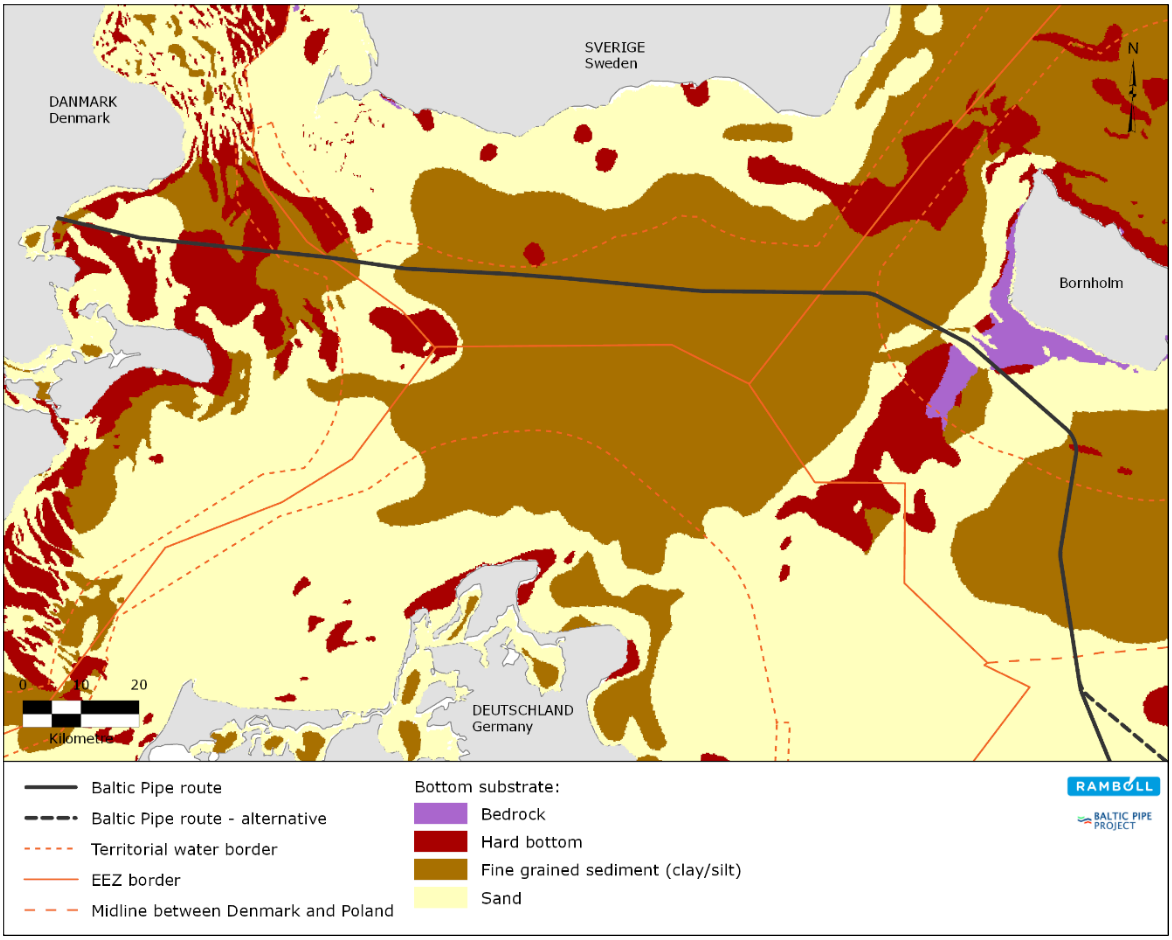

Figure 9-20 Seabed sediment distribution in the southern Baltic Sea (BALANCE, 2013).

The Baltic Pipe will mainly pass through areas of mud, sand, and hard bottom in the Danish section. The distribution of sediment on the seabed is controlled by sediment transport. Sediment will be transported across the seabed by currents and waves. The fine-grained sediment is more easily transported than coarser sediment (Geocenter Danmark, 2014). Fine grained sediment such as silt and clay will accumulate in the deeper parts of the ocean, such as the Arkona Basin west of Bornholm and the Bornholm Basin south of Bornholm. On Figure 9-20, it can be seen that in shallow waters along the Baltic Pipe route, the seabed will mainly be covered with sand with patches of hard bottom. In the deeper waters, the seabed is covered with mud, which is fine-grained and has a higher content of organic matter compared with the rest of the sediment on the route. The typical sediment net accumulation rates in these areas are in outlined in Section 9.2.1.

Seabed sampling and analysis

As part of the baseline monitoring for the Baltic Pipe project, a geochemical survey was performed, and sediment samples were collected in February and March 2018. Sediment was collected from 75 survey stations, of which 14 stations were in the Danish section of the Baltic Pipe route (see Figure 9-21).

The surface sediment from each survey station was sampled using a van Veen grab. The sediment was analysed for several contaminants as well as different sediment properties such as Total Organic Carbon (TOC), Loss on Ignition (LOI) and grain size distribution.

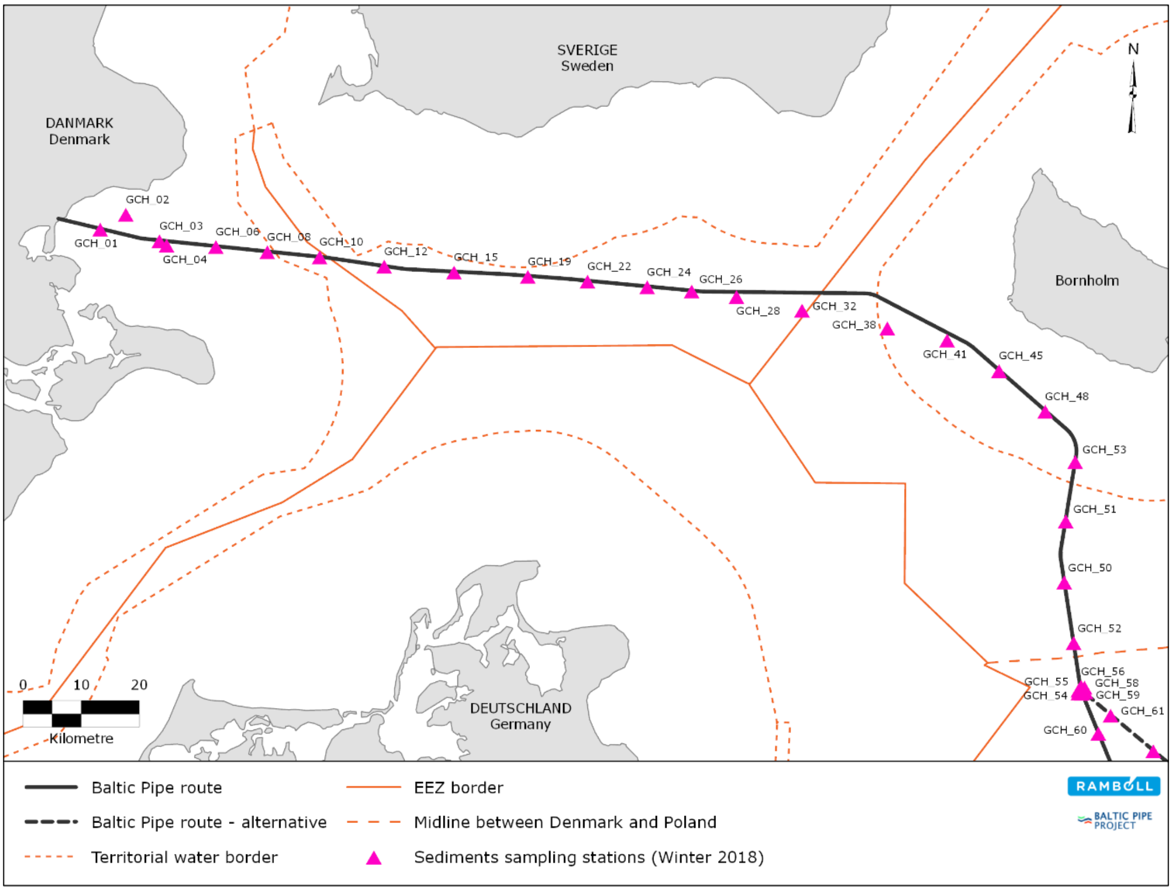

Figure 9-21 Location of geochemical survey stations along the Baltic Pipe route.

Due to route optimizations, the selected and assessed route is situated slightly north of the sediment survey stations. As the distances between the route and the survey stations are short, significant differences in sediment properties and contaminant levels are not likely, and hence the data are considered representative.

Sediment properties

The results of the analysis for TOC, LOI and grain size distribution are presented in Table 9-18 along with water depths at the sampling positions. LOI and TOC are both parameters that indicate the content of organic matter in the sediment, and they are therefore also important in relation to the contaminants, as many contaminants preferably bind to the organic content in the sediment.

The grain size is also of importance in relation to contaminants, as sediment with a smaller grain size will have a larger surface area than more coarse sediment. Sediments with grain sizes

<0.063 mm are referred to as silt (0.063-0.002 mm) or clay (<0.002 mm), whereas sediment with grain sizes between 0.063 mm and 2 mm is referred to as sand. Sediment with grain sizes >2 mm is referred to as gravel or cobble.

Table 9-18 Water depths and the sediment properties TOC, LOI and percent silt/clay, sand and gravel/cobbles at the survey stations in the Danish section.

Station	Depth	Silt/clay	Sand	Gravel / cobbles	TOC	LOI
Unit	[m]	[%]	[%]	[%]	[mg/kg]	[%]
GCH01	-9.9	0.8	75.3	23.9	83	0.26
GCH02	-11	55.2	44.8	0.0	130	0.27
GCH03	-11	2.8	97.1	0.1	17	0.26
GCH06	-22	2.0	98.0	0.0	31	0.19
GCH08	-27	77.4	22.6	0.0	2,400	1.5
GCH10	-34	93.3	6.7	0.0	2,800	1.7
GCH38	-44	88.9	11.1	0.0	24,000	5.3
GCH41	-28	1.0	98.8	0.2	38	0.28
GCH45	-15	0.8	96.9	2.3	100	0.48
GCH48	-17	0.2	99.7	0.1	44	0.33
GCH53	-44	90.8	9.2	0.0	2,400	2.2
GCH51	-53	100	0.0	0.0	140,000	12
GCH50	-51	98.7	1.3	0.0	11,000	2.5
GCH52	-42	93.7	6.3	0.0	1,500	1.1

The distribution of sediments in Table 9-18 are roughly divided between fine sediment (silt/clay), sediment with an intermedia grain size (sand) and more coarse sediment (gravel/cobbles).

As it can be seen in Table 9-18, the level of organic matter in the sediment is correlated with water depth, which furthermore is illustrated in Figure 9-22.

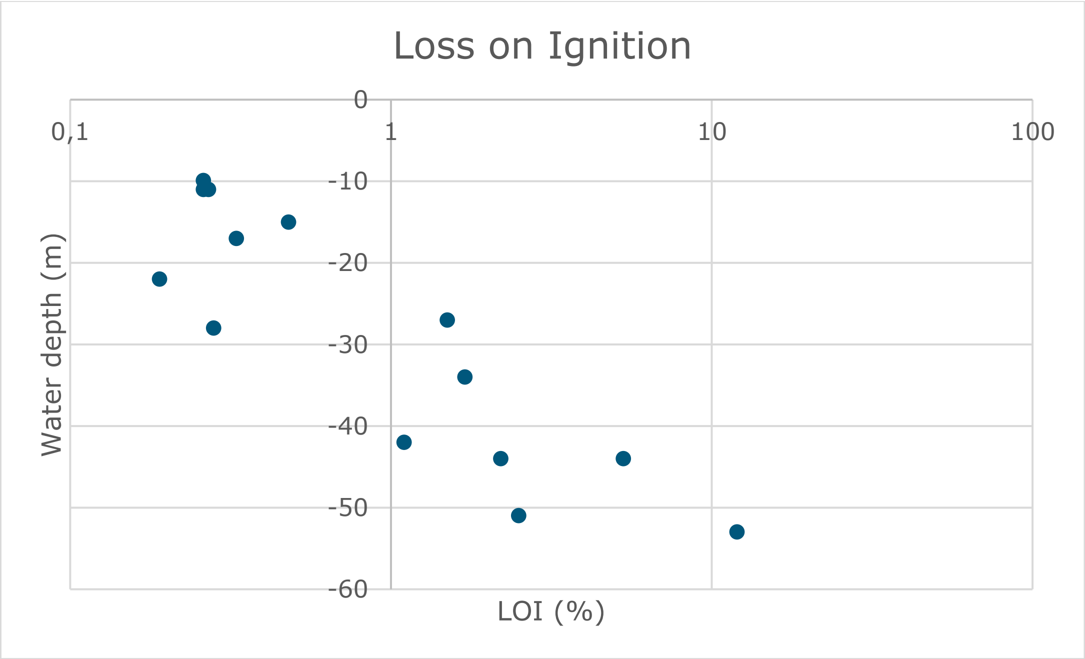

Figure 9-22 Loss on Ignition (LOI) as a function of water depth shown for the samples presented in Table 9-18. Note that LOI is illustrated on a logarithmic scale.

Figure 9-22 presents LOI as a function of water depth, and as it can be seen in the figure, the LOI is largest at the deeper parts of the pipeline route.

Figure 9-23 presents the different sediment types along the pipeline route, based on the survey data.

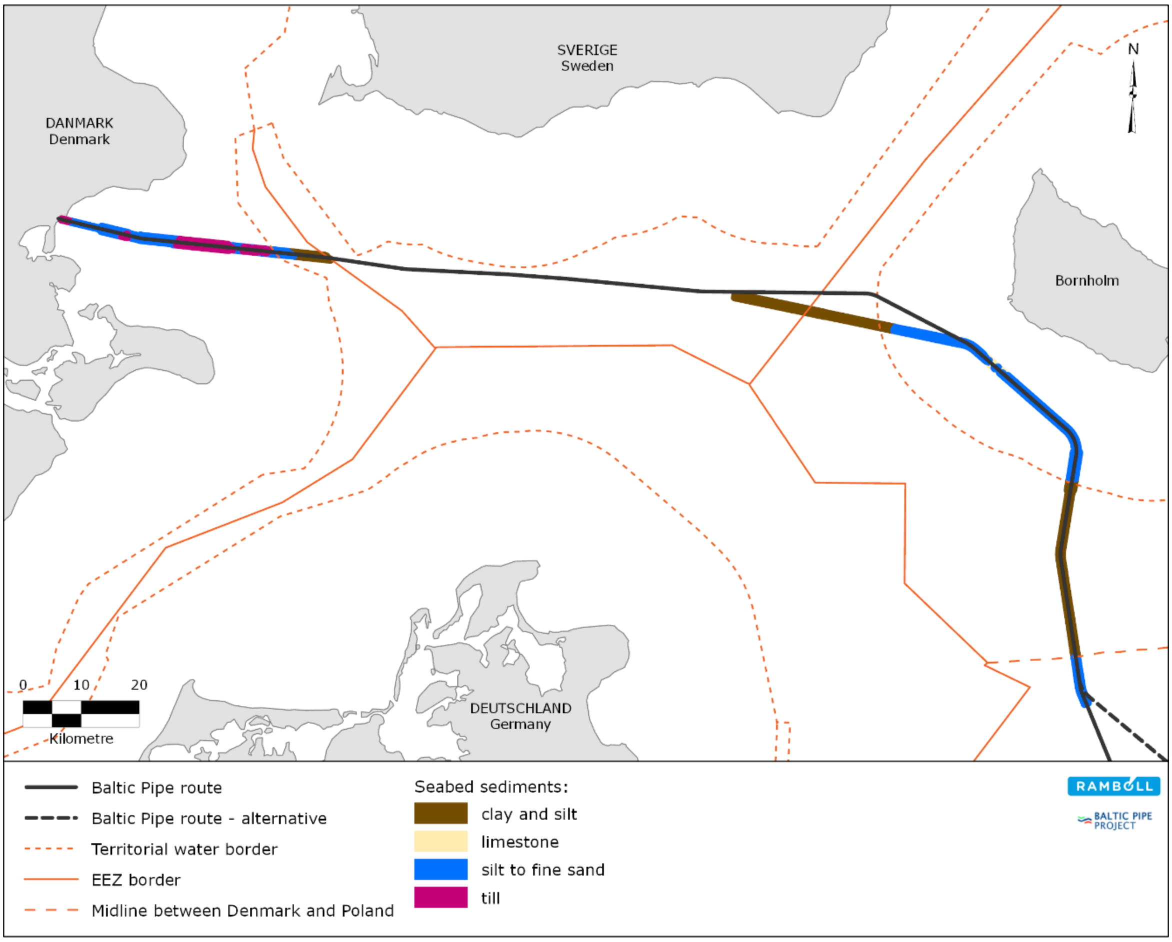

Figure 9-23 Distribution of sediment types along the Baltic Pipe route. The sediment types are estimated based on the survey data.

When comparing Table 9-18 and Figure 9-23, it can be seen that in the shallow areas, the surface seabed sediment mainly consists of sandy sediments and till, whereas the sediment in the deeper areas in the Arkona Basin and in the Bornholm Basin mainly consists of silt/clay with a high level of organic matter. This is because the deeper parts of the Baltic Sea are typically net accumulation areas for fine-grained sediments with a high organic content.

Contaminants

Contaminants enter the Baltic Sea via different routes such as outputs from industrial activities, wastewater treatment plants, waste deposition (e.g. sediment dumping) and atmospheric deposition (HELCOM, 2017b). The Baltic Sea has been exposed to contaminants since the beginning of industrialization, and it has been referred to as the most polluted ocean in the world (HELCOM, 2010a).

In general, heavy metals and organic contaminants will be bound to the sediment, and only a smaller fraction will be dissolved in the water phase. To a large extent, heavy metals and organic contaminants will adsorb to the organic content of the sediment. Furthermore, fine-grained sediment will adsorb larger amounts of contaminants then more coarse sediment, as the surface area is larger. Moreover, the surfaces of clay minerals and organic particles have a negative charge and, therefore, a large capacity to adsorb cations. Therefore, the fate of the contaminants in the Baltic Sea is closely related to the fate of the fine-grained suspended sediments, as outlined in Section 9.2.1.

Settled sediments (with their associated contaminants) may be resuspended after initial sedimentation to the seabed, and a proportion of the contaminants may become dissolved during resuspension events. The contaminated sediments may be subject to resuspension caused by currents, waves, bioturbation, trawling, etc. The resuspension events mix the top sediment and facilitate long-distance transport, depending on the physical conditions, sediment characteristics, etc. Eventually, most of the transported fine-grained sediments and associated contaminants end up in net accumulation areas for fine-grained sediments, located primarily in the deep parts of the Baltic Sea, in areas classified as "Fine-grained sediment (clay/silt)" in Figure 9-20.

The levels of contaminants can potentially be above the background level at the sediment dumping sites. Here, sediment from contaminated sites such as harbours is dumped, if the concentrations are below a level at which an ecotoxicological effect may be observed. The sediment at these sediment dumping sites will often be contaminated with TBT and heavy metals (Miljø- og Fødevareministeriet, 2018a). There are two sediment dumping sites in the waters near Faxe, and one in the waters near Rønne, see Figure 9-24. The survey stations closest to the sediment dumping sites are GCH01, GCH02 and GCH41.

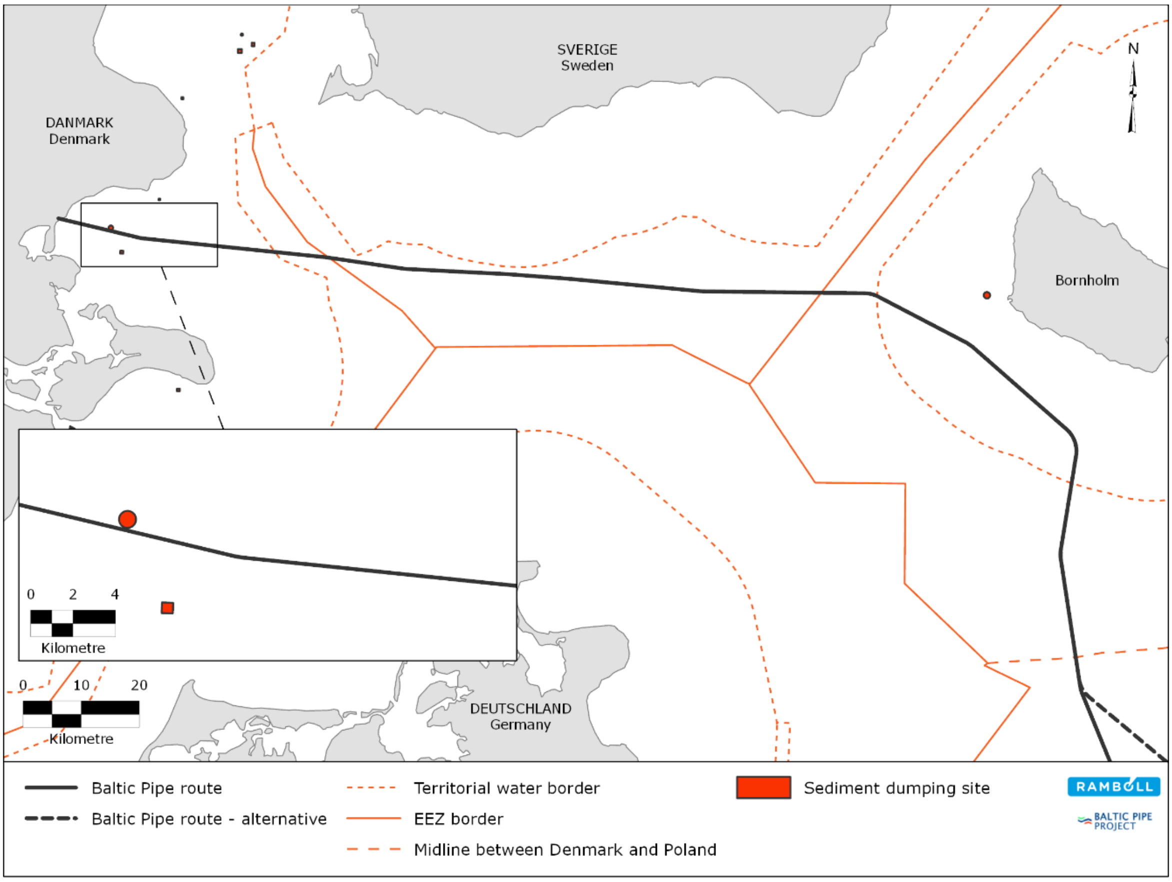

Figure 9-24 Sediment dumping sites near the pipeline route in Danish waters.

<u>Quality standards and thresholds</u>

In the following, the available quality standards and thresholds for contaminants are outlined. These standards and thresholds are compared with the actual concentrations measured in the seabed sediments along the pipeline route in Danish waters.

The Danish Environmental Protection Agency has established *National Environmental Quality Standards* (NEQS) for some contaminants. The NEQS are specified to secure good chemical status in Danish waters (Miljø- og Fødevareministeriet, 2017). Furthermore, the Danish Environmental Protection Agency has established a *Lower Action Level (LAL)* for the concentrations of contaminants in sediment dumping material. The LAL corresponds to background levels, or levels which are considered insignificant (Miljøstyrelsen, 2005).

The OSPAR Commission has established a set of assessment criteria for assessing unacceptable concentrations of hazardous substances. The *Environmental Assessment Criteria (EAC)* are defined for each contaminant as the concentration at which no chronic effect is expected to occur in the most sensitive marine species (OSPAR Commission, 2009). The OSPAR standards are not applicable in the Baltic Sea. However, as there are no specific thresholds for the Baltic Sea, the OSPAR standards are used by HELCOM to assess xenobiotics in the Baltic Sea (HELCOM, 2010a).

The *Effect Range Low (ERL)* threshold was developed by the US EPA. The ERL is a threshold, below which an ecotoxicological effect is only rarely observed in the marine environment (OSPAR Commission, 2009). However, it should be noted that an effect can still be observed for bioaccumulating substances (substances that accumulate in biota, as the uptake rate is higher than the excretion rate).

HELCOM (2017b) summarises the different threshold values of compounds of specific concern referred to as core indicators. These thresholds used by HELCOM include the Environmental Quality Standards (EQS) for sediment set by the EU and the Background Assessment Concentration (BAC) set by the OSPAR Commission.

Both the European EQS and the national EQS are based on a risk assessment and serve to protect both the environment and the human population (Strand & Larsen, 2013; Miljø- og Fødevareministeriet, 2018b). The environmental assessment criteria (EAC) is based on a similar risk assessment as the EQS and the NEQS. However, the EAC is an environmental assessment criterion and not a legislative requirement as the NEQS and EQS are (Strand & Larsen, 2013). Like the EAC, the ERL is an environmental assessment criterion, and not a legislative requirement. As opposed to the EAC, the ERL only focuses on the environment, and the concentration represents a concentration where an ecotoxicological effect is only rarely observed. The LAL is a legislative requirement but is only related to concentrations in sediment dumping material. This threshold is therefore not directly related to sediment concentration in normal seabed sediment. This threshold should therefore only be used in absence of the above-mentioned quality standards and thresholds.

In the following paragraphs, the concentrations of xenobiotics in the sediment will be evaluated based on the available quality standards and thresholds. The quality standards and thresholds are prioritised based on the recommendations from the DCE (Strand & Larsen, 2013) in the following order:

1) EQS (HELCOM, 2017b);
2) NEQS (Miljø- og Fødevareministeriet, 2017);
3) EAC (OSPAR Commission, 2009);
4) ERL (OSPAR Commission, 2009);

5) LAL (Miljøstyrelsen, 2005).

Heavy metals

One of the major sources of heavy metals in the Baltic Sea is atmospheric deposition from the burning of fossil fuel (HELCOM, 2017b).

In the marine environment, heavy metals tend to be adsorbed to the sediment particles, and only little will, therefore, be present in the water column.

Heavy metals are in general toxic to marine life. Some heavy metals, such as zinc and copper, are essential for life in low concentrations, but in high concentrations, these metals become toxic as well. Some metals, such as mercury and cadmium, are especially problematic in the marine environment, as they are bioaccumulating substances (HELCOM, 2017b).

Cadmium, lead, and mercury are assessed by HELCOM to be core indicators, which means that they are substances of specific concern in the Baltic Sea (HELCOM, 2017b). The atmospheric deposition of all three substances is decreasing. However, both mercury and cadmium fail to meet the thresholds at almost all the HELCOM monitoring stations, whereas lead shows a descending trend in sediment concentrations (HELCOM, 2017b).

Table 9-19 Heavy metals (µg/kg DW) in the sediment along the Baltic Pipe route with National EQS (Miljø- og Fødevareministeriet, 2017), BAC and ERL (OSPAR, 2012). The survey results are marked with bold, where the thresholds are exceeded.

Station	Cd	Pb	Hg	As	Cr	Zn	Cu	Ni	Mn
EQS	**2,300 ***	**120,000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
NEQS	**3,800**	**163,000**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
ERL	**1,200**	**47,000**	**150**	**-**	**81,000**	**150,000**	**34,000**	**-**	
GCH01	120	2,800	< 10	<1,250	3,200	7,900	1,400	1,700	64,000
GCH02	130	3,500	10	<1,250	2,500	7,800	1,300	1,200	52,000
GCH03	50	2,700	< 10	<1,250	2,100	4,800	1,100	740	47,000
GCH06	100	3,500	< 10	<1,250	1,800	6,600	1,200	880	30,000
GCH08	230	15,000	50	2,000	7,900	29,000	6,300	5,000	69,000
GCH10	160	6,400	10	2,600	8,100	18,000	5,100	5,000	76,000
GCH38	530	14,000	40	12,000	41,000	67,000	22,000	29,000	260,000
GCH41	120	3,300	< 10	2,300	2,500	8,600	1,100	1,400	21,000
GCH45	90	3,500	10	1,300	4,000	7,300	990	1,200	48,000
GCH48	110	2,700	< 10	1,300	2,000	6,600	890	920	21,000
GCH53	290	9,200	10	5,000	27,000	44,000	15,000	17,000	160,000
GCH51	910	**57,000**	50	15,000	46,000	100,000	**41,000**	29,000	250,000
GCH50	320	7,300	30	7,700	17,000	25,000	8,600	9,200	78,000
GCH52	140	8,000	10	2,600	9,100	18,000	4,600	5,400	74,000

*Bioavailable fraction

In Table 9-19, the concentrations of heavy metals in seabed sediment samples collected in February and March 2018 are shown, together with the EQS, NEQS and ERL limits. Only lead and copper exceeded the ERL, and none of the compounds exceeded the EQS or the NEQS. Lead and copper only exceeded the threshold at one survey station (GCH51), and it should be noted that lead did not exceed the EQS nor the NEQS. Both compounds exceeded the ERL by a factor 1.2.

GCH51 is placed in the Bornholm Basin and is the survey station with the greatest water depth. As illustrated in Table 9-18, the sediment consists of 100% silt/clay, is rich in organic content, and thereby has a greater potential to accumulate heavy metals than the other survey stations.

Mineral Oil

Spillage from ships is a source of mineral oil pollution in the Baltic Sea; however, the number of oil spills detected in the Baltic Sea is decreasing (HELCOM, 2018d).

While some oil components will evaporate or be dissolved or dispersed in the water column, some of the oil will sink to the bottom and be incorporated into the sediment (National Research Council (US) Committee on Oil in the Sea: Inputs, Fates, and Effects, 2003).

Oil incorporated in the sediment can lead to a chronic exposure of marine organisms and to both lethal and sublethal effects (National Research Council (US) Committee on Oil in the Sea: Inputs, Fates, and Effects, 2003).

Table 9-20 Mineral oil [mg/kg DW] in the sediment along the Baltic Pipe route, analysed in seabed samples from February and March 2018.

Station	Mineral Oil
GCH01	10
GCH02	9.7
GCH03	9.1
GCH06	< 5.0
GCH08	71
GCH10	36
GCH38	87
GCH41	14
GCH45	16
GCH48	22
GCH53	32
GCH51	76
GCH50	59
GCH52	19

The level of mineral oil is comparable to the level of Total Hydrocarbons (THC). There are no quality standards or thresholds for mineral oil or THC in seabed sediment, but there are quality standards and thresholds for some of the components in oil, such as PAHs (se section below).

When comparing the present results with other analysis results for THC in seabed sediment (Robson et al. 2000; Martins et al. 2016 and Jensen & Gustavson 2001), it can be concluded that the level of mineral oil in the sediment along the Baltic Pipe route is corresponding to or below similar survey results. Martins et al. (2016) furthermore argues that levels below 100 mg THC/kg in seabed sediment are low, which is the case for the sediment at all the Danish survey stations.

PAH

Polyaromatic hydrocarbons (PAHs) are a group of organic contaminants, composed of multiple aromatic rings. The main route for PAHs to enter the Baltic Sea is through the release of oil products and atmospheric deposition from incomplete combustion of fuel, waste, wood, etc. (HELCOM, 2017b).

PAHs will bind to particulate matter and settle down to the seabed sediments. The tendency of PAHs to bind to the sediment will, however, vary depending on the properties of the specific PAH (Pikkarainen, 2004).

PAHs are hydrophobic and will concentrate in the fatty acids of the marine organisms. The compounds are known to affect both the reproductive and the immune systems (OSPAR Commission, 2012). The toxicity of PAHs varies depending on their molecular weight. PAHs with a low molecular weight, such as anthracene, are more toxic than compounds with a high molecular weight, such as benzo(a)pyrene (HELCOM, 2017b).

Benzo(a)pyrene is considered by HELCOM to represent the group of compounds referred to as PAHs, and benzo(a)pyrene is assessed to be a core indicator. The levels of benzo(a)pyrene in the Baltic Sea are stable and generally below the set thresholds. However, the levels of the more toxic anthracene exceed the threshold at the HELCOM monitoring stations in the southwestern part of the Baltic Sea (HELCOM, 2017b). The measured levels of PAHs in the sediment along the pipeline route is shown in Table 9-21.

Table 9-21 PAH (µg/kg DW) in the sediment along the Baltic Pipe route with National EQS (Miljø- og Fødevareministeriet, 2017), BAC and ERL (OSPAR, 2012). The survey results (February and March 2018) are marked with bold, where the thresholds are exceeded.

Station	Naph-thalene	Phenan-threne	Anthracene	Acenaph-thylene	Acenaph-thene	Fluorene
LOQ	**1**	**1**	**1**	**1**	**1**	**1**
NEQS	**138**	**-**	**4.8**	**-**	**-**	**-**
ERL	**160**	**240**	**85**	**-**	**-**	**-**
GCH01	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH02	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH03	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH06	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH08	2.0	9.0	3.0	2.0	< 1.0	1.0
GCH10	2.0	2.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH38	2.0	6.0	1.0	1.0	1.0	1.0
GCH41	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH45	2.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH48	< 1.0	1.0	< 1.0	< 1.0	1.0	< 1.0
GCH53	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH51	14	35	**9.0**	4.0	2.0	6.0
GCH50	1.0	1.0	< 1.0	< 1.0	1.0	1.0
GCH52	4.0	6.0	3.0	< 1.0	< 1.0	1.0
Station	**Fluoran-thene**	**Pyrene**	**Benzo(a) anthracene**	**Chrysene**	**Benzo(b) fluoranthene**	**Benz(a) pyrene**
LOQ	**1**	**1**	**1**	**1**	**1**	**1**
NEQS	**-**	**-**	**-**	**-**	**-**	**-**
ERL	**600**	**665**	**261**	**384**	**-**	**430**
GCH01	1.0	1.0	< 1.0	1.0	1.0	< 1.0
GCH02	1.0	1.0	< 1.0	1.0	1.0	< 1.0
GCH03	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH06	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH08	31	27	18	22	37	25
GCH10	3.0	3.0	1.0	2.0	4.0	1.0
GCH38	8.0	8.0	6.0	10	25	11

GCH41	1.0	1.0	1.0	1.0	2.0	1.0
GCH45	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
GCH48	1.0	< 1.0	< 1.0	1.0	1.0	< 1.0
GCH53	1.0	1.0	< 1.0	2.0	2.0	1.0
GCH51	93.0	75	46	62	207	62
GCH50	2.0	2.0	1.0	2.0	7.0	2.0
GCH52	23.0	16	12	13	23	12

Station	Indeno (1,2,3,-cd) pyrene	Dibenzo (a,h)anthra-cene	Benzo (g,h,i)peryl ene	Benzo(k) fluoranthene	Total PAH
LOQ	**1**	**1**	**1**	**1**	**-**
NEQS	**-**	**-**	**-**	**-**	**-**
ERL	**240**	**-**	**85**	**-**	**-**
GCH01	< 1.0	< 1.0	< 1.0	1.0	6.0
GCH02	1.0	< 1.0	< 1.0	1.0	6.0
GCH03	< 1.0	< 1.0	< 1.0	1.0	1.0
GCH06	1.0	< 1.0	< 1.0	< 1.0	1.0
GCH08	54	11	35	38	310
GCH10	3.0	< 1.0	2.0	3.0	26.0
GCH38	45	8.0	39	17	190
GCH41	3.0	< 1.0	2.0	2.0	15
GCH45	< 1.0	< 1.0	< 1.0	< 1.0	2.0
GCH48	< 1.0	< 1.0	1.0	1.0	8.0
GCH53	2.0	< 1.0	1.0	1.0	11
GCH51	**480**	69	**300**	170	160
GCH50	14	2.0	10	4.0	50
GCH52	35	6.0	31	14	200

As illustrated in Table 9-21, the NEQS for anthracene and the ERL for indeno(1,2,3,-cd)pyrene and benzo(g,h,i)perylene have been exceeded in the sediment from survey station GCH51 by a factor of 1.9 for anthracene, a factor 1.7 for indeno(1,2,3,-cd)pyrene and a factor 3.5 for benzo(g,h,i)perylene. The thresholds are not exceeded at any other survey station.

As described previously, the sediment at GCH51 in the Bornholm Basin is very fine-grained and rich in organic matter, which provides a high potential for adsorbing xenobiotics such as PAHs.

PCB

The main sources of polychlorinated biphenyl (PCB) in the marine environment are inappropriate waste handling or leakage from transformers and similar systems (HELCOM, 2017b).

PCB is hydrophobic, and in the aquatic environment, the contaminant accumulates in seabed sediments. Like other organic contaminants, PCB mainly adsorbs to the organic matter and clay minerals in the sediment and is especially found in fine-grained sediment rich in organic content (Schneider & Leipe, 2007).

HELCOM assesses PCB to be a core indicator, as the compound is toxic to marine organisms, very persistent and biomagnifies in the marine food web (HELCOM, 2017b). PCB has been banned since the mid-1980s, but the concentrations in the Baltic Sea are stable (HELCOM, 2017b).

Table 9-22 PCB congeners (µg/kg DW) in the sediment along the Baltic Pipe route with BAC and EAC (OSPAR, 2012). Seabed sampling took place in February and March 2018.

Station	CB28	CB52	CB101	CB118	CB138	CB153	CB180	Sum PCB congeners
EAC	1.7	2.7	3	0.6	7.9	40	12	-
GCH01	0.1	0.1	0.3	0.2	0.8	1.0	1.3	3.8
GCH02	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	-
GCH03	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
GCH06	< 0.1	< 0.1	0.3	0.1	0.2	0.2	0.2	1.0
GCH08	0.1	0.1	< 0.1	0.1	0.1	0.2	0.1	0.7
GCH10	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
GCH38	0.1	0.1	1.1	0.1	0.6	0.6	0.7	3.3
GCH41	0.1	0.1	0.5	**3.6**	0.4	0.4	0.4	5.5
GCH45	< 0.1	< 0.1	0.4	0.1	0.2	0.2	0.2	1.1
GCH48	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
GCH53	< 0.1	< 0.1	0.4	< 0.1	0.1	0.1	0.1	0.7
GCH51	0.1	0.1	0.2	0.1	0.2	0.3	0.1	1.1
GCH50	< 0.1	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	0.3
GCH52	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1

As illustrated in Table 9-22, the threshold is only exceeded for CB118, and only in the sediment at station GCH41. The threshold is exceeded by a factor of 6. The sediment at GCH41 is mostly sand with a low content of organic matter. The reason for the increased level of CB118 at this survey station is unknown, as PCBs will typically adsorb to fine grained-sediment rich in organic matter.

<u>Organochlorine pesticides (Chlordane, HCH, HCB and DDT)</u>
The main source of pesticides such as chlorodane, hexachlorocyclohexane (HCH), hexachlorobenzene (HCB) and dichlorodiphenyltrichloroethane (DDT) in the Baltic Sea is through leaching from contaminated soil to which the pesticide has been applied, and subsequently transported by streams and rivers to the Baltic Sea. A further source of HBC is atmospheric deposition, as it is a by-product of the metal industry (HELCOM, 2010a). The organochlorine pesticides will tend to bind to the sediment, once in the aquatic environment, and especially fine-grained sediment will accumulate these pesticides (Schneider & Leipe, 2007).

The organochlorine pesticides may bioaccumulate and biomagnify in the marine food web. Even though the compounds are designed as insecticides or fungicides, they are also toxic to marine organisms, and at higher trophic levels, the compounds can cause endocrine disruption (HELCOM, 2010a; Miljøstyrelsen, 2004).

Even though persistent organochlorine pesticides such as chlordane, DDT and HCB have been banned in the EU since 1979 (Miljøstyrelsen, 2004), the compounds are still found in the Baltic Sea, but the levels are decreasing (HELCOM, 2010a).

The survey results of the organochlorine pesticide analysis are not included, as the concentrations were below the limit of quantification for all components at all survey stations.

<u>Organotin compounds (TBT, DBT, MTB)</u>
Tributyltin (TBT) has been widely used as ship paint and as an anti-fouling agent, but it has been banned globally since 2001. The main source of TBT is leaching from ships treated with TBT.

Dibutyltin (DBT) is used in PVC products, and monobutyltin (MBT) is used as a precursor in glass coating. DBT and MBT enter the aquatic environment through wastewater discharge or leaching from sewage sludge. Furthermore, DBT and MBT are both degradation products of TBT (Cole *et al.*, 2015).

In the marine environment, organotin compounds adsorb to the organic compounds in the sediment and are often bound to finer sediment (Cole *et al.*, 2015).

The organotin compounds TBT, DBT and MTB are toxic and affect the hormonal function of marine animals (Cole *et al.*, 2015). Tributyltin (TBT) is the most toxic of the three mentioned, and the compound is assessed by HELCOM to be a core indicator. Sediment concentrations in the southwestern part of the Baltic Sea (e.g. in the Arkona Basin) are still problematic, and imposex in marine snails is observed at several locations in the Baltic Sea (HELCOM, 2017b).

Table 9-23 Organotin compounds (TBT cation, DBT cation and MTB cation) (µg/kg DW) in the sediment along the Baltic Pipe route with National LAL (Miljøstyrelsen, 2005). The survey results are marked with bold, where the thresholds are exceeded. Seabed sampling took place in February and March 2018.

Station	TBT'	DBT+	MTB´
LAL	**7**	**-**	**-**
GCH01	< 10	< 1	5.0
GCH02	< 10	< 1	5.0
GCH03	< 10	< 1	5.0
GCH06	< 10	11	5.0
GCH08	**10**	15	5.0
GCH10	< 10	< 1	5.0
GCH38	< 10	< 1	< 5
GCH41	< 10	< 1	5.0
GCH45	< 10	< 1	5.0
GCH48	< 10	< 1	5.0
GCH53	< 10	< 1	< 5
GCH51	**10**	35	8.0
GCH50	< 10	< 10	< 5
GCH52	< 10	< 10	5.0

As presented in Table 9-23, the TBT threshold is exceeded in the seabed sediment at survey stations GCH08 and GCH51 by a factor 1.4 at both stations. It should, however, be noted, that the limit of quantification is greater than the threshold LAL. This means that some or all of the results below the limit of quantification may potentially exceed the threshold.

The sediment at both survey stations is fine-grained and has a high organic content, especially at GCH51. This provides a high potential for adsorbing xenobiotics such as organotin compounds.

Nitrogen and phosphorous (N and P)

The nutrients nitrogen (N) and phosphorous (P) are released to the Baltic Sea mainly through rivers flowing into the Baltic Sea, runoff from diffuse sources in coastal areas, discharges from ships, or atmospheric deposition of N, see Section 9.2, Hydrography and water quality. Also, there is an exchange of N and P with the water flowing between the Baltic Sea and the surrounding sea, through the Danish straits. In the aquatic environment, N and P are used by plants and algae, but excess nutrients are stored in the sediment. The release of the N and P is the main driver of eutrophication in the Baltic Sea, which causes elevated plant and algae growth, oxygen depletion, increased turbidity, and changes in species composition (HELCOM, 2014b).

Even though the input levels of N and P have been decreasing since the 1980s, the levels in the Baltic Sea have not decreased accordingly (HELCOM, 2014b).

Table 9-24 Total N and P (mg/kg DW) in the sediment along the Baltic Pipe route.

Station	Total N	Total P
GCH01	< 200	350
GCH02	< 200	250
GCH03	< 200	180
GCH06	< 200	170
GCH08	790	410
GCH10	730	440
GCH38	1,000	640
GCH41	< 200	240
GCH45	< 200	810
GCH48	< 200	470
GCH53	< 200	550
GCH51	6,000	1,200
GCH50	1,400	630
GCH52	410	310

There are no thresholds for N and P in seabed sediment. For comparison, Nord Stream 2 also measured N and P were also measured in the southwestern part of the Baltic Sea in 2015 in connection with the Nord Stream 2 project (Rambøll / Nord Stream 2 AG, 2017b). The survey found that the N levels were between 345 and 3,110 mg/kg DW and the P levels were between 600 and 1,220 mg/kg DW (Table 9-24).

The level of nitrogen at GCH51 is higher than the Nord Stream 2 measurements, but otherwise the present survey data are much in accordance with the Nord Stream 2 measurements.

9.3.2 Impact assessment

During the construction of the Baltic Pipe, there will be physical disturbance of the seabed leading to exposure of deeper sediments and furthermore, sediment and potentially contaminants and nutrients will be suspended in the water column and settle again. In the operation phase, the presence of the pipeline can affect sediment erosion and deposition patterns and the pipeline anodes will potentially release metals to the surrounding environment. See Table 9-25 for an overview of potential impacts.

Table 9-25 Potential impacts on surface sediment.

Potetial impacts	Construction	Operation
Physical disturbance of seabed	X	
Sedimentation	X	
Contaminants and nutrients	X	
Presence of pipeline		X
Release of contaminants from anodes		X

Physical disturbance of seabed

As described in Chapter 5 on potential impacts, there will be disturbance of the seabed during trenching, rock installation and anchor handling carried out as part of the construction work. The activities will result in suspension of seabed sediments in the water column, which will be described in the following section on sedimentation.

Furthermore, the trenching activities will result in exposure of the deeper and possibly anoxic sediment layers. This can affect the redox fronts and thereby the mobility of certain contaminants in the sediment (Emili *et al.*, 2013). The effect will be limited to the area where the anoxic sediment is exposed, and thereby only to the areas where trenching will be conducted.

Trenching will be conducted in several locations along the Danish part of the pipeline route, see Section 3.5.3. Trenching will take place at least 2-2.5 m below the surface. As only the sediment in the top layer has been analyzed for contaminants, no knowledge of the redox conditions or contaminant levels in the deeper sediment has been obtained. These layers are, however, expected to mainly consist of clean geological materials, deposited prior to industrialization (as outlined in Section 9.2.1, the net accumulation rate in sedimentation areas in the Baltic Sea is in the range 0.5-2.0 mm·year^{-1}). The survey results showed that several contaminants exceeded the applicable thresholds at survey station GCH51, but it should be noted that no trenching will be conducted in this part of the pipeline route. Besides GCH51, the thresholds were only exceeded at two other survey stations (CB118 exceeded the threshold by a factor 6 at GCH41 (Table 9-22) and TBT exceeded the threshold by a factor 1.4 at GCH08 (Table 9-23)). There will not be performed trenching in the area of GCH08 or GCH41.

Based on the survey results, it is assessed that it is unlikely that the contaminant levels in the deeper layer are at problematic levels. Furthermore, the sediment will only be exposed locally in the limited area where the trenching is conducted.

As it is unlikely that sediment with problematic levels of contaminants will be exposed, and as exposed sediments only will remain anoxic over a short-term period, it is assessed that the potential impact is not significant, Table 9-26.

Table 9-26 Impact significance on surface sediment from physical disturbance.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance of seabed	Medium	Medium	Local	Short-term	Minor	Not significant

Sedimentation

During the seabed intervention work, sediment will be suspended in the water column and deposited again on the seabed. Figures 5-5, 5-6 and 5-7 illustrates the layer of spilled sediment, that will be deposited on the seabed after finalization of the seabed intervention work. As illustrated in the figures, the impacts will be greatest in shallow water. During tunneling, up to 20,000 g sediment/m^2 will be deposited on the seabed in the very close vicinity of the intervention work and trenching in this area will result in the deposition of up to 5,000 g sediment/m^2. Trenching in the deeper waters west and southwest of Bornholm will only will result in the deposition of up to 2,000 g sediment/m^2 and only in the very near vicinity of the pipeline (see Figure 5-7). The majority of the sediments deposited in shallow water will gradually be re-suspended and transported to net deposition areas in the deeper parts of the Baltic Sea.

The sediment suspended during the seabed intervention work will settle on the seabed within a few kilometers of the pipeline within hours to days (see results of modelling of sediment dispersion and sedimentation in Chapter 5, Potential impacts).

As described in Section 9.2.1, transportation of sediment occurs naturally in the project area, but on smaller scale, and the sedimentation caused by the project will be higher in the affected areas than the rate of natural sedimentation. This is, however, not assessed to have any significant impact on the seabed.

Table 9-27 Impact significance on surface sediment from sedimentation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Sedimentation	Medium	Minor	Regional	Short-term	Minor	Not significant

Contaminants and nutrients

When the seabed is disturbed, and sediment is suspended in the water column, the contaminants and nutrients in the sediment can be reactivated. When reactivated, the chemical and biological availability of the sediment will increase (HELCOM, 2010a).

The areas impacted will be those areas close to the seabed intervention work, where the sediment will be suspended into the water column. As most of the contaminants will settle onto the seabed again, the duration will be short-term.

Any impact on the concentration of contaminants in the sediment from this chemical and biological reactivation will in theory be positive, as the concentration would decrease. However, the concentration in the seawater could increase (see Section 9.2).

The average concentration for all survey stations and EQS for surface water are presented in Table 9-28.

Table 9-28 Average concentration in the seabed sediment at all survey stations along the pipeline route and corresponding EQS (Miljø- og Fødevareministeriet, 2017) for surface water. The EQS for surface water are not directly comparable with the concentrations in the seabed sediments, but they give an indication of the theoretically required dilution if all contaminants were dissolved in the water column.

Contaminant	Average conc. in sediment [mg/kg DW]	EQS surface water [mg/l]
Cd	0.36	0.0002
Pb	20.8	0.0013
Hg	0.05	0.00007[a]
As	6.18	0.0006
Cr	15.19	-
Zn	41.5	0.0078
Cu	11.58	0.0049
Ni	9.36	0.0086
Mn	106	0.15
Mineral Oil	54.4	-
Acenaphthylene	0.002	0.00013
Naphtalene	0.004	0.002
Phenathrene	0.013	0.0013
Anthracene	0.003	0.0001
Acenaphtene	0.002	0.00038
Fluorene	0.003	0.00023
Fluoranthene	0.029	-

Contaminant	Average conc. in sediment [mg/kg DW]	EQS surface water [mg/l]
Pyrene	0.026	$1.7*10^{-6}$
Benzo(a)anthracene	0.016	$1.2*10^{-6}$
Chrysene	0.021	$1.4*10^{-6}$
Benzo(b)fluoranthene	0.06	b
Benz(a)pyrene	0.021	$1.7*10^{-7}$
Indeno(1,2,3,-cd) pyrene	0.14	b
Dibenz(a,h)anthracene	0.02	$1.4*10^{-7}$
Benzo(g,h,i)perylene	0.088	b
Benzo(k)fluoranten	0.044	B
Total PAH	0.475	-
CB28	<0.0001	-
CB52	<0.0001	-
CB101	0.0002	-
CB118	0.0002	-
CB138	0.0003	-
CB153	0.0003	-
CB180	0.0002	-
Sum PCB congeners	0.0012	-
TBT	<0.01	-
DBT	0.004	-
MTB	0.005	-
HCB	<0.005	-
HCH	<0.04	-
DDT	<0.04	0.000025
Chlorodane	<0.01	-
N	1,556	-
P	463	-

a: Maximum concentration allowed at any point (even short term), no EQS available.
b: Benzo(a)pyrene is a marker for this group of compounds (PAH).

As it is not expected that the concentration of contaminants in the sediment will change remarkably in this short-term period of reactivation, it is assessed that there will be no impact on the seabed sediment (Table 9-29).

Table 9-29 Impact significance on contaminants and nutrients in the seabed sediment.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Contaminants and nutrients	Medium	Minor	Local	Short-term	Negligible	Not significant

Presence of pipeline
The presence of the pipeline and the trench can affect erosion, transportation, and sedimentation on the surface sediment. It should, however, be noted, that the pipeline is designed to ensure that the risk of erosion (scour) is minimized.

Furthermore, erosion, transportation, and sedimentation on the surface sediment will be controlled in the survey and maintenance (operational) phase of the project. If any undesirable effects occur, they will be handled, and thereby no negative impacts on the seabed will occur (Table 9-30).

Table 9-30 Impact significance on surface sediment of presence of the pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Presence of pipeline	Medium	No impact	Local	Long-term	Negligible	Not significant

Release of contaminants from anodes

The anodes will consist of aluminium, zinc, indium, cadmium, copper and silicon. As the anodes will be mainly comprised of aluminium, and the other components will only be present (and released) in insignificant amounts, the following assessment will only consider aluminium (see also Section 9.2.2).

Some of the released aluminium will accumulate in the sediment. A conservative estimate is that a maximum of 7.9 kg/km/year will be released from the anodes, and approx. 95% of this release will be aluminium (see Section 3.3.1). As outlined in Section 5.2.5, experience from comparable projects has shown that even 1-2 m from the anodes, the concentrations in the seawater will be indistinguishable from background concentrations. It is therefore assessed that there will only be a local increase in the aluminium concentration within the near vicinity of the pipeline.

Aluminium is very common in the environment, and the level of released aluminum is of such a small magnitude, that it is assessed not to have any impact on the seabed sediment (Table 9-31). Furthermore, the toxicity of aluminium is very low, and aluminium is not considered by HELCOM to be of specific concern.

Table 9-31 Impact significance on surface sediment from release of contaminants from anodes.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Release of contaminants from anodes (aluminium)	Medium	Medium	Local	Long-term	Minor	Not significant

9.3.3 Conclusion

The potential impacts on surface sediment resulting from construction and operational activities of the planned pipeline within Danish waters are summarized in Table 9-32.

Table 9-32 Overall impact significance for surface sediment.

Potential impact	Severity of impact	Significance	Transboundary
Physical disturbance of seabed	Minor	Not significant	No
Sedimentation	Minor	Not significant	No
Contaminants and nutrients	Negligible	Not significant	No
Presence of pipeline	Negligible	Not significant	No

Potential impact	Severity of impact	Significance	Transboundary
Release of contaminants from anodes (aluminium)	Minor	Not significant	No

9.4 Climate and air quality

Climate and air quality is in this context (as a basis for assessing impacts from the Baltic Pipe project) related to greenhouse gas emissions as well as its consequences and to air pollutants. Greenhouse gas emissions have a transboundary impact contributing to global climate change, whereas air pollutants can have a local and/or regional impact. Both factors influence the environment and the living conditions for flora and fauna as well as humans.

BOX 9-1: Main air emissions from the project

CO_2: CO_2 is not harmful per se, but it is considered as the most important greenhouse gas, contributing to climate change globally.

NO_X: Emission from the combustion of fossil fuels contains a mix of nitrogen oxides, consisting mainly of NO and a small proportion of NO_2. The sum of these two components is described as NO_X. NO_2 is harmful to human health, whereas NO is not harmful, as it is converted to NO_2 by oxidation in the atmosphere. High concentrations of NO_2 can cause inflammation of the human respiratory system and NO_X emissions have a negative impact on the environment by contributing to acid deposition and eutrophication.

SO_X: SO_X refers to components containing sulphur and oxygen molecules. Sulphur dioxide (SO_2) accounts for the main part of SO_X emissions (approx. 95%) and contributes to acid deposition, which can lead to changes in soil and water quality. Also, SO_X in high concentrations is harmful to human health.

PM: Particulate matter is usually divided into the following categories based on the size of the particles:

- PM_{10}: Particles with an aerodynamic diameter < 10 µm;
- $PM_{2.5}$: Particles with an aerodynamic diameter < 2.5 µm;
- $PM_{0.1}$: Particles with an aerodynamic diameter < 0,1 µm;
- TSP (Total Suspended Particles): Particles < 40 µm.

The background level of particles in the air originates from natural sources (such as fine dust particles) and from particles transported long-distance, mainly from non-Danish sources (up to 2/3 of the background level). Adding to the background level are local activities from cities and transportation.

Particles can cause severe health effects by accumulating in the lungs, causing respiratory and cardiovascular diseases, amongst others. The smaller particles are considered the most harmful.

During construction and operation of the Baltic Pipe project, there will be a need for vessels to undertake surveys, carry out construction works, transport materials etc. The combustion of fossil fuel from vessel operation will result in the emission of several components. Based on experience from other comparable projects, the following components are considered as the main contributors to air emissions: CO_2 (carbon dioxide), NO_X (nitrogen oxides), SO_X (sulphur oxides) and PM particulate matter (see Box 9-1).

9.4.1 Statutory requirements

The statutory requirements relevant to the Baltic Pipe project are divided in the following into the requirements relating to greenhouse gas emissions (CO_2) and to air quality.

Greenhouse gas emissions (CO_2)

Denmark has ratified the UN Kyoto Protocol on the reduction of greenhouse gas emissions and committed to reduce CO_2 emissions by 21% in 2020 (compared to 1990 levels). In addition, Denmark has, as a member of the EU, an individual binding target to cut CO_2 emissions by 39% from non-ETS sectors[34] in 2030 (compared to 2005 levels).

Air quality

The International Maritime Organization (IMO) under the UN has, as part of the MARPOL Convention, designated the Baltic Sea as an Emission Control Area (ECA) under regulation 14 of MARPOL Convention Annex VI to limit the emission of SO_X (also known as SECA). This means that the sulphur limit for fuel oil used in SECAs from 1 January 2015 is 0.1%. The regulation has led to a significant reduction of SO_2 emissions in the Baltic Sea, since it has come into effect (Johansson & Jalkanen, 2016).

Furthermore, the Baltic Sea has been designated as an ECA from 2021 under Regulation 13 of MARPOL Convention Annex VI to limit the emission of NO_X (also known as NECA). This means that all vessels built after 2021 are required to reduce NO_X emissions by 80% compared to the present emission level. It is expected that a lengthy period of fleet renewal is needed before the regulation will show full effect.

The EU has adopted the Air Quality Directive[35], including limit values[36] for air pollutants, which also applies as limit values in Denmark (implemented in the Danish Statutory Order on Air Quality[37]). The limit values apply over different time periods because the observed impacts associated with the various pollutants occur over different exposure times.

The limit values for the polluting components described at the start of this section are shown in Table 9-33.

[34] Non-ETS sectors are not a part of the EU Emissions Trading System (ETS). The non-ETS sectors includes e.g. transportation, agriculture and heating.

[35] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

[36] Limit values are in the Air Quality Directive defined as: *"(…) a level fixed on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained".*

[37] Statutory Order no. 1472 of 12 December 2017 on assessment and control of the air quality.

Table 9-33 Relevant limit values for the protection of human health according to the Air Quality Directive.

Polluting components	Averaging period	Limit values [µg/m³]
NO_2	1 hour	200, not to be exceeded more than 18 times per calendar year
NO_2	Calendar year	40
SO_2	1 hour	350, not to be exceeded more than 24 times per calendar year
SO_2	24 hours	125, not to be exceeded more than 3 times per calendar year
$PM_{2.5}$	Calendar year	25 (20)*
PM_{10}	24 hours	50, not to be exceeded more than 35 times per calendar year
PM_{10}	Calendar year	40

* Number in parentheses is a proposed limit value for 2020.

9.4.2 Baseline

Existing CO_2 emissions and emissions of air pollutants related to the offshore part of the project mainly originate from vessels operating in the Baltic Sea. Table 9-34 shows an overview of emissions from vessels in the Baltic Sea in 2016 and the total annual emissions in Denmark in 2016 for comparison.

Table 9-34 Total emissions from all vessels in the Baltic Sea in 2016 (Johansson & Jalkanen, 2017) and total annual emissions in Denmark in 2016 (Aarhus University, 2018b).

Polluting components	Emissions from vessels in the Baltic Sea [ton]	Total emissions in Denmark [ton]
CO_2	14,700,000	37,117,000
NO_X	318,000	115,000
SO_X	10,000	-
SO_2	-	10,000
$PM_{2.5}$	9,000	21,000
PM_{10}	-	31,000
PM (TSP)	-	91,000

The CO_2 emissions from vessels from the Baltic Sea correspond to 4,792,000 tons of fuel (Johansson & Jalkanen, 2017).

Air quality in Denmark is monitored by the Danish Centre for Environment and Energy (DCE) at a number of stations around the country. The air quality is monitored in rural areas and in cities (background emissions in cities and emissions on heavily trafficked streets). DCE publishes two reports each year as a part of its monitoring programme: One focuses on air pollutants with an effect on human health (Ellermann *et al.*, 2017) and one focuses on air quality in relation to nature (deposition) (Ellermann *et al.*, 2018).

The two reports can be used as additional baseline data for the air quality in the project area. However, the report focusing on human health is not relevant in relation to the offshore baseline of the project, as there are no relevant data available in the report for the Baltic Sea. The report focusing on air quality in relation to nature includes model calculations for the concentrations of NO_X and SO_2, which also cover the Danish part of Baltic Sea. It is judged that these results can also be used as an indication of the air quality in relation to human health.

The results of the model calculations for the Danish part of the Baltic Sea are shown in Table 9-35.

Table 9-35 Modelled concentrations of NO_X and SO_2 in the Danish part of the Baltic Sea in 2016 (Ellermann *et al.*, 2018).

Polluting components	Averaging period	Modelled concentrations in Danish part of the Baltic Sea, 2016 [µg/m³]
NO_X	Calendar year	6 - 10
SO_2	Calendar year and winter	0.25 – 1.50

9.4.3 Impact assessment

The only potential impacts from the project on climate and air quality is emissions to air, which can have an impact both during construction and operation, Table 9-36.

Table 9-36 Potential impacts on climate and air quality, offshore.

Potential impact	Construction	Operation
Emissions to air	X	X

Emissions to air

The main emissions from the offshore part of project during construction is related to combustion of fossil fuels from the various vessels operating in the Baltic Sea as part of the pipe-lay activities. During operation, the emissions are related to combustion of fossil fuels from survey and maintenance vessels.

Emissions to air from the offshore part of the project include both CO_2 emissions, which have an impact on climate, and polluting components, which impact air quality.

CO_2 emissions

In Table 9-37, the CO_2 emissions from construction and operation of the offshore part of the project and from material production is presented. For operation, the results are shown per year on average during the estimated operation lifetime (50 years). CO_2 emissions from material production covers the two main materials, steel and concrete, used for the pipes and tunnel elements.

Table 9-37 CO_2 emissions from offshore construction, including production of the main materials, and operation (per year on average for an operation lifetime of 50 years).

	CO_2 emissions [tonnes]
Construction activities offshore	125,200
Material production (steel and concrete)	181,800
Construction, total	307,000
Operation (per year on average)	60

The sensitivity of the climate as a receptor is considered high because of its potential impact on ecosystems in general. CO_2 emissions have a negative, secondary, transboundary and irreversible impact on climate.

CO_2 emissions from operation are considered negligible, as the yearly emissions constitute of less than 0.003‰ of the total emissions from all vessels in the Baltic Sea and an even lower percentage of the total annual Danish CO_2 emissions. However, the CO_2 emissions during construction, including CO_2 emissions from material production, are considerably higher than during operation and account for approximately 0.8% of the total annual Danish CO_2 emissions in 2016 and for approximately 2.1% of CO_2 emissions from vessels in the Baltic Sea. As the duration is short-term, it is considered a minor impact and thus, not significant (Table 9-38).

Table 9-38 Impact significance on climate, offshore.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Emissions to air (CO_2 emissions, construction)	High	Medium	Transboundary	Short-term	Minor	Not significant
Emissions to air (CO_2 emissions, operation)	High	Minor	Transboundary	Long-term	Negligible	Not significant

The CO_2 emissions from the total Baltic Pipe project in Denmark is assessed jointly in the document "Environmental Impact Assessment – Introduction and overall conclusion" (see Figure 1-3).

Polluting components

In Table 9-39, the emissions of polluting components from construction and operation of the offshore part of the project are presented.

Table 9-39 Polluting components from offshore construction and operation.

	Air emissions [tonnes]				
	NO_X	SO_2	PM (TSP)	PM_{10}	$PM_{2,5}$
Construction (offshore)	3,400	80	150	150	150
Operation (pr. year in average)	1	0	0	0	0

In the estimates, it has not been taken into account that the Baltic Sea has been designated as a NECA area, which means that all vessels built after 2021 are required to reduce NO_X emissions by 80% compared to the present emission level. This means that the overall NO_X level could potentially be lower, especially during operation. The ships and fuel used during the construction activities for the Baltic Pipe project will be required to comply with legislation in force, including the legislation resulting from the designation of NECA and SECA areas.

The sensitivity of air quality is assessed as low offshore, as the background level is low and there are good spreading conditions. The above calculated air emissions cover for the total construction activities offshore and will therefore be emitted at very low levels along the pipeline route during the construction period. The intensity is assessed as minor during construction and with no impact during operation. The scale is mainly local or regional, but as the pipeline route is close to both Swedish and Polish borders, the impact is also transboundary. The severity of the impact is assessed as minor during construction and negligible during operation (Table 9-40).

Table 9-40 Impact significance on air quality, offshore.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Emissions to air (polluting components, construction)	Low	Minor	Local, regional and transboundary	Short-term	Minor	Not significant
Emissions to air (polluting components, operation)	Low	No impact	Local, regional and transboundary	Long-term	Negligible	Not significant

Impacts on human health because of increased air emissions from the project are assessed in Section 9.32.

9.4.4 Conclusion

The potential impacts on climate and air quality resulting from construction and operational activities of the proposed pipeline within Danish waters are summarized in Table 9-41.

Table 9-41 Overall impact significance for climate and air quality.

Potential impact	Severity of impact	Significance	Transboundary
Emissions to air (CO_2 emissions, construction)	Minor	Not significant	Yes
Emissions to air (CO_2 emissions, operation)	Negligible	Not significant	Yes
Emissions to air (polluting components, construction)	Minor	Not significant	Yes
Emissions to air (polluting components, operation)	Negligible	Not significant	Yes

Impacts on human health because of increased air emissions from the project are assessed in Section 9.32.

9.5 Underwater noise

In this section the baseline for underwater noise is described and impacts from the project are addressed.

9.5.1 Baseline

General

Sound in water travels as compressional waves in which water particles are alternately compressed and decompressed. The sound speed in water is nearly five times faster than in atmospheric air, which is due to density and compressibility differences between the two media. Marine life is sensitive to sound (acoustic) pressure and particle motion, or both, depending on the type of sensory systems they possess (Verfuß *et al.*, 2015).

Sound is always present in the underwater environment, irrespective of the status of the sea. A commonly accepted division of sound is *natural* versus *anthropogenic* generated sound, where natural generated sound encompasses all kinds of events that are produced by either animals or geophysical processes, while anthropogenic generated sound is produced by humans. The primary sources of natural sound in sea are gas bubbles mainly produced by breaking waves. Examples of geophysical processes which are sporadically occurring are rain, waves, ice, thunder, seismic activity, and thermal noise. Natural sounds also include biological sounds (animal vocalization) produced by, for example, cetaceans, seals, fish, and crustaceans. Anthropogenic sources include, for example, ships, piling, sonars, seismic airguns, underwater explosions, and operational infrastructure noise (Verfuß *et al.*, 2015).

The definitions of the various parameters used to characterize noise levels are given in Section 5.1.5 Underwater noise.

The typical sound pressure levels and their respective frequency ranges caused by natural and anthropogenic sources in the sea are shown in Figure 9-26. The loudest acoustical sources with the main energy in the low frequency region are earthquakes and underwater explosions, followed by biological (animal) sound, spanning a wide frequency range up to and including the ultrasound region. Figure 9-26 also shows the relationship between ambient noise levels and sea state levels (Verfuß *et al.*, 2015).

The source level of underwater sounds varies. Generally, lightning strikes, seismic eruptions and underwater explosions are some of the loudest sound sources, and have source levels of 260-280 dB re 1 µPa at 1 m. Loud ships can also generate high noise levels, with source levels of up to 190 dB re 1 µPa at 1 m. Sound sources can also be biological; dolphins have been known to have source levels of approximately 230 dB re 1 µPa at 1 m, whilst cod, when they grunt, can produce sounds with source levels of approximately 150 dB re 1 µPa at 1 m (Verfuß *et al.*, 2015). Quieter sound sources such as wind and rain, with sound levels of 40-90 dB re 1 µPa. Monitoring for the Nord Stream 2 project showed that the average noise levels within the main shipping lanes ranged from 100-130 dB re 1 µPa in the 50-200 Hz frequency range (Rambøll / Nord Stream 2 AG, 2017a).

Underwater noise in the Baltic Sea
As part of a project to study the influence of anthropogenic noise on the Baltic Sea (the Baltic Sea Information on the Acoustic Soundscape (BIAS) project), a series of measurements were undertaken over one year (2014) at 38 locations covering the whole Baltic Sea. These measurements have been used as a basis for numerical modelling of the underwater noise in the entire Baltic Sea. Input data comprised measurements of ship noise close to the main shipping routes, and the model results have been calibrated against the measurements carried out far from the main shipping routes (Tougaard *et al.*, 2017). A portion of the modelling results is shown in Figure 9-25.

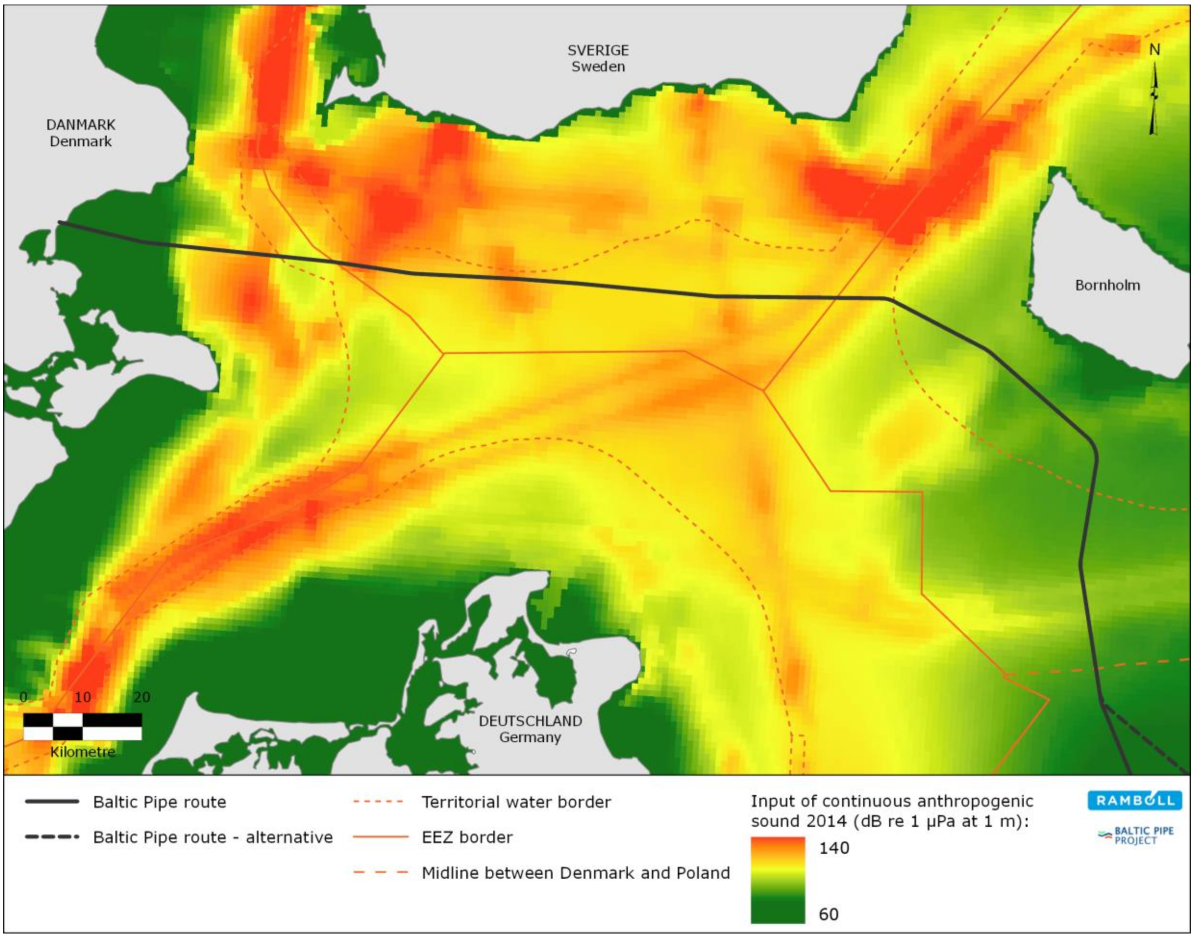

Figure 9-25 Underwater spectrum level map of noise in the Baltic Sea Picture generated by numerical modelling based on shipping traffic data and measurements conducted in June 2014 by the BIAS project, represented as median values at the 125 Hz one-third octave band. The map includes both natural and human-induced noise. The largest shipping lanes are clearly shown (from SYKE, 2017).

Figure 9-25 shows that there is a close correlation between underwater noise levels and the density of ship traffic; the highest noise levels are associated with the major shipping lanes.

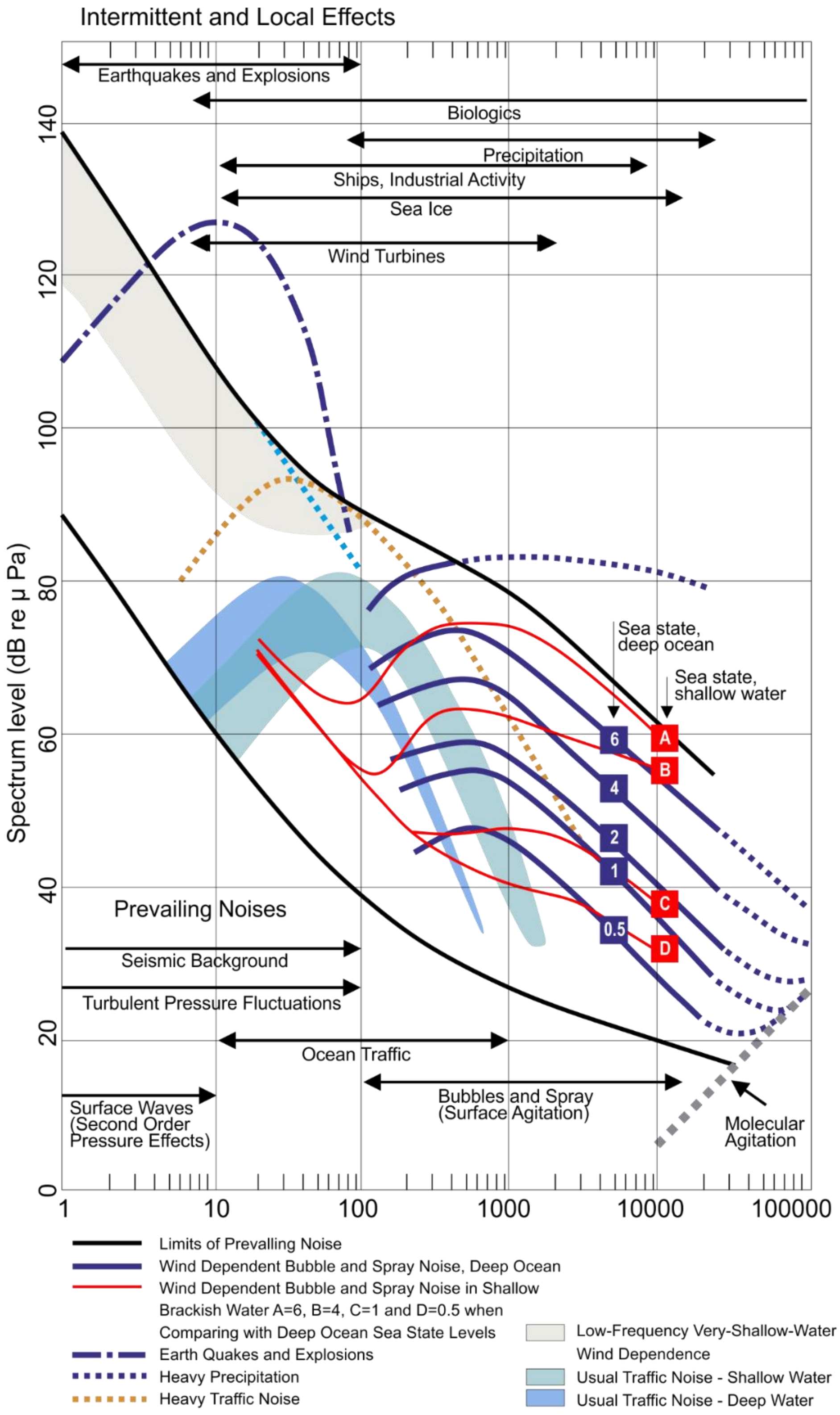

Figure 9-26 Underwater noise spectrum levels in the deep ocean and Baltic Sea, including both natural and anthropogenic sources (after Verfuß *et al.*, 2015).

9.5.2 Impact assessment

The results of underwater noise propagation modelling for the noise-emitting construction activities are reviewed in Section 5.1.5. The applied model for calculating underwater sound propagation is "Parabolic". The underwater sound propagation has been modelled and calculated in the commercial software program dBSea, version 2.2.

Offshore construction activities such as rock installations, trenching, pipe-lay, anchor handling and ship traffic are characterised as continuous noise sources. As described in Section 5.1.5, the underwater noise generated from the construction activities is not distinguishable from ambient noise levels, as the background levels in the Baltic Sea (with large volumes of ship traffic) are relatively high. Hence only noise from munitions clearance is included in the underwater noise propagation modelling. Due to the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapters 4 and 5) and is dealt with as such in the assessments.

The impact on underwater noise (or underwater sound) as a receptor is irrelevant, as it is the marine life perceiving the noise that can be impacted. The impacts on the biological receptors, such as invertebrates, fish and marine mammals are assessed in Sections 9.11 (benthic fauna), 9.12 (fish) and 9.13 (marine mammals). The subject will therefore not be assessed further in this section.

PHYSICAL-CHEMICAL ENVIRONMENT - ONSHORE

9.6 Landscape

In this section, the baseline for landscape onshore near the landfall at Faxe S is described on a general level, and the impact from the project is assessed.

9.6.1 Baseline

The landscape at the landfall was formed during the last glacial period and is a typical subglacial moraine landscape with rolling hills, where a relatively thin moraine layer was deposited under the ice on top of the existing landscape made of lime. In addition, cliffs have subsequently been formed along the coast, as can be seen at Strandegård Dyrehave and further south to the landfall.

The terrain varies between 10-20 m above sea level, but where the lime is very close to the surface, a distinctive formation has arisen, and the city of Faxe has an elevated location of 50 m.

According to the present municipal plan of Faxe, the area is both designated as "larger continuous landscape"[38] and "landscape worth preserving"[39], as presented in Figure 9-27 (Faxe Municipality, 2013b).

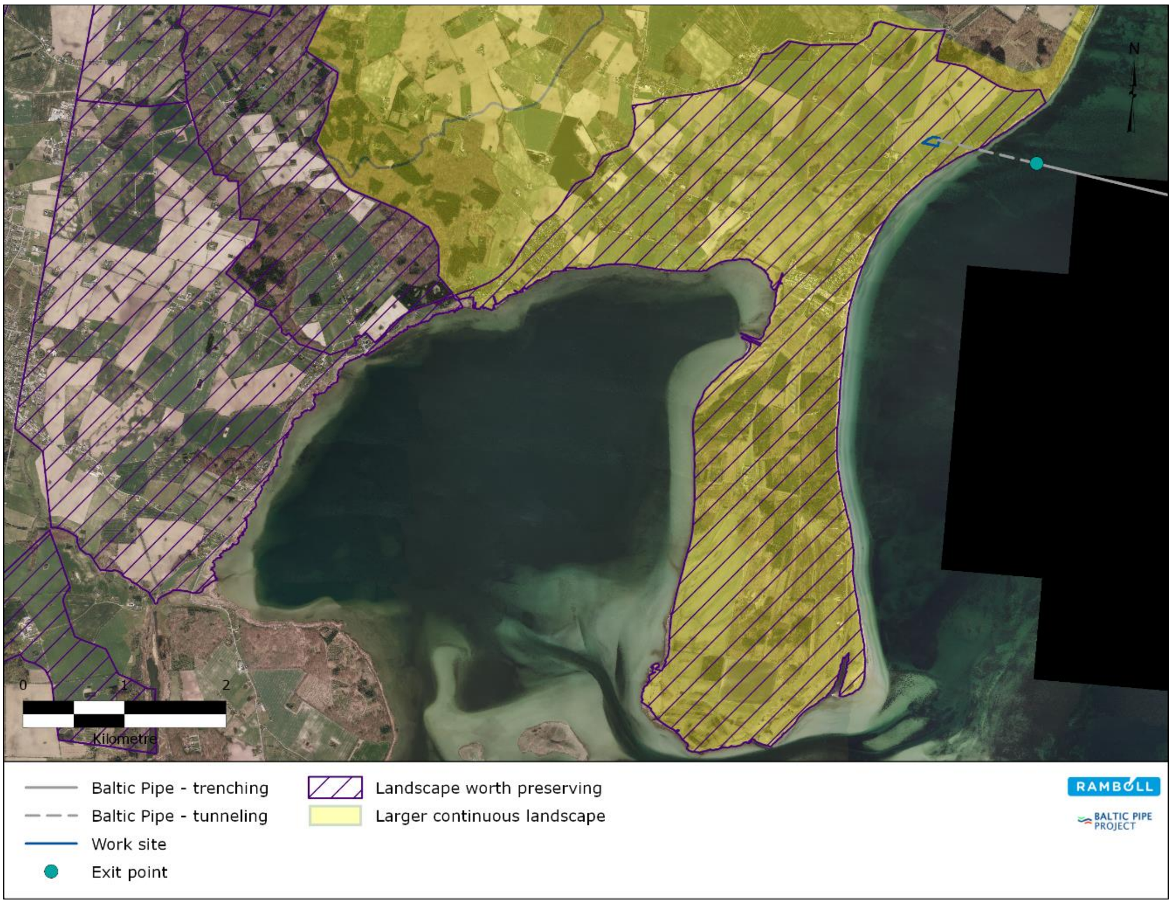

Figure 9-27 Designated landscape interests in the area of the Baltic Pipe landfall at Faxe S.

[38] *Større sammenhængende landskab.*

[39] *Bevaringsværdigt landskab.*

Guidelines for these designations are:

- No major technical facilities should be established;
- Urban development should only take place after a specific assessment.

Furthermore, the coast from Strandegård Dyrehave to Feddet, with Faxe Bugt and Præstø Fjord, is of national geological interest (Gravesen *et al*., 2017). Feddet is the largest spit formation in Denmark and is being constantly transformed due to the erosion of material from the north at Strandegård Dyrehave, which is then transported by sea along the coast to deposition in the drift lines at Feddet.

The composite landscape consists of farmland, forest, different types of coastal stretches, streams, and meadows. The high cliffs provide good views, but also in the open agricultural areas, long views can be achieved in several places. The landscape is to a high degree defined by the many forested areas separated by small, winding roads, some solitary farms, scattered ponds and groves (Faxe Municipality, 2013a).

9.6.2 Impact assessment

The potential impact on landscape onshore are shown in Table 9-42.

Table 9-42 Potential impacts on geological features and landscape.

Potential impact	Construction	Operation
Physical disturbance	X	

Physical disturbance

As the landfall will be constructed by tunnelling, the cliff formations will not be destroyed. Therefore, the only potential disturbance-related impact from the project on landscape is the visual disturbance from the work site and construction activities.

<u>Visual disturbance</u>

Visual disturbance from construction equipment, tunnel elements in concrete, trucks etc., can potentially impact the landscape, as the landfall area is an open field close to the coast with few visual barriers. The construction activities will take place for approximately 11 months for tunneling activities and 2 months for pre-commissioning, but the work site be occupied for 1½-2 years and will be fenced for the whole period. After construction, the area will be re-established, and the landscape will appear as before construction was initiated, i.e. as agricultural fields.

The sensitivity of the landscape to this impact is assessed to be high, as the landfall area is part of designated landscape interests in Faxe Municipality and also part of the national geological interest point that includes Feddet. Additionally, there are few visual barriers. The intensity is assessed to be medium, with a local scale and short-term duration. Combined, the severity of the impact is assessed as minor and not significant (Table 9-43).

Table 9-43 Impact significance on landscape.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance (visual disturbance)	High	Medium	Local	Short-term	Minor	Not significant

9.6.3 Conclusion

The potential impacts on geological features and landscape at the landfall are summarized in Table 9-44.

Table 9-44 Overall impact significance for landscape.

	Severity of impact	Significance	Transboundary
Physical disturbance (visual disturbance)	Minor	Not significant	No

9.7 Geology, groundwater and surface water

In this section, the baseline for geology, groundwater, and surface water in the onshore area at the landfall is described and the impact of the project is assessed.

9.7.1 Baseline

The baseline description is divided into descriptions for geology and groundwater and for surface water.

Geology and groundwater

The description of geology at the landfall is based on information from existing boreholes (GEUS, 2018a), new boreholes, the existing official regional geological model for Sjælland (GEUS, 2018b) and the Danish soil map (GEUS, 2015).

Five new boreholes have been established as part of the initial geotechnical surveys at the landfall. The locations of these boreholes are presented in Figure 9-28. All boreholes were performed to a depth of 30 m and provided detailed information both with respect to geological and geotechnical properties. Figure 9-28 also shows the locations of the two geological profiles at the landfall presented in Figure 9-29 and Figure 9-30. The geological profiles show data from the boreholes and layers from the existing geological model (GEUS, 2018b).

Figure 9-28 Location of boreholes and geological profiles.

The five new boreholes at the landfall are also shown in the geological profile in Figure 9-29. The boreholes show that more than 30 m of clay-dominated glacial deposits superimpose the Cretaceous chalk. Within the clay, there are layers of sand and according to the new boreholes 1F, 2F and 3F, the regional sand layer in the area is found around 20-22 m below terrain and is 1-2 m thick, which is less than the interpreted yellow sand layer originating from the existing geological model also shown in Figure 9-29 and Figure 9-30. In some of the new boreholes, there are also 1-2 m thick sand lenses present at around 5-6 and 12-13 m below terrain, which are both saturated with groundwater.

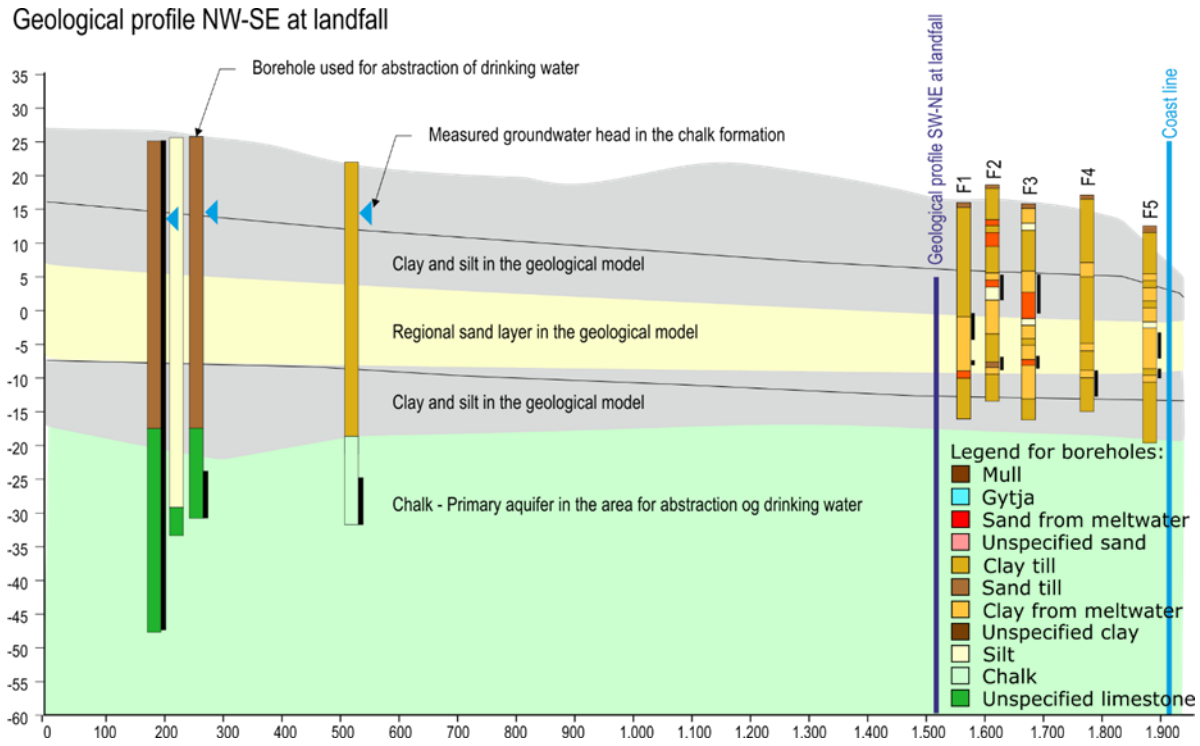

Figure 9-29 Geological profile from northwest to southeast. Interpreted layers from the existing regional geological model are shown on the profile together with borehole data.

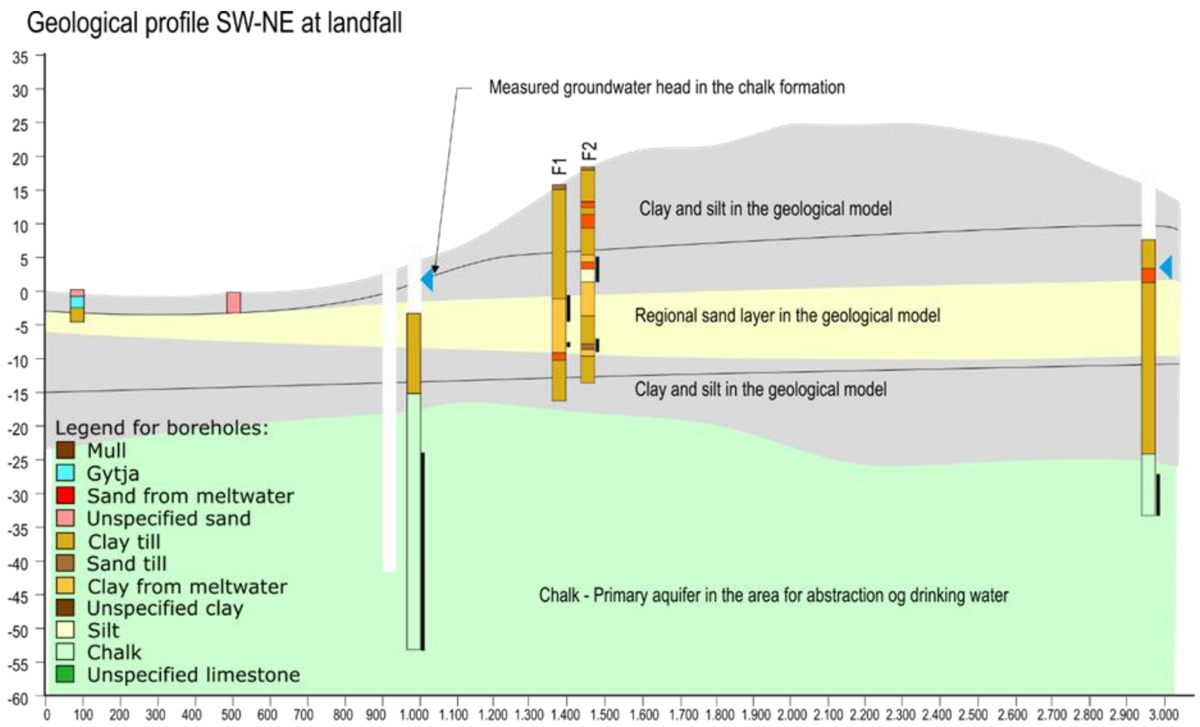

Figure 9-30 Geological profile from southwest to northeast. Interpreted layers from the existing regional geological model are shown on the profile together with borehole data.

The primary aquifer used for abstraction of drinking water is the chalk formation (see Figure 9-29). The groundwater head in the chalk formation is found between 7-12 m below terrain (corresponding to an elevation of 13.5-15 m in DVR90) and the groundwater flow is directed towards the southeast.

Measurements of the groundwater table in the sand layers from the new borehole F2 indicate that the groundwater head in the upper sand is approximately 4 m below terrain (corresponding to an elevation of 14.5 m in DVR90). The groundwater head in the regional sand layer is approximately 6 m below terrain measured in the new boreholes (corresponding to an elevation of 10 m in DVR90). There is thus an upward gradient between the head in the primary aquifer and the head in the sand layers.

As shown in Figure 9-31, there are no designated interests of drinking water within the landfall area and no groundwater abstraction takes place. Designated areas for drinking water interests begin approx. 400 m from shore, outside of the landfall area. There are no groundwater wells or waterworks within the landfall area. The nearest groundwater well, including a smaller waterworks (for water supply of up to 9 households) is located approximately 1,300 m northwest of the coast (St. Elmue Waterworks). The landowner of the landfall area has stated that the water supply for Feddet and Strandegård comes from Orup Waterworks, which is located approximately 1,600 m north of the landfall area (outside the map in Figure 9-31).

Figure 9-31 Groundwater and surface water at the landfall.

As stated above, no water abstraction is occurring at or nearby the landfall area. Furthermore, the primary aquifer is assessed to be well-protected in the area, based on the thickness of the clay overlying the aquifer and the upward gradient. Thus, there are no potential impacts from the project on drinking water and the primary aquifer, which will not be dealt with further. <

Surface water
The nearest stream (Orup Bæk) is located more than 1 km from landfall. Approximately six ponds (small lakes) are scattered around the landfall area. All ponds are located at least 200 m from the work site where construction activities will take place.

9.7.2 Impact assessment

The potential impacts on groundwater and surface water is shown in Table 9-45.

Table 9-45 Potential impacts on groundwater and surface water.

Potential impact	Construction	Operation
Physical disturbance	X	

Physical disturbance
During construction of the Baltic Pipe project, several activities will occur at the work site that cause physical disturbance. The potential impact from physical disturbance on groundwater and surface water is related to lowering of near-surface groundwater when excavating the launch shaft for tunnelling and potential spillage from construction equipment etc. used at the work site.

<u>Lowering of near-surface groundwater</u>
The depth of the launch shaft used for tunnelling is approximately 10 m. As stated in the baseline description, there may be 1-2 m thick sand lenses saturated with near-surface groundwater at this depth. As a result, it may be necessary to drain smaller amounts of near-surface groundwater when establishing the launch shaft. The launch shaft will be established with sheet piles, which will cut off the potential groundwater flow to the shaft. The amount of groundwater that need to be handled is thus expected to be low.

Based on the above, it is unclear whether lowering of near-surface groundwater will be necessary. Near-surface groundwater that may require handling can e.g. be discharged to the sea, which requires a permit from Faxe Municipality, or taken to a wastewater treatment plant.

The sensitivity of surface water to this potential impact is assessed as minor, as the upper soil layers consist of clay with no expected hydrological contact to the ponds. The intensity is minor with a local scale and an immediate duration, as the impact will only occur during excavation of the launch shaft. Overall, lowering of the near-surface groundwater is assessed to be a negligible and not significant impact (Table 9-46).

Table 9-46 Impact significance on surface water.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance (lowering of near-surface groundwater)	Low	Minor	Local	Immediate	Negligible	Not significant

<u>Spillage from construction equipment etc.</u>
During construction at the landfall area, there is a risk of spill at the work site from the construction equipment, including mobile fuel tanks. This could potentially lead to an impact on local groundwater. The risk of a spill will be minimized by complying with existing regulations,

including, *inter alia,* the Act on environmental protection[40] and Administrative Order on oil tanks[41]. Furthermore, a contingency plan (*beredskabsplan*) for the work site will be prepared, which will describe actions to be implemented to minimize the impact on the environment in the event of a spill or accident. The contingency plan must be approved by the authorities.

The sensitivity of the groundwater to this impact is assessed as low, since the primary aquifer is well-protected by a thick clay layer. As the work site will be relatively small, the intensity of the impact is minor. With a local scale and short-term duration, the severity of the impact is assessed as negligible and not significant (Table 9-47).

Table 9-47 Impact significance for ground water.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance (spillage from construction equipment)	Low	Minor	Local	Short-term	Negligible	Not significant

9.7.3 Conclusion

The potential impacts on groundwater and surface water at the landfall are summarised in Table 9-48.

Table 9-48 Overall impact significance for groundwater and surface water during construction.

	Severity of impact	Significance	Transboundary
Physical disturbance (lowering of near-surface groundwater)	Negligible	Not significant	No
Physical disturbance (spillage from construction equipment)	Negligible	Not significant	No

9.8 Climate and air quality

As it is the case with climate and air quality offshore, the focus of this section will be on greenhouse gas emissions and air pollutants. Based on experience from comparable projects, the following components are considered relevant and will be assessed: CO_2, NO_X, SO_X and PM (see Section 9.4 for a description of the polluting components).

9.8.1 Statutory requirements

The statutory requirements regarding greenhouse gas emissions and the limit values for the protection of human health included in the EU Air Quality Directive, which are provided in Section 9.4.1, also apply to climate and air quality in the onshore part of the project.

The limit values from the Air Quality Directive are quality standards for the protection of human health and can be used as assessment criteria for determining the significance of any potential changes in local air quality resulting from the project.

[40] Consolidated Act no. 1121 of 03/09/2018 on environmental protection *(bekendtgørelse af lov om miljøbeskyttelse)*.

[41] Administrative Order no. 1611 of 10/12/2015 on oil tanks *(bekendtgørelse om indretning, etabling og drift af olietanke, rørsystemer og pipelines)*.

9.8.2 Baseline

The onshore part of the project at Faxe S is at present developed as agricultural fields. The existing emissions of CO_2 and air pollutants relate to agricultural machinery and are considered to be relatively small. There are no data available for the existing emissions in the area. In Table 9-49 the total annual emissions in Denmark in 2016 are listed as baseline data.

Table 9-49 Total annual emissions in Denmark in 2016 (Aarhus University, 2018a).

Polluting components	Total emissions in Denmark [ton]
CO_2	37,117,000
NO_X	115.000
SO_2	10,000
PM_{10}	31,000
$PM_{2.5}$	21,000
PM (as total suspended particles (TSP))	91,000

It is assessed that the air quality in the area – especially the amount of NO_X and SO_2 in the air – is dominated by the background level of air emissions, coming from cities or other countries. The air quality in Denmark is monitored by the Danish Centre for Environment and Energy (DCE) at a number of stations around the country. The air quality is monitored in rural areas and in cities (both background emissions in cities and emissions at heavily trafficked streets). Faxe S is considered a rural area. The closest rural monitoring station is at Risø, approximately 55 km from Faxe S. Monitoring data from Risø (hourly based averages) are presented in Table 9-50, which is considered representative for the background level at the landfall at Faxe S.

Table 9-50 Monitoring data from the nearest rural monitoring station, Risø, 2016 (Ellermann *et al.*, 2017), which is considered representative for the background level at the landfall at Faxe S.

Polluting components	Risø monitoring station, 2016 [µg/m^3]
NO_2	7
SO_2	No data available*
PM_{10}	14
$PM_{2.5}$	9

* According to DCE (Ellermann *et al.*, 2017), the concentration of SO_2 has reached very low levels in Denmark. Hence, only limited monitoring at two trafficked stations are considered necessary and there are no data available from rural stations. The limit values are far from exceeded at the most heavily trafficked street in Copenhagen, H.C. Andersens Boulevard.

Figure 9-32 shows a wind rose for a point in Faxe Bugt and is considered as representative for the wind conditions for the landfall at Faxe S. The wind mainly comes from the west / southwest, blowing offshore.

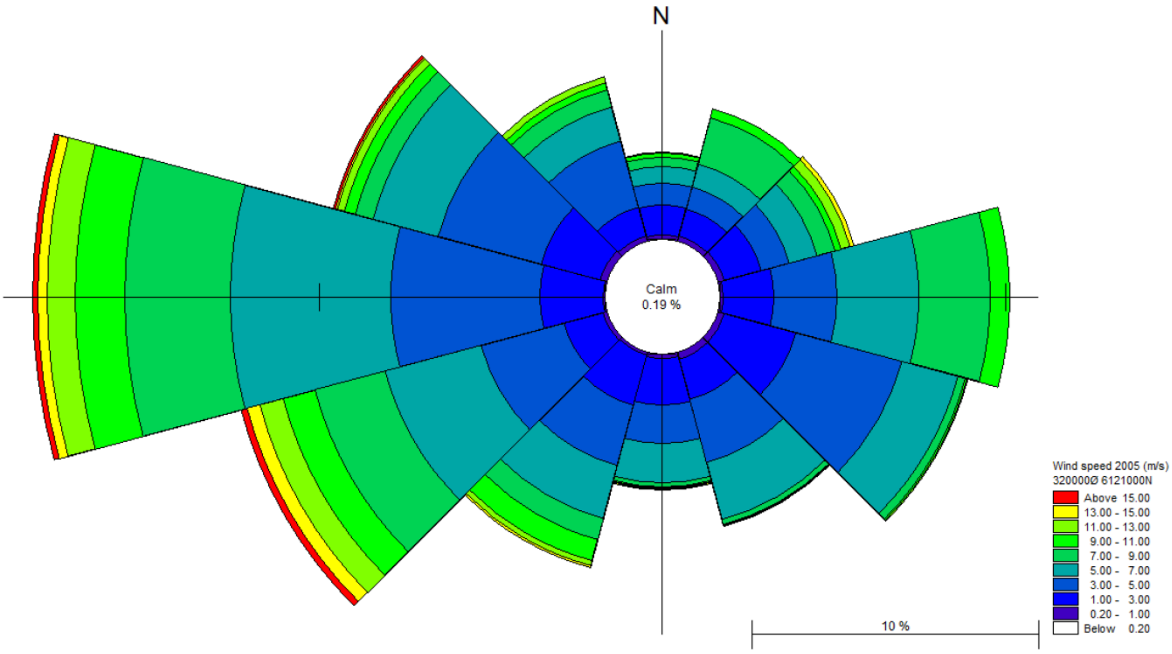

Figure 9-32 Wind rose for Faxe Bugt (2005).

9.8.3 Impact assessment

The only potential impacts from the project on climate and air quality is emissions to air. As stated in Chapter 5, no impacts are expected during operation of the project, as there will be no operational activities at the landfall area (Table 9-51).

Table 9-51 Potential impacts on climate and air quality, onshore.

Potential impact	Construction	Operation
Emissions to air	X	

Emissions to air

Emissions from construction onshore are mainly related to the tunnelling activities and from trucks driving with equipment and soil to/from the landfall area. Furthermore, there are emissions from pre-commissioning, which involves the use of pumps for flooding, cleaning and gauging. The various equipment used for tunnelling will be powered by diesel-driven generators.

To limit the emissions to air, construction equipment covered by the European emission standards for engines in non-road machinery (e.g. dredgers and dozers) should as a minimum live up to stage IIIA. The following assessment is based on this.

Emissions to air from the construction activities on land include both CO_2 emissions, which have an impact on climate, and polluting components, which impact the air quality.

<u>CO_2 emissions</u>

In Table 9-52, the CO_2 emissions from onshore construction activities are shown.

Table 9-52 CO_2 emissions from onshore activities, including pre-commissioning.

	CO_2 emissions [tonnes]
Construction onshore	540

The sensitivity of the climate as a receptor is considered high because of the impact it has on ecosystems in general. CO_2 emissions have a negative, secondary, transboundary, and irreversible impact on climate.

As the yearly emissions constitute approximately 0.001% of the total annual Danish CO_2 emissions, the CO_2 emissions from construction onshore are considered negligible (Table 9-53).

Table 9-53 Impact significance on climate onshore.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Emissions to air (CO_2 emissions) (construction)	High	Minor	Trans-boundary	Short-term	Negligible	Not significant

The CO_2 emissions from the total Baltic Pipe project in Denmark is assessed jointly in the document "Environmental Impact Assessment – Introduction and overall conclusion" (see Figure 1-3).

Polluting components

In Table 9-54, the emissions of polluting components from onshore construction are shown.

Table 9-54 Air emissions from construction onshore, including pre-commissioning.

	Air emissions [tonnes]				
	NO_X	SO_2	PM (TSP)	PM_{10}	$PM_{2,5}$
Construction onshore	9	22*	0.1	0.6*	0.4*

* It has only been possible to estimate SO_2, PM_{10} and $PM_{2.5}$ emissions from the generator used for tunnelling and from trucks driving to and from the work site. Thus, emissions from other contractor machinery are not included for these polluting components.

The air emissions from the onshore construction activities account for less than 1% of the annual emissions in Denmark for all polluting components, which is considered low.

The results of OML modelling of the air quality during tunnelling, which is the phase during construction with the highest impact on air quality, are presented in Table 9-55 (see Section 5.3.4 for further information on OML modelling). The limit values and the modelling results, including the background level (see Table 9-50) at a distance of 175 m from the work site are presented, as this is the nearest location at which the limit values according to the Air Quality Directive must be complied with due to the presence of a dwelling (see Section 9.4.1).

Table 9-55 shows that the air quality during tunnelling decreases with the distance from the work site. The limit values for all parameters at a distance of a minimum of 175 m from the work site are complied with.

Table 9-55 OML modelling results for the impact on air quality in the surroundings during tunnelling, including the background level of the air quality (see Table 9-50). Furthermore, limit values according to the Air Quality Directive by comparison.

Distance from work site	NO_x [µg/m³]		SO_2 [µg/m³]		PM_{10} [µg/m³]		$PM_{2.5}$ [µg/m³]
	1 hour*	Calendar year	1 hour**	24 hours ***	24 hours ****	Calendar year	Calendar year
50 m	601	112	1460	749	21	16	10
100 m	566	95	538	291	17	15	10
175 m	163	24	214	110	15	14	9
250 m	71	14	118	59	15	14	9
500 m	34	9	53	19	14	14	9
1,000 m	19	8	27	9	14	14	9
1,500 m	15	7	17	5	14	14	9
Limit value	200	40	350	125	50	40	25 (20)

* The 19th largest average concentration in an hour.

** The 25th largest average concentration in an hour.

*** The 4th largest average concentration in 24 hours.

**** The 36th largest average concentration in 24 hours.

The sensitivity of the air quality at landfall as a receptor is considered low, as the existing background level is low, the spreading conditions in the area are good and the wind direction is mainly coming from west / southwest, blowing offshore. The intensity of the impact is minor with a short-term duration. The scale is mainly local but can also be regional. Combined, the severity of the polluting components from construction equipment at the work site is assessed as negligible (Table 9-56).

Table 9-56 Impact significance on air quality onshore.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Emissions to air (polluting components)	Low	Minor	Local to regional	Short-term	Negligible	Not significant

9.8.1 Conclusion

The potential impacts on climate and air quality resulting from the onshore construction activities at the landfall in Faxe S are summarized in Table 9-57.

Table 9-57 Overall impact significance for climate and air quality onshore.

Potential impact	Severity of impact	Significance	Transboundary
Emissions to air (CO_2 emissions)	Negligible	Not significant	Yes
Emissions to air (polluting components)	Negligible	Not significant	No

Impacts on human health because of increased air emissions from the project are assessed in Section 9.32.

9.9 Noise

In this section, the baseline for noise is described and the impacts from the project are assessed. The assessment is made on the basis of guidelines for noise from construction work including guiding limit values, which is related to people and human health. Thus, the conclusions from this section is used as input in the assessments regarding the receptors people and human health (Section 9.32) and tourism and recreational areas (Section 9.33).

9.9.1 Guidelines for noise from construction work

Noise from construction work will often vary, even over a shorter period. During a day, many activities can take place at the same time or sequentially, which causes variations in the construction noise. Also, over an extended period, there may be very significant variations when the construction work progresses from one phase to another. Finally, it is characteristic that construction work, and hence the noise, is temporary and will eventually cease altogether when the construction work is complete.

Guiding limit values for noise from construction work

Noisy construction work must be notified to the municipality where the work is to be performed, in this case Faxe Municipality, prior to commencement. The municipality can thus demand the limitation of possible nuisance from noise and other influences.

In Denmark, there are no general indicative limit values for noise from construction work. It is normal practice that noise considerations related to construction work are primarily aimed at limiting nuisance for dwellings for permanent residence and buildings with similar applications, according to the guiding noise limit values and regular working hours indicated in Table 9-58. These guiding limit values will be applied for assessing the impact of noise from the construction activities of the Baltic Pipe project. If the values are complied with, the noise from the construction work is considered to be not significant.

Table 9-58 Guiding limit values for noise from construction work. The values are the energy equivalent, corrected, A-weighted noise level, Lr in dB. The values are used to assess noise on the facade of dwellings for permanent residence and buildings with similar application.

Period of time	Guiding limit values for noise from construction activities
Regular working hours (day period on weekdays, Monday – Friday at 07-18)	70 dB(A)
All other periods of time	40 dB(A)

The guiding limit values are equivalent noise levels, i.e. the average noise level over a given period. The averaging period varies over the day and over the week[42], see Table 9-59.

Table 9-59 Periods of time and associated averaging periods for assessing construction noise.

Period of time	Averaging period
Monday – Friday at 07-18	Continuous 8 hours with the most noise
Saturday at 07-14	Entire period (7 hours)
Saturday at 14-18	Entire period (4 hours)
Sunday at 07-18	Continuous 8 hours with the most noise
All days at 18-22	Most noisy 1 hour
All days at 22-07	Most noisy ½ hour

[42] Guidance on noise policy from the Danish EPA (nr. 5/1984, Ekstern støj fra virksomheder).

Impulses and tones in the noise
For certain types of construction work, there is a risk that noise will contain clearly audible pulses or tones that are considered particularly irritating. The additional nuisance associated with clearly audible pulses and tones corresponding to the measured or calculated noise level will receive an additional 5 dB. The surcharge is never more than 5 dB, even if both impulses and tones occur in the noise simultaneously.

However, it is only in a controlled situation during the performance of the work that one can safely determine whether these phenomena are included in the construction noise and whether noise from other sources, such as traffic noise, is masking any impulses or tones so that they are not clearly audible.

During the construction work at the landfall area, clearly audible impulses in sheet piling are likely to occur, if the distance to the piling work is less than a few hundred meters. At greater distances, the likelihood of audible pulses is reduced because other noise can mask how clearly the impulses can be heard.

For the other construction activities, it is less likely that audible impulses or tones will appear in the noise regardless of the distance between the construction work and the nearest dwellings.

Low frequency noise
Low-frequency noise is the part of the total noise that is in the frequency range 10 - 160 Hz. Low-frequency noise is assessed indoors in buildings. It is not expected that the construction work will include noise sources that particularly emit low-frequency noise. Therefore, it will be the total noise (i.e. all audible frequencies) that determine whether noise in general will give rise to a significant nuisance. This will also be the case at greater distances from the noise sources, although the noise can be perceived as more low-frequency, because high-frequency noise attenuates more rapidly than low-frequency noise over greater distances.

9.9.2 Baseline
The work site for the landfall is located in a partly secluded and rural area south of Faxe Ladeplads with a very limited number of dwellings within a radius of 1,000 m from the planned work site. There are only minor roads leading to the work site, and the average road traffic noise level is considered to be relatively low.

The noise level in the area originates from agricultural machinery and traffic to the recreational area at 'Feddet' south of Dyrehavegård and is considered mostly seasonal and relatively low. There are no data available for the existing noise level in the area.

9.9.3 Impact assessment
Noise from the offshore activities at the landfall relates to the construction activities at the work site and the extra amount of traffic. The potential impacts on noise is listed in Table 9-60.

Table 9-60 Potential impacts on noise.

Potential impact	Construction	Operation
Airborne noise	X	

Airborne noise
Airborne noise is related to noise from the work site and noise from the construction related traffic.

Noise from the work site

Construction work at the landfall area involves the use of a variety of machines and equipment that can cause disturbing noise in the surroundings. Calculations have been made for the activities within each construction phase, which have been assessed as the noisiest (see Section 5.3.3 for information about airborne noise modelling):

- Phase 1 - Clearing of the work site;
- Phase 2 - Sheet piling and excavation (launch shaft);
- Phase 3 – Tunnelling;
- Phase 4 - Pre-commissioning;
- Phase 5 - Restoration of the launch shaft and work site.

The modelling results are compared to the applied guiding limit values for significant noise from construction work (Section 9.9.1) in order to describe the extent of the noise impact zones within regular working hours (distance to the energy equivalent, corrected, A-weighted noise level, L_r, of 70 dB(A)) and outside regular working hours (distance to the noise level, L_r, of 40 dB(A)).

For each of the five construction phases, approximate distances based on propagation calculations from the work site to the noise impact zones are specified in Table 5-17. The measures in the table indicates the distance from the acoustical centre of the construction work to the noise impact zones for 70 dB(A) and 40 dB(A), respectively.

Table 9-61 Distances calculated from the acoustical centre of the construction work during each of the five construction phases to the extent of the noise impact zones within and outside regular working hours, respectively.

Construction phase	Noise impact zone	Distance
Phase 1 Clearing of the work site	70 dB(A)	60 m
	40 dB(A)	800-900 m
Phase 2 Sheet piling and excavation (launch shaft)	70 dB(A)	140-150 m
	40 dB(A)	1,600-2,600 m
Phase 3 Tunneling	70 dB(A)	25 m
	40 dB(A)	400-550 m
Phase 4 Pre-commissioning	70 dB(A)	70 m
	40 dB(A)	1,000-1,500 m
Phase 5 Restoration of the launch shaft and work site	70 dB(A)	30 m
	40 dB(A)	500-600 m

A large proportion of the construction noise is comparable to the operating noise from agricultural machinery that is expected to be well-known in the area, which is presently agricultural in use. However, noise from operating a dozer during the initial phase of clearing the work site, some of the noise from tunnelling and pre-commissioning and especially the noise from sheet piling will differ from the usual soundscape in the area. Sheet piling is expected to be the most significant noise source during the construction phase.

Noise maps illustrating the noise contours for 70 dB(A) and 40 dB(A) noise levels for construction phases 2, 3 and 4 are presented in Figure 9-33, Figure 9-34 and Figure 9-35, respectively, as they represent the phases that are either the noisiest or have the longest duration. The locations of the nearest dwellings, St. Elmuevej 2 and Feddet 3A and 3B, are specified on the maps.

Figure 9-33 Noise map for phase 2, sheet piling and excavation (launch shaft) (1-2 weeks duration) presenting the noise contour for 70 dB(A) level. Sheet piling is expected to take place within regular working hours, where the applied guiding limit value is 70 dB(A). The 40 dB(A) noise contour is not presented, as it occurs primarily outside the extent of the map.

Phase 2, sheet piling as part of excavating and establishing the launch shaft for tunnelling, will take 1-2 weeks, which is considered an immediate duration. This construction phase will affect most dwellings with noise levels above 40 dB(A), see Figure 9-33. However, the construction activities of this phase are expected to take place during regular working hours, where the applied guiding limit value is normally 70 dB(A). No dwellings will be affected above 70 dB(A) and the applied guiding limit value is thus complied with. The intensity of the impact is assessed as large and the scale is regional. The sensitivity of the receptor is medium, as the impact takes place during regular working hours. Combined, the severity of phase 2, sheet piling is assessed as minor, as the duration is immediate and the applied guiding limit values are complied with. The impact is thus not significant, Table 9-62.

Figure 9-34 Noise map for phase 3, tunnelling (20 weeks duration), presenting the noise contours for 40 dB(A) levels and 70 dB(A) levels. The activities during this phase will take place 24 hours a day.

Phase 3 comprises tunnelling and is expected to take approximately 20 weeks. The noise from this phase mainly relates to the diesel-driven generators providing power for the construction equipment. The activities will take place 24 hours a day over a short-term duration. The sensitivity of the receptor is high outside regular working hours. A few dwellings will be impacted by noise levels above 40 dB(A) outside regular working hours and thus the applied guiding limit value is exceeded for these dwellings, see Figure 9-34. The intensity of the impact is assessed as medium with a local scale. Combined, the severity of noise from phase 3, tunnelling, is assessed as moderate and significant.

Phase 4, pre-commissioning, is expected to take approximately 2 months, also with activities taking place 24 hours a day. Thus, the sensitivity of the receptor is assessed as high. Noise from this phase is mainly generated from the diesel-driven pumps and the applied guiding limit value of 40 dB(A) is exceeded for dwellings located within a range of 1,000-1,500 m from the work site. The intensity of the impact is assessed as medium with a local scale. Combined, the severity of the noise from phase 4, tunnelling, is assessed as moderate and significant (Table 9-62).

Figure 9-35 Noise map for phase 4, pre-commissioning (two months), presenting the noise contours for 40 dB(A) levels and 70 dB(A) levels. The activities during this phase will take place 24 hours a day.

Phase 1 and 5 are assessed together, as the activities are very similar. Both phases are expected to take 1-2 weeks and the noise will come from dozers, dredgers and trucks. These phases will take place within regular working hours. The sensitivity of the receptor during regular working hours is assessed as medium. The intensity of the impact is minor, the scale is local, and the duration is considered as immediate. Combined, the severity of the impact is negligible and thus not significant (Table 9-62).

Table 9-62 Impact significance on noise at the landfall area from airborne noise – before mitigation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise (construction phase 1 and 5)	Medium	Minor	Local	Immediate	Negligible	Not significant
Airborne noise (construction phase 2)	Medium	Large	Regional	Immediate	Minor	Not significant
Airborne noise (construction phase 3)	High	Medium	Local	Short-term	Moderate	Significant
Airborne noise (construction phase 4)	High	Medium	Local	Short-term	Moderate	Significant

Mitigation measures

During the phases of tunnelling (phase 3) and pre-commissioning (phase 4) the activities are expected to take place 24 hours a day for periods of up to 20 weeks for tunnelling and two months for pre-commissioning. The results of the noise calculations for these phases show noise levels exceeding the applied guiding limit value for construction work carried out outside regular working hours at nearby dwellings. Mitigation measures must therefore be considered necessary during the phases that will require work outside of regular working hours.

The construction noise at the nearest dwellings is shown in Table 9-63.

Table 9-63 Noise levels at the nearest dwellings during the phases 3, tunnelling, and phase 4, pre-commissioning.

Construction phase	Location	Noise level, L_r
Phase 3 Tunneling	Feddet 3A & 3B (summer house)	50 dB(A)
	St. Elmuevej 2 (dwelling, Strandegård)	45 dB(A)
Phase 4 Pre-commissioning	Feddet 3A & 3B (summer house)	55 dB(A)
	St. Elmuevej 2 (dwelling, Strandegård)	50 dB(A)

As the applied guiding limit value outside regular working hours is 40 dB(A), the exceedance ranges from 5-15 dB. Construction noise from tunnelling must be limited by approximately 10 dB and noise from pre-commissioning by approximately 15 dB, which will be rectified with mitigation measures in order to comply with the guiding limit value.

The mitigation measures may consist of a combination of the use of noise barriers, sound insulation of the stationary machinery i.e. generators and pumps and/or less noisy machinery. A commonly used temporary noise barrier at similar construction projects is metal shipping containers stacked atop each other to a sufficient height; usually two or three layers result in a combined height of 5-7.5 m. Similar screening effects can be obtained using large straw bales stacked atop one another. It is expected that a combination of temporary noise barriers and sound insulation of the static machinery or application of less noisy machinery may provide a sufficient reduction of the construction noise at the nearby dwellings to comply with the stricter guiding limit value of 40 dB(A) outside regular working hours. This will result in a medium intensity of the impact for the phases 3 and 4, and the severity of the impact is assessed to be minor and not significant (Table 9-64).

Table 9-64 Impact significance on noise at the landfall area from airborne noise – after mitigation (only phases 3 and 4).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise (construction phase 3)	High	Medium	Local	Short-term	Minor	Not significant
Airborne noise (construction phase 4)	High	Medium	Local	Short-term	Minor	Not significant

Noise from traffic

The traffic related to the construction activities at the work site will mainly consist of trucks to/from the local road, St. Elmuevej. When traveling on public roads, the noise from the trucks is considered road traffic noise, which is governed according to other guidelines without requirements for limiting nuisance for the adjacent dwellings.

Approximately 1,180 trucks will be needed during the whole construction period. On average the daily number of trucks to the work site are expected to be approximately 6 (resulting in 12 transports in total). Most of the trucks will be needed for transport of excavated soil from the tunnel away from the site. During the most intensive period, where both soil from tunnelling will be transported away from the work site and pre-fabricated tunnel elements will be transported to the work site, approximately 18 trucks will be needed per day for three weeks and 15 trucks will be needed per day for another six weeks, resulting in a total of approximately 36 and 30 transports each day, respectively. Additionally, transport of personnel to and from the work site will also generate traffic throughout the construction period.

As the average road traffic noise level is considered relatively low on the minor roads leading to the work site, it must be expected that the residents along these roads will experience a temporary, but significant increase in the road traffic noise due to the increased number of trucks. The sensitivity of the receptor is assessed as medium and the intensity as medium on average, but large during the most intensive periods. The scale is local to regional, and the duration is short-term. All combined, the severity of the impact is considered minor on average and moderate during the most intensive periods. However, the impact is not significant (Table 9-65).

Table 9-65 Impact significance on noise from traffic.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise (traffic)	Medium	Medium to large	Local to regional	Short-term	Minor to moderate	Not significant

9.9.4 Conclusion

The potential impacts on noise from the work site and construction related traffic from the onshore construction activities of the Baltic Pipe project are summarized in Table 9-66.

Table 9-66 Overall impact significance on noise after implemented mitigation measures (only for the phases 3 and 4).

Potential impact	Severity of impact	Significance	Transboundary
Airborne noise (construction phase 1 and 5)	Negligible	Not significant	No
Airborne noise (construction phase 2)	Minor	Not significant	No
Airborne noise (construction phase 3)	Minor	Not significant	No
Airborne noise (construction phase 4)	Minor	Not significant	No
Airborne noise (traffic)	Minor to moderate	Not significant	No

Impacts on human health due to increased noise from the project activities at the landfall at Faxe S are assessed in Section 9.32.

BIOLOGICAL ENVIRONMENT - OFFSHORE

9.10 Plankton

In this section, the baseline for phyto- and zooplankton in the area is described and the impact of the project is assessed. As the subject has been scoped out for the Danish section of the Baltic Pipe (per the scoping decision from the Danish Energy Agency), this section therefore contains a description of the baseline situation for plankton, which is included for alignment with the Swedish and Polish EIAs concerning the Baltic Pipe project. No impact assessments are included in this report.

9.10.1 Baseline

The pelagic environment (the free water masses) of the oceans contains a huge number of microscopic organisms, called plankton. The movement of plankton in the water is largely determined by the movements of the water masses. Phytoplankton and zooplankton are the primary key components of the planktonic communities. However, bacterio- and ichthyoplankton also play a vital role, as these species groups are resilient to impact.

Phytoplankton

Phytoplankton are photosynthetic organisms, which are the main contributor to the primary production in the oceans and form the primary link in the marine ecosystem and food web between the primary production and the higher trophic levels. Phytoplankton also play a significant role in the biogeochemical cycles of the oceans, especially the carbon and the nutrients cycles.

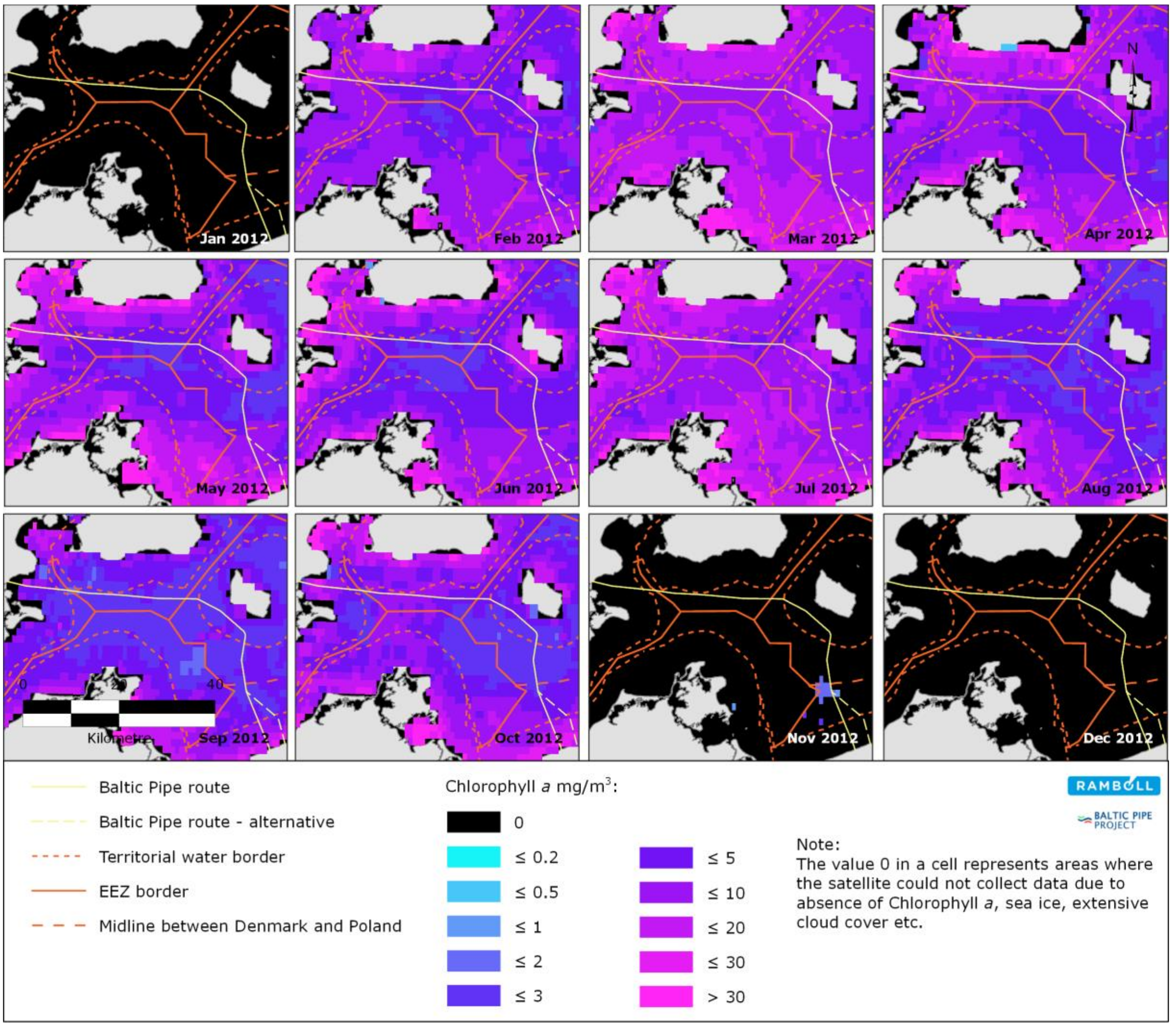

Figure 9-36 Surface chlorophyll-*a* concentration per month during 2012 (a representative year) based on the MODIS satellite (European Commission, 2015).

The annual cycle of phytoplankton growth is controlled mainly by the water temperature, light availability and nutrient concentrations in the photic zone (see Section 9.2.1). Consequently, the spring bloom occurs when the water temperature and light availability are sufficient, and a smaller autumn bloom occurs when winds cause mixing of the nutrient-rich bottom waters to the photic zone. In the Arkona Basin, the average timing of the onset of the spring bloom is in February-March, but the timing can shift depending on weather conditions (Sand-Jensen ed., 2006).

The phytoplankton production in the Baltic Sea is often measured by the chlorophyll-*a* content in the water column. The average chlorophyll-*a* concentration per month during a full year (2012) is presented in Figure 9-36. Along the pipeline route in Danish waters, the highest concentrations of chlorophyll-*a* were seen in the coastal areas at Faxe Bugt, see Figure 9-36 (European Commission, 2015). In the offshore areas, the chlorophyll-*a* concentration is often low (<5 mg/m^3), indicating a low phytoplankton production, see Figure 9-36 (European Commission, 2015).

Long-term measurements of chlorophyll-*a* concentrations have been taken from monitoring stations in the Arkona Basin (Feistel *et al.*, 2008). In Figure 9-37, the seasonal variation has been presented, with the initiation of spring bloom in February (on average) and the peak of the bloom in March-April.

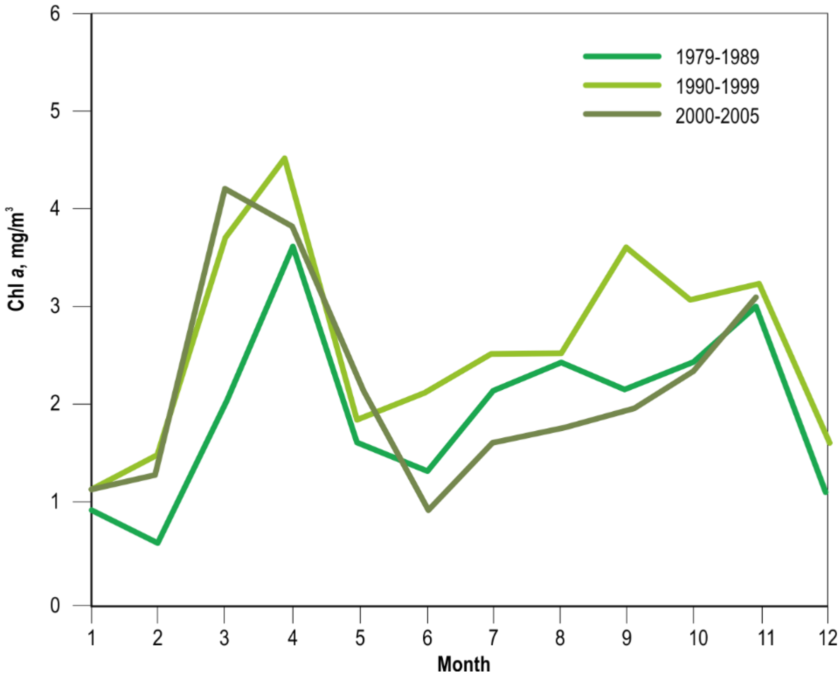

Figure 9-37 Seasonal variation of chlorophyll-*a*. Figure redrawn from Feistel *et al.*, 2008. Chl a: Chlorophyll-*a.*

The chlorophyll-*a* concentrations have been measured as profile sampling in connection with the Baltic Pipe project. Data analyses have been presented in Section 9.2. The data analyses show that the spring bloom has started, which corresponds with the average onset of the spring bloom presented in Figure 9-37.

As the growth rate of phytoplankton is very fast (2-6 days), phytoplankton is not sensitive to impacts that can lead to reductions in growth (e.g. reduced light availability). On the other hand, phytoplankton can respond quickly by increasing their growth rate, if nutrients and light become available. Hence phytoplankton or chlorophyll-*a* is often used as an indicator of eutrophication/excess nutrient loading.

Diatoms and dinoflagellates are characteristic in the southern Baltic Sea, where the salinity is higher than in the remaining parts of the Baltic Sea (Hansen *et al.*, 2018). During spring, the dominating genera, which are all diatoms, are *Chaetoceros*, *Coscinodiscus*, *Rhizosolenia*, *Skeletonema* and *Thalassioseira*, whereas *Actinocyclus*, *Cerataulina*, *Dactyliosolena, Probiscia* and *Pseudonitzschia* are predominant during the summer period. In autumn, the phytoplankton is dominated by *Coscinidiscus granii* and the dinoflagellates *Ceratium* and *Prorocentrum* (Andersson *et al.* 2017, Wasmund *et al.,* 2008, 2011). The survey results (March 2018) confirmed that diatoms dominated the sampling campaigns both with respect to abundance and biomass, and the samples were dominated by *Thalassiosira levanderi*, *T. decipiens, T. baltica, Skeletonema marinoi, Chaetoceros subtilis*, *Chaetoceros* spp and *Actinocyclus* spp.

Zooplankton

Zooplankton are microscopic animals, which in the classical food web form the link between the photosynthetic organisms and the higher organisms, such as fish.

In the Arkona Basin, the zooplankton production fluctuates during the year and is closely linked to their food source, the phytoplankton (and microzooplankton, such as ciliates and flagellates).

The spring bloom occurs in connection with the phytoplankton bloom, though it is slightly delayed and at a lower intensity. The turnover rate of zooplankton is less than 1 year. The overall dominating species group is the calanoid copepods (Ojaveer *et al*., 2010), which has been confirmed by the monitoring performed in connection with this project (on 23 and 26 March 2018), where *Acartia* spp. was the overall dominating species, both with respect to abundance and biomass. Other identified species included *Centropages hamatus, Temora longicornis* and *Pseudocalanus acuspes*.

9.10.2 Conclusion

Plankton organisms are not sensitive to construction or operation of the pipeline. Nearshore, very short-term and local impacts can occur in connection with sediment spill because of the resulting reduction in light availability (shading), which can reduce growth of phytoplankton or cause a delay of the spring bloom (if shading effects occur simultaneously with the bloom). Offshore, an impact on plankton is not likely to occur, as the majority of the spill will occur below the halocline and below the depth of phytoplankton growth.

Impacts are not likely to be significant and will not be dealt with further (potential impacts are scoped out, per the 2018 scoping decision from the Danish Energy Agency).

9.11 Benthic habitats, flora and fauna

In this section, the baseline for benthic habitats, flora and fauna is described and the impacts from the project are assessed.

9.11.1 Baseline

Benthic habitats

In order to assess the potential impact on the benthic environment, knowledge of the prevailing physical living conditions is essential. Distinct characteristics of these living conditions can be integrated into so called habitats. Habitats can be defined as *"a particular environment which can be distinguished by its abiotic characteristics and associated biological assemblage, operating at particular, but dynamic spatial and temporal scales in a recognizable geographic area"* (ICES, 2006).

Benthic habitat mapping within a distinct region into specific geographic areas provides a tool for determining the fundamentals of good ecological status in the sea. Therefore, benthic habitat mapping is central for implementing the EU Marine Strategy Framework Directive and the HELCOM Baltic Sea Action Plan (HELCOM, 2007).

To determine the habitats of the project area, the BALANCE project (BALANCE, 2013) has been used, together with the Danish marine substrate classification system (Naturstyrelsen, 2013). The BALANCE project meets the needs of straight forward and reproducible habitat mapping within the Baltic Sea region. For the entire Baltic Sea region, 60 different benthic habitat types have been identified, and each of the habitat types reflect its specific combination of basic physical properties, i.e. *substrate*, *light* and *salinity*. These three constrains form the basic living conditions for the benthic organisms, which potentially can inhabit the specific area. The impact of the pipeline construction and operation on the benthos should be assessed in relation to how these conditions are disturbed.

<u>Substrate</u>

Four categories of substrate are applied in this baseline for describing the habitat types based on the BALANCE mapping and the Danish classification system for marine sediments (see details in Box 9-1):

- Bedrock;
- Hard bottom complex, which includes patchy hard surfaces and coarse sand (sometimes also clay) to boulders;
- Sand, including fine to coarse sand (with gravel exposures);
- Fine grained sediment (silt and clay), including particulate organic matter.

BOX 9-2: BALANCE substrate types and Danish marine substrate classification

The classification of the seabed sediment applied in the BALANCE mapping of the Baltic Sea consists of five substrate classes:

I) Bedrock;
II) Hard bottom complex, which includes patchy hard surfaces and coarse sand (sometimes also clay) to boulders;
III) Sand including fine to coarse sand (with gravel exposures);
IV) Hard clay sometimes/often/possibly exposed or covered with a thin layer of sand/gravel and pebbles;
V) Mud consisting of fine grained particles (clay and silt) and some organic compounds.

In this EIA, the two BALANCE substrate types "hard clay bottom" and "mud bottom" are merged into a single category called "fine grained sediment", since these two bottom types virtually appear only in the non-photic zone at depths greater than 20 m. Both grain types and textures generally represent similar physical constraints for benthic fauna. In this way, the number of different defined habitat types is reduced accordingly, thereby making the task of describing habitat baselines more operative.

The definition of marine substrate used by the Danish authorities (Naturstyrelsen, 2013) for classification of the seabed of Danish coastal waters is subdivided into four categories of sediment types with or without pronounced biogenic structures:

1) Sand, silt and clay with varying components of shells and gravel;
2) Coarse sand, gravel and pebbles;
3) Sand, gravel and pebbles with a sporadic presence of stone;
4) Bedrock areas and reefs with 25-100% coverage of boulders from spread distribution to more aggregated forms (reefs with or without hollow-forming elements)

The Danish classification diverges to some degree from the BALANCE classification especially due to the wide patchy presence of pebbles and stones in Danish waters. BALANCE substrate class I and II correspond to Danish substrate type 4. Because bedrock is a rather scarce feature in Danish waters and furthermore offers the same physical properties as reef structures, bedrock in the Danish classification is included in the reef substrate type 4. On the other hand, bottom areas with a sporadic presence of stones and pebbles on a sandy bottom, and which belong to a separate class (substrate type 3) in Denmark, fall in between substrate class II and III in the BALANCE classification. The Danish substrate type 2 corresponds to substrate class III, while Danish substrate type 1 covers both substrate class IV and V in the BALANCE classification.

The planned pipeline route of the Baltic Pipe project will cross all four substrate types defined above (Figure 9-38). The seabed mapping used for the habitat description corresponds well to the substrate types revealed by the survey performed along the pipeline route in June 2018 (Section 9.3). The four categories used in the survey, i.e. clay/silt, limestone, silt/fine sand and till, can be compared with some overlap to the BALANCE categories shown in Box 9.2. Clay/silt corresponds to the BALANCE category IV and V, whereas "silt to fine sand" encompasses both the coarser part of category V and the finer part of category III in Box 9.2. "Till", which describes glacial deposits, can be the found in both BALANCE categories II and III, while limestone belongs in category I. The reason for using the BALANCE classification system for the habitat mapping is because the BALANCE delimitation of the substrate categories better reflects the living condition related to the substrate texture than the categories used for describing the seabed in Section 9.3.

Generally, epibenthic organisms (not buried in the sediment) will mainly be associated with solid surfaces, which comprise the hard bottom substrate. However, many species of epiphytes and epifauna can also benefit from the physical presence of other organisms and will thus also appear on substrate types classified as sand, hard clay, or mud. This applies especially to environments that allow the presence of eelgrass and mussels. Otherwise, mainly infauna (buried in the sediment) and motile species of crustaceans, molluscs and echinoderms (nectobenthos) dominate the sandy and muddy bottom areas.

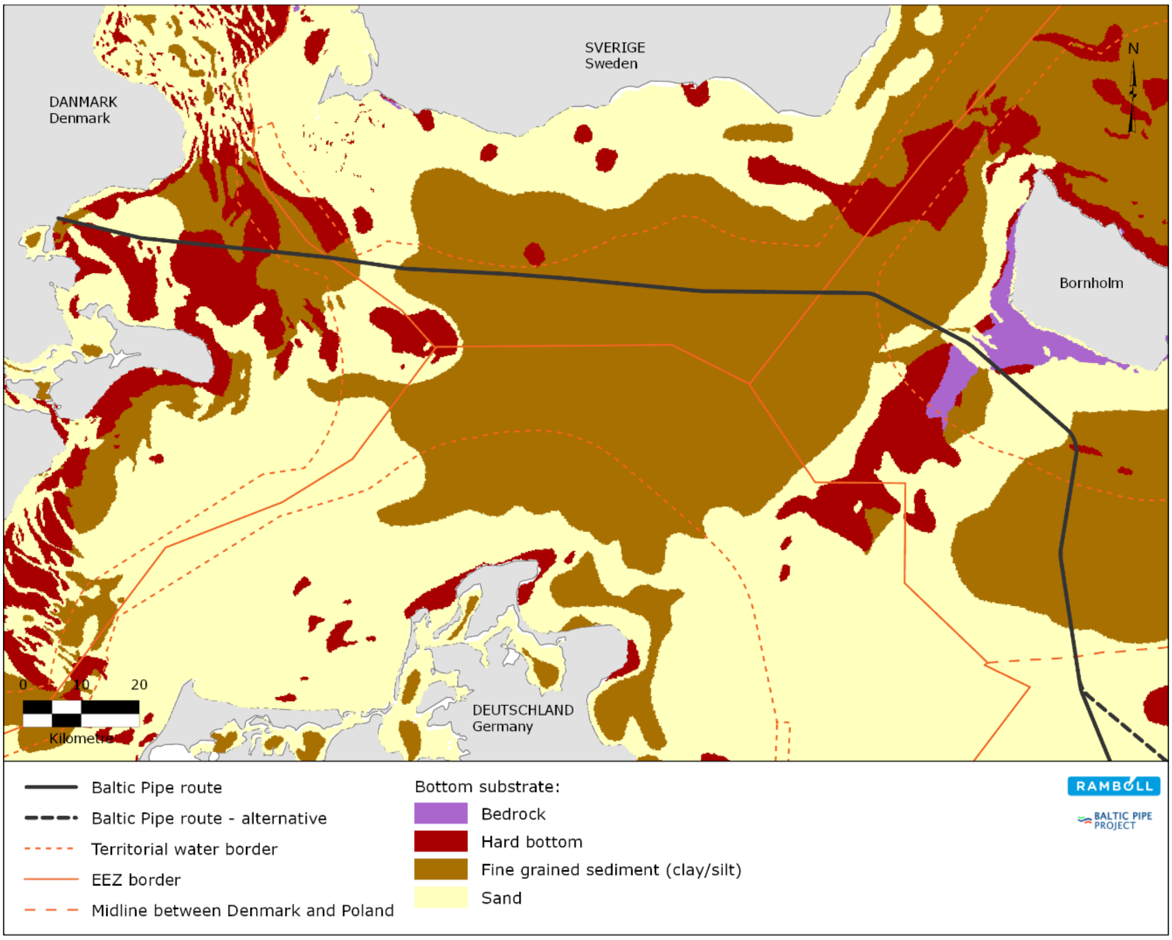

Figure 9-38 Substrate types along the Baltic Pipe project transect routes. Modified from BALANCE (BALANCE, 2013).

Light

Light is a primary physical parameter influencing and structuring the biological communities in the marine environment, as it is the driving force behind the primary production by providing the energy for photosynthesis. The depth of the photic zone is traditionally defined for benthic flora as the depth where at least 1% of the surface irradiance (as measured just below the water surface) is available for photosynthesis. Generally, less than 1% of the surface light will remain at depths between 15 to 20 m (non-photic zone) in the south-western part of the Baltic Sea during the productive season (March-October), and only a relatively limited area of the seabed in the Danish part of the Baltic Sea lies within the photic zone (Figure 9-39).

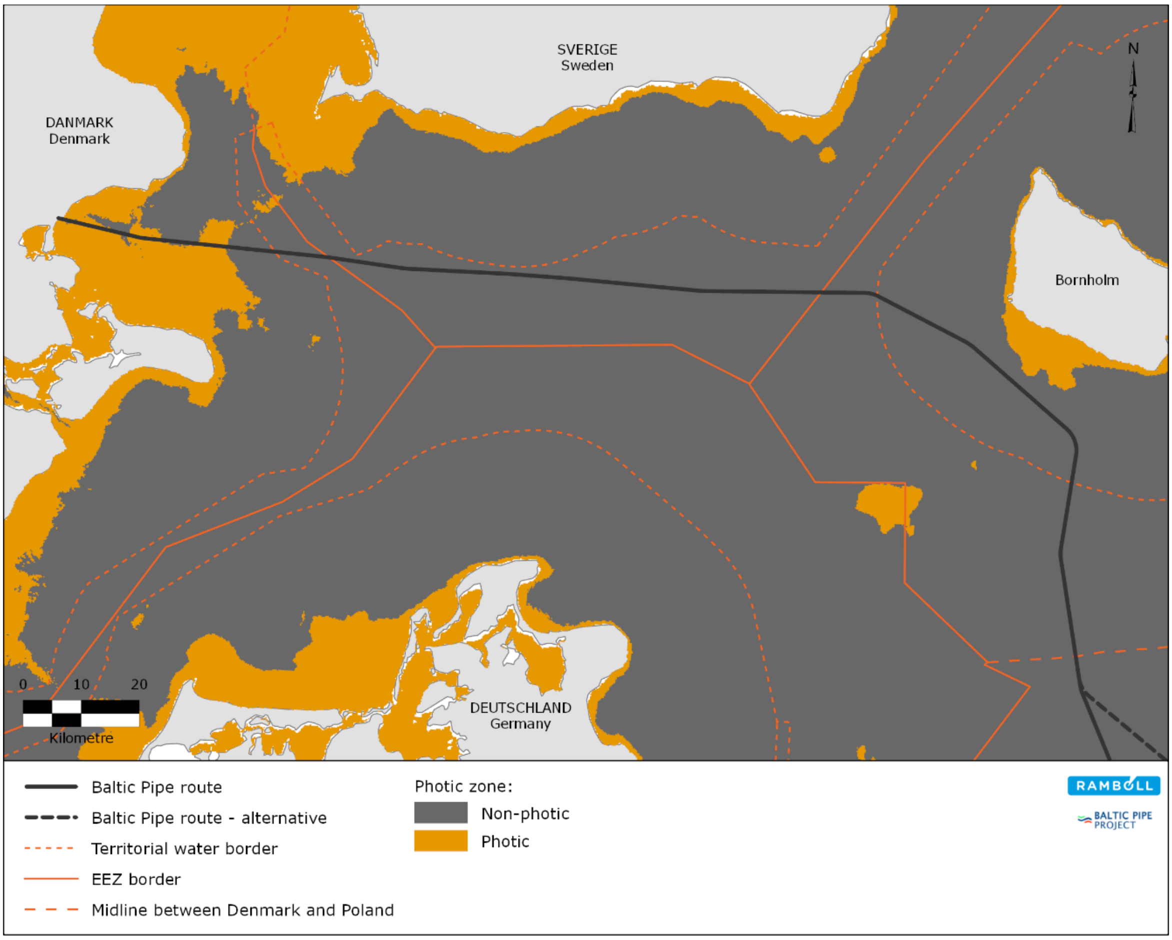

Figure 9-39 Modelled data on the photic and aphotic zones in the south-western Baltic Sea (Arkona Basin). Modelling results are based on irradiance data sampled between March and October in 1980-1998 (BALANCE, 2013).

<u>Salinity</u>

Salinity has been included as one of the primary physical parameters structuring the habitats within the Baltic Sea. A general trend is the pronounced decrease in the number of marine invertebrates, plants, and fish species along the salinity gradient from the Kattegat to the Baltic Sea, while the number of freshwater species increases in the Gulf of Bothnia and the Gulf of Finland. The overall salinity of the project area is described in Section 9.2.

In the BALANCE habitat mapping project, salinity in the entire Baltic Sea has been split into six categories reflecting different biological constraints. Two of these categories of salinity regimes dominate the living conditions along the Baltic Pipe project routes in the Baltic Sea (Figure 9-40). The north-western parts usually encounter a bottom salinity of between 11 and 18 PSU, while the salinity of the bottom water in the south-eastern part typically ranges between 5 and 11 PSU.

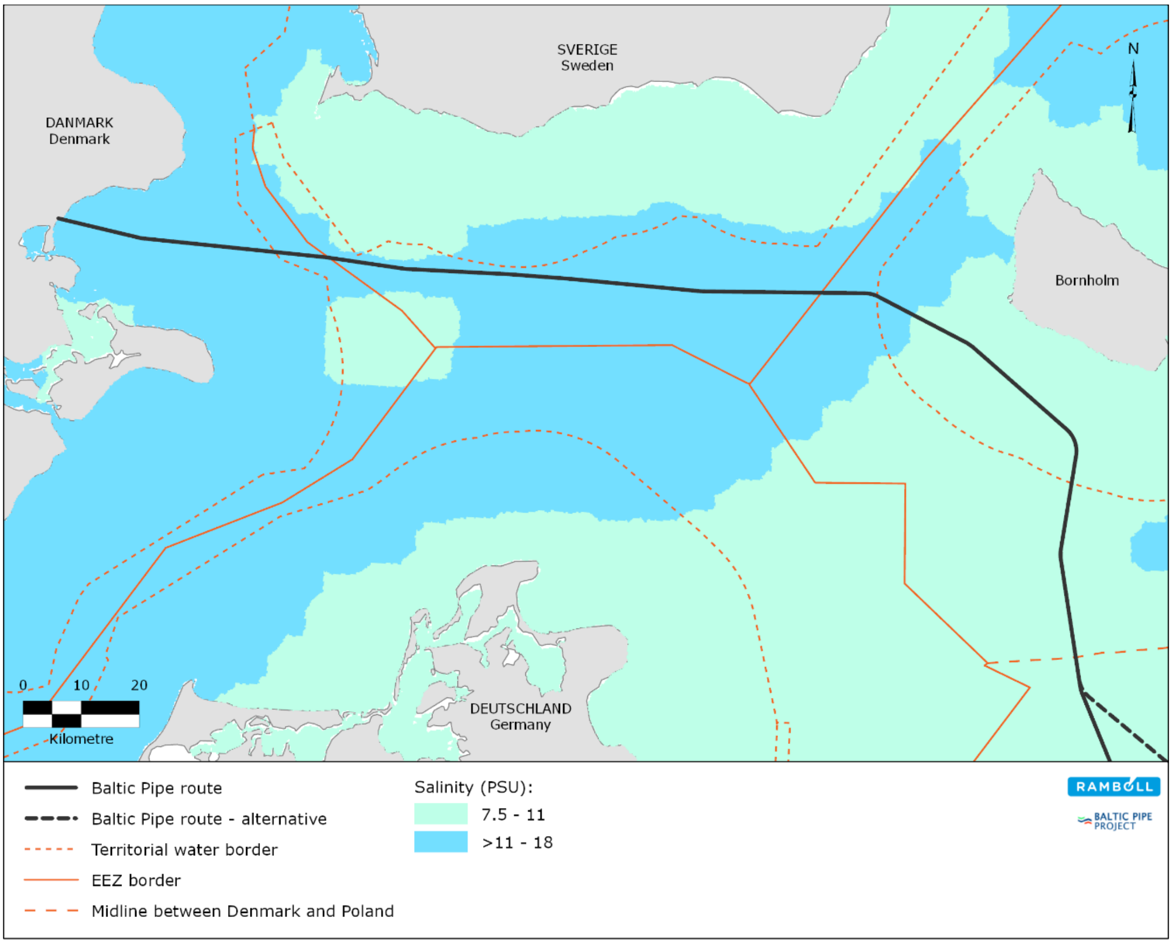

Figure 9-40 The general range of salinity in the bottom water predominating in the south-western Baltic Sea, according to BALANCE (BALANCE, 2013). In the part of the Baltic Sea, where the route for the Baltic Pipe project is situated, only two of the categories for sea bottom salinity reflect the ambient salinity regime, i.e. 7.5-11 PSU and 11-18 PSU.

<u>Habitat delineation</u>

Based on the substrate, salinity and light criteria described above, 18 habitat types in the region of the Baltic Pipe project can be identified. Of these, 15 are found in the vicinity of the pipeline route in Danish waters (Figure 9-41).

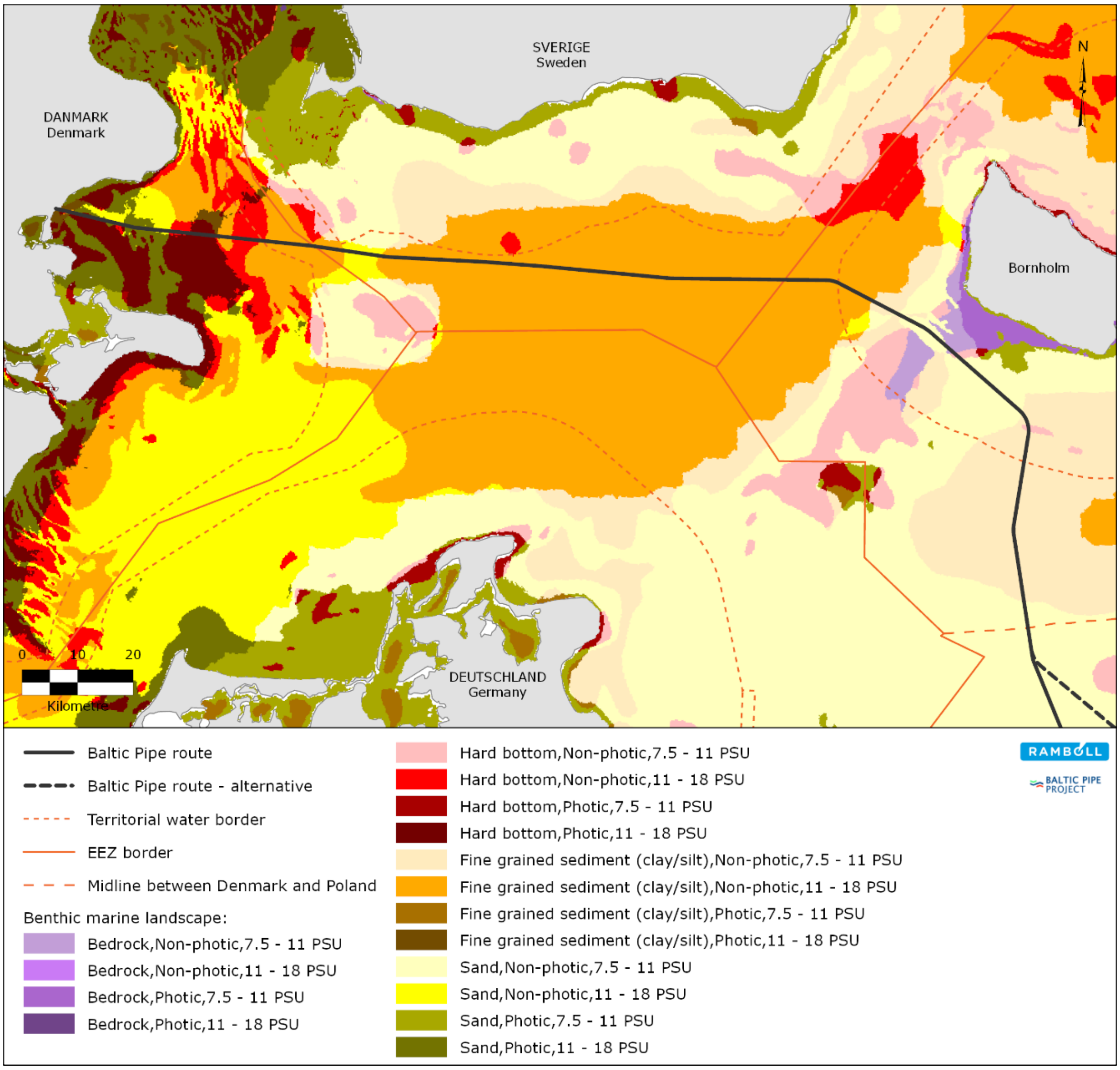

Figure 9-41 Map showing the different general habitat types in the south-western region of the Baltic Sea, covering the area of the Baltic Pipe route between Poland and Denmark. The criteria defining the habitats follow the guidelines from the BALANCE project (BALANCE, 2013).

The predominant seabed habitat type along the pipeline route consists of soft sediments (clay, silt, sand) at depths below the photic zone (non-photic zone). The salinity in the eastern part (Bornholm) is in the lower end, i.e. in the range of 5-11 PSU, and in the western part (Faxe Bugt), salinity is in the range of 11-18 PSU.

Benthic flora and fauna

Benthic organisms encompass all kinds of flora and fauna that live on or in the seabed. The composition of each benthic community is dependent on many biotic and abiotic factors. The most important abiotic factors comprise the habitat (salinity, light and substrate conditions), oxygen concentration as well as water movement from current and wave action. In addition, water quality, nutrient load, food supply, competition from alien species, etc. also contribute to the community structure.

The number of species which can be found strongly depends on the ambient salt concentration, resulting in a generally higher number in the north-western part of the Baltic Sea compared to the south-eastern part of the Baltic Sea.

The baseline description is based on recent surveys performed along the pipeline route. At the Danish land-fall site at Faxe Bugt the mapping of macrophytobenthos was done as a combination of video surveys and collection of flora at designated transects and stations in July 2018 (Rambøll, 2018q). The distribution and coverage of key species was assessed in the coastal shallow water based on 29 video transects. Moreover, the coverage at 26 stations was verified with SCUBA divers. The density was estimated from 100 samples of phytobenthos collected at 20 stations divided between the Faxe Bugt and the more offshore waters of the Rønne Bank area (Rambøll, 2018q).

The macrozoobenthos was identified to the lowest possible taxonomic level and enumerated in terms of biomass and abundance (Rambøll, 2018r). Bottom samples were taken every 5 km along the pipeline routes in June-July 2018, including the former alternative variant (see Chapter 6). In Danish waters this encompassed 56 soft bottom sampling stations and 14 hard bottom sampling stations. The soft bottom macrofaunal samples were collected using a van Veen grab (catching area 0.1 m^2), while the hard bottom samples were collected with a ROV mounted probe (catching area of 154 cm^2) (Rambøll, 2018r).

Benthic flora

Benthic flora comprises macroalgae associated with hard substrates and flowering plants (angiosperms), which can be found in soft bottom areas of the shallow coastal zone. The methods and the results of the mapping of macrophytobenthos can be found in the survey report (Rambøll, 2018o).

In the shallow water at the Faxe South area, the bottom is soft, which allows for a dominance of the flowering eelgrass (*Zostera marina*). The charophyte *Tolypella nidifica* was also recorded within the eelgrass investigation area. Eelgrass dominated the shallow soft bottom macro vegetation, with a spot-wise assemblage of filamentous algae. When hard substrate was present, other algae such as *Fucus vesiculosus* occurred.

Eelgrass is a key factor in determining good environmental status for coastal areas in the Water Framework Directive (Chapter 10). As eelgrass is highly sensitive to low light conditions, the vertical distribution (the depth limit) is primarily determined by the transparency of the water column. Eelgrass is considered as vulnerable to mechanical disturbance of the seabed.

The areal coverage of eelgrass in relation to depths in Faxe Bugt is shown in Figure 9-42.

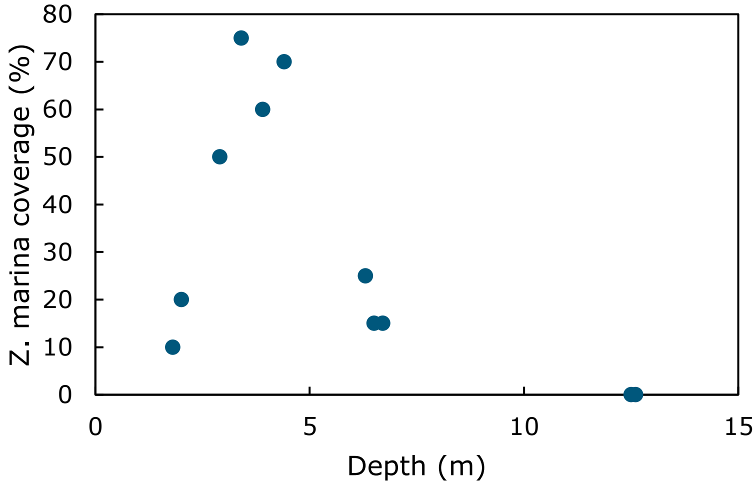

Figure 9-42 Eelgrass coverage estimated by divers along transects off the landfall site at Faxe.

During the surveys in Faxe Bugt, it was observed that between 0 and 2 m, eelgrass was almost absent. This is most likely due to the strong mechanical influence from waves at shallow depths. From 2 m water depth, the eelgrass cover increases rapidly until it reaches a maximum coverage of 75% between 3 to 5 m depth. Below this depth range, the abundance of eelgrass decreased until a depth limit at about 7 m. From approximately 4-6 m water depth, eelgrass coverage is patchy, and the vegetation seems to be increasingly dominated by annual filamentous red algae of the genus *Polysiphonia* (based on the Remotely Operated Vehicle (ROV) registrations). At water depths of 7 m and deeper, eelgrass was absent.

The biomass of eelgrass reached a maximum of 176 g DW m^{-2} and a maximum shoot density of 868 m^{-2}, which is in accordance with other good condition eelgrass locations in Danish waters.

Twenty macroalgae species were found at the diver sampling sites in the two Danish sectors (Figure 9-43). The majority were red algae, with 15 species, followed by 3 species of brown algae and 2 species of green algae (Table 9-67).

Table 9-67 List of identified macroalgae taxa in samples collected during the diver survey in July/August 2018.

<table>
<tr><th>Class</th><th>Order</th><th>Genus</th><th>Species</th></tr>
<tr><td rowspan="15">Rhodophyceae</td><td rowspan="10">Ceramiales</td><td>Aglaothamnion/Callithamnion</td><td>Aglaothamnion/ Callithamnion sp.</td></tr>
<tr><td rowspan="2">Ceramium</td><td>Ceramium tenuicorne</td></tr>
<tr><td>Ceramium virgatum</td></tr>
<tr><td>Delesseria</td><td>Delesseria sanguinea</td></tr>
<tr><td>Membranoptera</td><td>Membranoptera alata</td></tr>
<tr><td>Phycordys</td><td>Phycodrys rubens</td></tr>
<tr><td rowspan="2">Polysiphonia</td><td>Polysiphonia elongata</td></tr>
<tr><td>Polysiphonia fibrillose</td></tr>
<tr><td>Rhodomela</td><td>Rhodomela confervoides</td></tr>
<tr><td>Vertebrata</td><td>Vertebrata fucoides</td></tr>
<tr><td rowspan="5">Gigartinales</td><td rowspan="2">Coccotylus</td><td>Coccotylus brodiei</td></tr>
<tr><td>Coccotylus truncates</td></tr>
<tr><td>Cystoclonium</td><td>Cystoclonium purpureum</td></tr>
<tr><td>Furcellaria</td><td>Furcellaria lumbricalis</td></tr>
<tr><td>Phyllopora</td><td>Phyllophora pseudoceranoides</td></tr>
<tr><td rowspan="2">Clorophyceae</td><td rowspan="2">Cladophorales</td><td>Chaetomorpha</td><td>Chaetomorpha linum</td></tr>
<tr><td>Cladophora</td><td>Cladophora sp.</td></tr>
<tr><td rowspan="3">Phaeophyceae</td><td>Laminariales</td><td>Saccharina</td><td>Saccharina latissimia</td></tr>
<tr><td rowspan="2">Ectocarpales</td><td>Ectocarpus</td><td>Ectocarpus sp.</td></tr>
<tr><td>Pylaiella</td><td>Pylaiella sp.</td></tr>
</table>

Macroalgae biomass was sampled at the depth range of between 8 and 20 m in Danish waters. The biomass attained a maximum at 10-15 m water depth, with an average biomass of approximately 400 g DW/m^2. Below this depth interval, the biomass declined until a depth limit of about 20 m (Figure 9-45).

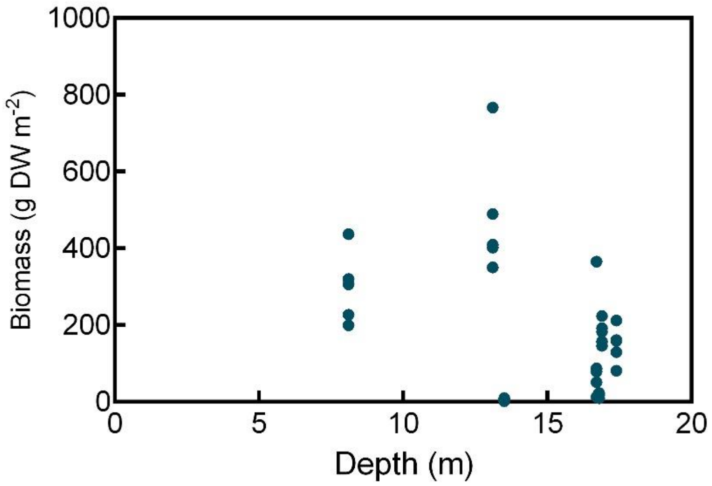

Figure 9-43 Total macroalgae biomass (g DW m^{-2}) representing suitable sites for growth (>5-10 % coverage) at different depths in the Danish waters.

None of the benthic flora species included on the HELCOM Red List (HELCOM, 2013a) occur close to the Baltic Pipe route.

<u>Benthic fauna</u>
Benthic fauna refers to invertebrates associated with the seabed surface (epifauna) or living buried in the seabed (infauna). For this EIA, benthic organisms include macrofauna >1 mm.

Based on abundance data (Gogina *et al*., 2016) of benthic fauna from the entire Baltic Sea, seven general benthic fauna communities dominate the southern Baltic Sea (Figure 9-44). This is a very general classification of the benthic fauna communities but can serve as a rough overview of the distribution of the predominant macroinvertebrates in the part of the Baltic Sea, where the planned route is situated. Three of these communities are found along the planned pipeline route (Figure 9-44).

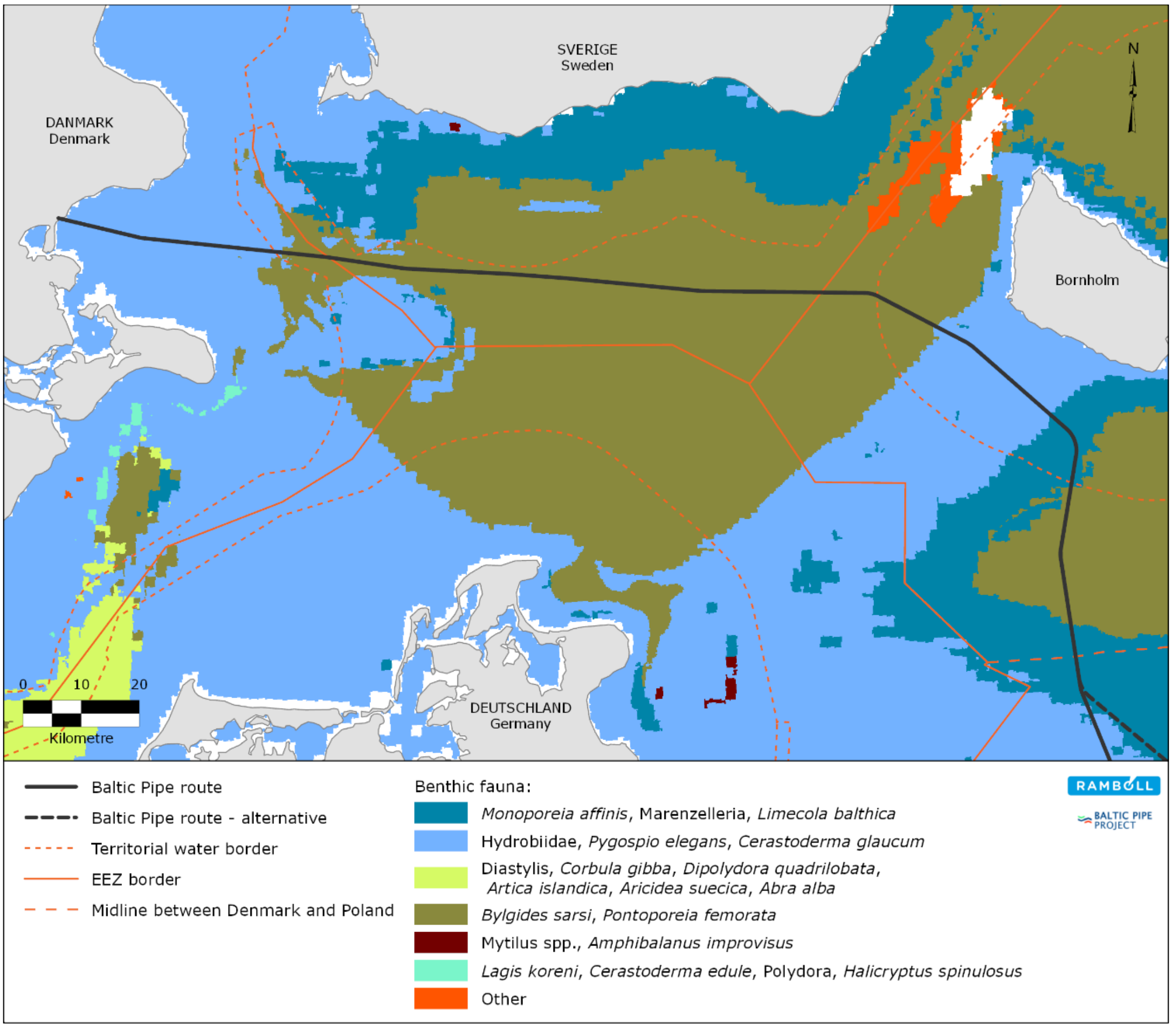

Figure 9-44 Benthic fauna communities in the south-western Baltic Sea, based on abundance data from the period 2000-2013 (Gogina *et al.*, 2016), showing the most abundant or characteristic species in the Baltic Sea (*Macoma balthica = Limecola balthica*).

In connection with the field surveys performed along the pipeline route in the Danish sector in July 2018, the quantitative inventory of the 66 different macrozoobenthos species were found (Table 9-68). All animals were determined to the species or lower taxonomic level. For the species determined to a lower taxonomic level, only one representation of the taxonomic group, e.g. genus, is accounted for as sp. in the species list below. For the genus *Mytilus* both *M. edulis* and *M. trossulus* (or hybrid between these two species) is found in the region. Because these two species are very difficult to distinguish morphologically, specimens of *Mytilus* is denoted as *M.* spp. and accounted as one species. The method used for sampling and determination is described in the survey report (Rambøll, 2018p).

Table 9-68 Macrozoobenthic species found in the two Danish sectors in June 2018.

Species	Taxonomic group	Species	Taxonomic group
Halcampa duodecimcirrata	Anthozoa	*Clitellio arenarius*	Oligochaeta
Arctica islandica	Bivalvia	*Enchytraeidae* sp.	Oligochaeta
Astarte borealis	Bivalvia	*Tubificoides benedii*	Oligochaeta
Astarte elliptica	Bivalvia	*Tubificoides pseudogaster*	Oligochaeta
Cerastoderma glaucum	Bivalvia	*Alitta succinea*	Polychaeta
Limecola balthica	Bivalvia	*Alkmaria romijni*	Polychaeta

Species	Taxonomic group	Species	Taxonomic group
Mya arenaria	Bivalvia	*Ampharete acutifrons*	Polychaeta
Mytilus spp.	Bivalvia	*Ampharete baltica*	Polychaeta
Tellinidae sp.	Bivalvia	*Anaitides maculata*	Polychaeta
Hydrobia sp.	Gastropoda	*Arenicola marina*	Polychaeta
Onoba semicostata	Gastropoda	*Aricidea cerrutii*	Polychaeta
Peringia ulvae	Gastropoda	*Aricidea (Aricidea) minuta*	Polychaeta
Retusa obtusa	Gastropoda	*Aricidea (Strelzovia) suecica*	Polychaeta
Retusa truncatula	Gastropoda	*Bylgides sarsi*	Polychaeta
Piscicola sp.	Hirudinea	*Capitella capitata*	Polychaeta
Bathyporeia pilosa	Malacostraca	*Fabricia stellaris*	Polychaeta
Carcinus maenas	Malacostraca	*Fabriciola baltica*	Polychaeta
Corophium volutator	Malacostraca	*Hediste diversicolor*	Polychaeta
Crassicorophium crassicorne	Malacostraca	*Heteromastus filiformis*	Polychaeta
Cyathura carinata	Malacostraca	*Marenzelleria* sp.	Polychaeta
Diastylis rathkei	Malacostraca	*Neoamphitrite figulus*	Polychaeta
Gammarus salinus	Malacostraca	*Nephtys caeca*	Polychaeta
Gammarus tigrinus	Malacostraca	*Nephtys ciliata*	Polychaeta
Jaera (Jaera) albifrons	Malacostraca	*Ophelia rathkei*	Polychaeta
Jaera (Jaera) praehirsuta	Malacostraca	*Pygospio elegans*	Polychaeta
Monoporeia affinis	Malacostraca	*Scoloplos armiger*	Polychaeta
Mysidae sp.	Malacostraca	*Streblospio shrubsolii*	Polychaeta
Phoxocephalus holbolli	Malacostraca	*Streptosyllis websteri*	Polychaeta
Pontoporeia femorata	Malacostraca	*Terebellides stroemi*	Polychaeta
Saduria entomon	Malacostraca	*Travisia forbesii*	Polychaeta
Amphiporus bioculatus	Nemertea	*Halicryptus spinulosus*	Priapulidae
Lineidae sp.	Nemertea	*Priapulus caudatus*	Priapulidae
Baltidrilus costatus	Oligochaeta		

Although the species composition varied significantly along the route, there were an overall predominance of the polychaete *Scoloplos armiger* and the bivalve *Limecola balthica*. The data confirm previous monitoring at NOVANA station DMU444 during recent years (2000-2015) (Novana, 2018). However, the conditions at this station have changed since the 1980s toward a less abundant benthic community. *S. armiger* is considered as an indicator for a quite unfavourable environment.

The relatively high number of species found in this study indicates that some improvement of the environmental conditions has taken place in this part of the Baltic Sea.

Concerning the HELCOM Red List for benthic fauna species (HELCOM, 2013a) two species of crustaceans *Monoporeia affinis* and *Pontoporeia femorata*, listed as Least Concern, are found at the Rønne Banke/Adler Grund region in the eastern part of the Danish sector.

<u>Distribution</u>
The number of macrozoobenthic species along the pipeline route in Danish waters is depicted in Figure 9-45.

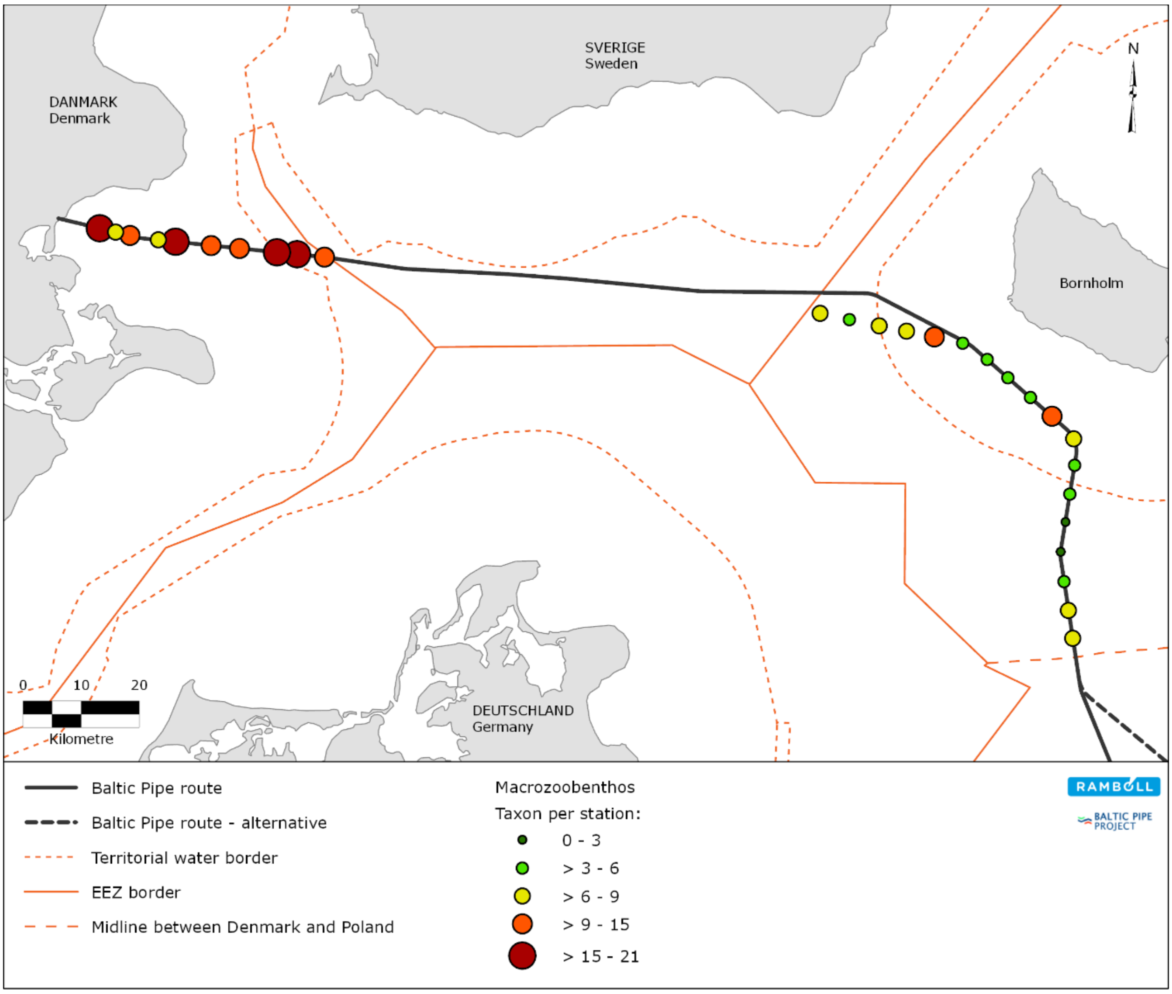

Figure 9-45 The number of macrozoobenthic species found in Danish waters along the Baltic Pipe route in June 2018.

In general, the highest number is found in the western part of the Danish sector. The water depth in this part is mainly in the range of 0-20 m, while the eastern part is generally deeper (>20 m). The diversity strongly depends on the presence of polychaetes at all locations, followed by mussels (Bivalvia) and crustaceans (Malacostraca) in the eastern part.

The abundance of macrozoobenthos shows almost the same pattern as the diversity (Figure 9-46). An exception was seen at one station located in the eastern part of Rønne Bank, south of Bornholm, where five times as many individuals were found compared to any of the other eastern stations.

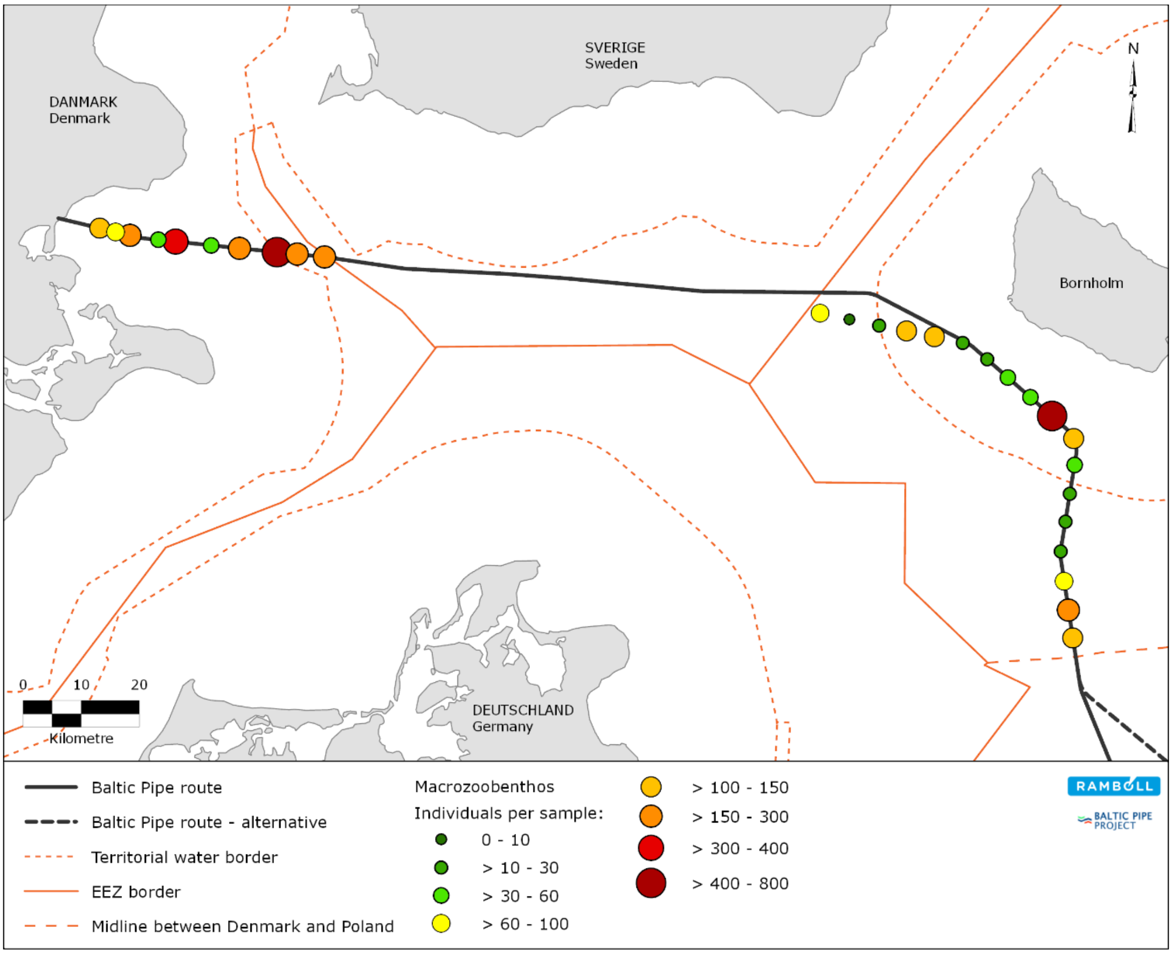

Figure 9-46 The abundance of macrozoobenthos in Danish waters along the Baltic Pipe route in June 2018.

At the two stations with >400 individuals per sample (0.1 m^2) (Figure 9-46) the little snail Hydrobia represented ca. 50% of the individuals.

The biomass varied remarkably between the stations in the western part of the Danish sector (Figure 9-47).

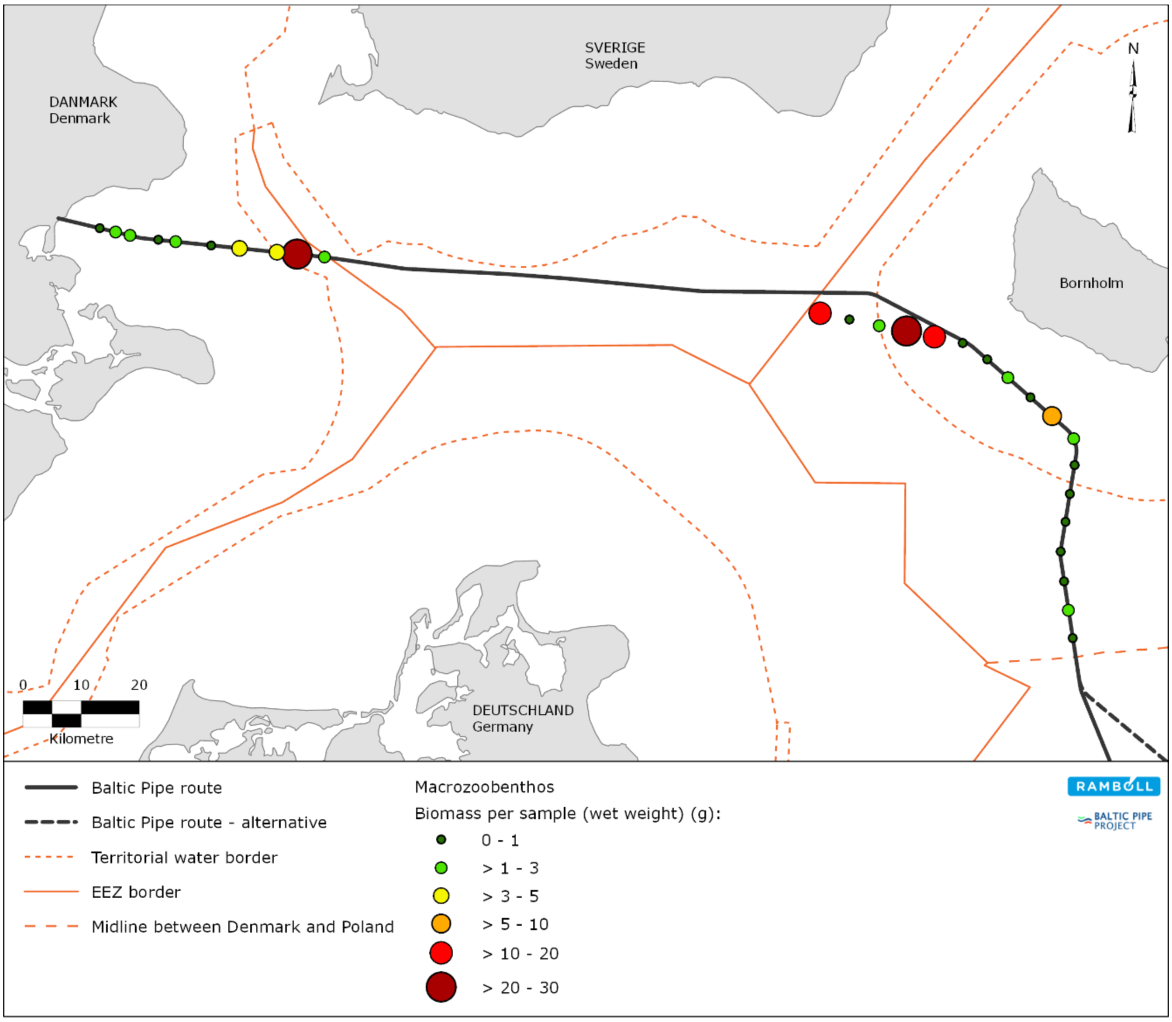

Figure 9-47 The biomass of macrozoobenthos in Danish waters along the Baltic Pipe route in June 2018.

The high biomass found at one station in the western part is due to the inclusion of a common shore crab (*Carcinus maenas*), which contributed to 94 % of the biomass. In the eastern part of Danish waters, the high biomass found at three of the stations (Figure 9-47) is due to the presence of the mussel *Astarte borealis*, which constituted 84-99% of the biomass. However, an overall proportionality in the distribution pattern of the macrozoobenthos was found between all three terms of index (i.e. species, abundance and biomass).

A ranking of the similarity between the stations concerning the species composition and abundance is shown as a so-called MDS plot (Figure 9-48).

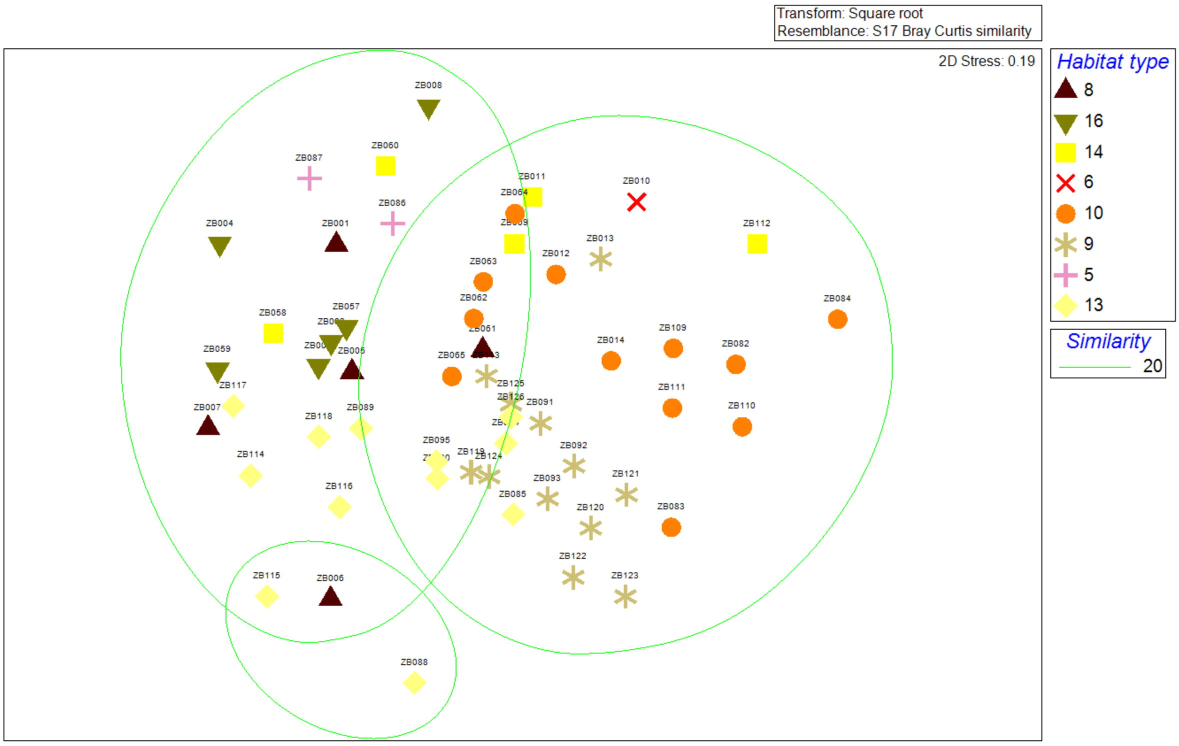

Figure 9-48 MDS plot showing the relative evenness between the stations in the Danish sectors regarding the composition of macrozoobenthos. The Bray-Curtis similarity matrix has been used to calculate the position of the stations in the plot. An overall grouping of the stations representing 20% similarity is shown. The stations are given a signature according to the habitat type to which they belong (Figure 9-41).

The stations in the MDS plot have subsequently been grouped into the eight habitat types which were identified along the pipeline route (Figure 9-41). The classification of sampling locations in relation to their similarity is consistent with the specific identified habitat areas. The data analyses show a good correlation between the habitat defined by its physical properties and the composition macrozoobenthos. Hence, the close compliance shown between the composition of some basic physical features (i.e. substrate, salinity and light) and the benthic fauna composition provides a reliable means of assessing the biological impact of mechanical disturbance of the seabed.

9.11.2 Impact assessment

The following potential impacts on benthic habitats, flora and fauna from construction and operation of the planned project have been identified (Table 9-69).

Table 9-69 Potential impact on benthic habitats, flora and fauna.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediments	X	
Sedimentation	X	
Presence of pipeline		X

The following potential impacts are screened out:

- **Underwater noise (construction):** Noise emissions within the predicted levels (Section 5.1.5 and 5.2.4) will not cause somatic damage on benthic fauna (invertebrates), and due to its temporary nature, will not cause any detrimental behavioural effect.
- **Non-indigenous species (construction):** Accidental introduction of alien species is not likely because of the local/regional origin and placement of the material used for construction and maintenance (Section 5.1.9). Furthermore, the Baltic Pipe project will follow and implement the recommendation from the joint HELCOM Guide to Ballast Water Management in the Baltic Sea (HELCOM, 2014a).
- **Heat from pipeline (operation):** Experience from similar projects shows no significant temperature difference between the surface of the pipeline and the marine environment (Section 5.2.3). Therefore, no impacts on benthic flora and fauna is expected.
- **Contaminants and nutrients (construction):** As outlined in Section 5.1.3, the release of contaminants and nutrients is insignificant compared to the annual amounts entering the Baltic Sea. As benthic flora and fauna live in and on the seabed, from which the released contaminants originate, there will be no additional risk of contaminant exposure.
- **Release of contaminants from anodes (operation):** Monitoring of similar projects has showed that toxic metals will only be elevated within a few meters from the pipeline (Section 5.2.5). In addition, a large part of the pipeline will be buried, and most of the released metals will therefore be bound to the sediment. Therefore, no impacts on benthic flora and fauna are expected.

For an overall assessment of the mechanical disturbance (physical disturbance, suspended sediment/sedimentation and the presence of pipeline) on benthic flora and fauna, it is in most cases the change in living conditions on a population level, which is relevant to consider. Hence, the significance of the impact on benthic communities depends on the relative disturbance of their habitats. This again depends on 1) the character of the impact and how it differs from the ambient natural conditions, and 2) the proportion of the disrupted habitat in relation to the extent of the habitat. Only in the presence of endangered species will it be relevant to address the impact directly for the species concerned. Since no endangered benthic species have been encountered along the pipeline route in Danish waters, the following impact assessment for benthic fauna and flora is exclusively based on whether the habitat conditions are affected.

Physical disturbance of seabed
Activities during construction that may physically change or disturb the seabed and thereby temporarily modify the living conditions of benthic species comprise intervention works (trenching, backfilling and rock installation), pipe-lay and anchor handling.

Nine of the identified habitats (Figure 9-41) along the pipeline will be directly impacted by intervention works:

- Fine grained sediment (clay/silt), Non-photic, 11 - 18 PSU;
- Fine grained sediment (clay/silt), Non-photic, 7.5 - 11 PSU;
- Hard bottom, Non-photic, 11 - 18 PSU;
- Hard bottom, Non-photic, 7.5 - 11 PSU;
- Hard bottom, Photic, 11 - 18 PSU;
- Sand, Non-photic, 11 - 18 PSU;
- Sand, Non-photic, 7.5 - 11 PSU;
- Sand, Photic, 11 - 18 PSU;
- Sand, Photic, 7.5 - 11 PSU.

Trenching will not occur in areas with bedrock or hard bottom with stones and sedimentary rock but will only take place in areas with fine grained sediment or sand. These areas will be restored by backfilling of sediment, which will occur both by natural processes and mechanically (artificially) as part of the seabed restoration. Impacts on seabed habitats will therefore be temporary, with a duration depending on the duration of backfilling activities.

Pipe-lay will also cause disturbance of the seabed. The pipe-lay vessels will use either a dynamical positioning system (DPS) with powerful thrusters or anchors to keep the lay vessel in position (see Section 3.5.2, Pipe-lay). In general, DP vessels for pipe-lay will be used where the water depth is greater than 20 m, and the anchor vessel will be used where the water depth is less than 20 m. Both positioning methods may impact the seabed surface (see Section 5.1.1).

As the impact scale on flora and fauna depends on the physical features that define the habitat, the impact assessment will be based on the system's ability to recover (resilience) following disturbance of the seabed. This involves both a time scale and a spatial scale. The time scale is given by the recovery time of the substrate, biological structures such as eelgrass meadows and mussel beds, and landscape features, while the spatial scale accounts for how far the disturbance travels from the affected site.

Benthic flora

The sensitivity of benthic flora to changes in seabed habitats is highly linked to the time required to recover from the above impacts and depends on the type of floral communities. Viable benthic flora are only present in the photic zone near the coastlines along the Baltic Pipe project route (Figure 9-39). Along the pipeline at a water depth of less than 18 m south of Bornholm, macroalgae coverage of up to 25% was observed on the hard bottom. In Faxe Bugt, the coverage of macroalgae on stones at a depth of 8-18 m is 50-100%. Macroalgae will usually recover quickly after a mechanical disturbance, and since no endangered species of macroalgae were found along the pipeline route in Danish waters, eelgrass is the only macrophyte that could potentially be seriously affected by the pipeline project. The eelgrass density on the sand bottom off the landfall site at Faxe at water depths of 2-6 m is between 10 and 75%, peaking at a water depth of 3.5 m. Eelgrass has a long recolonization time (>10 years, FEMA, 2013a) after detrimental impacts and the sensitivity to physical disturbance of the seabed is, therefore, considered high, whereas other observed algal communities, which have high growth rates, are assessed to have a low sensitivity to this impact.

As the impact from physical disturbance of the seabed is highly linked to areas with eelgrass, only the impact on eelgrass will be assessed. The expected impact will cause a short to long-term impact, depending on the activity; where anchor handling is a short-term source of impact and the exit hole for tunnelling and trenching activities represents a long-term source of impact.

In the most nearshore waters in Faxe Bugt, the use of tunnelling for crossing the cliff at the landfall down to a water depth of approximately 4 m (see Section 3.4) will prevent an impact on the eelgrass at water depths of less than 4 m. The footprint of the exit hole for TBM and the transition trench will be approximately 5,000 m^2 (Box 5-1). In total, the excavated material will comprise approximately 13,500 m^3 (Box 5-1). The width of the eelgrass belt from the exit hole to the eelgrass depth limit (7 m) is 825 m. If all material is deposited in the eelgrass area and includes the footprint area, this will have a major impact on the eelgrass (approximately 2 ha).

To reduce the impact on the eelgrass beds, the excavated material will be moved to a temporary disposal area without a coverage of eelgrass (>7 m water depth).

Impacts nearshore in Faxe Bugt from activities related to tunnelling and trenching are assessed to be of high intensity, as the eelgrass beds will be lost over a local scale, and with a long-term duration of the impact (>10 y), due to the long recovery time of eelgrass in combination with the recovery time of suitable substrate conditions. The shallow coastal zone (2-6 m water depth) around the landfall site between the harbour of Faxe Ladeplads and the south-eastern tip of Feddet covers an area of more than 500 ha. This area of Faxe Bugt possesses the same physical and biological properties and can therefore be compared to the natural nearshore conditions of the landfall site. Since the affected part of this habitat corresponds to less than 1% of the total area, the impact severity is assessed to be moderate and not significant (Table 9-70).

For the spots of anchoring in connection with pipe-lay in the eelgrass belt, the benthic macroflora will be torn up without being able to recover for years. The disturbed seabed, however, is very limited in spatial extent compared to the surrounding eelgrass area. The intensity of the impacts on benthic communities from pipe-lay is therefore assessed to be medium and the impact is considered minor and not significant (Table 9-70).

Benthic fauna

Because of the temporary nature of the construction works, the impact magnitude on benthic fauna depends on their capability to recover and the recolonization, which occurs through migration of organisms from the nearby seabed and through settling of drifting larvae transported via the water column. The duration of impact depends on the benthic community structure and may take from a few to several years. Opportunistic species recover fast, whereas long-lived species recover more slowly.

The conditions for the recovery depend on whether the disturbed natural physical properties of the affected area will be artificially re-established as a part of a restoration of the seabed (short-term recovery) or be naturally re-established due to the natural forces of sand transportation and deposition (usually long-term recovery). For the soft bottom areas of the pipeline route, where backfilling is not planned, the recovery of the disturbed seabed will take years. However, since this disturbance is restricted to a diminutive area in comparison with the overall habitat, there will be no de-facto change of the benthic habitat type in the area. The intensity of the impact on benthic communities from the construction works is therefore assessed to be medium and the impact is considered minor and not significant (Table 9-70).

For pipe-lay, the area of the disturbed seabed is restricted to a very small proportion of the overall, surrounding benthic habitat. The intensity of the impact on benthic communities from pipe-lay is therefore assessed to be minor and the impact is considered minor and not significant (Table 9-70).

Table 9-70 Impact significance on benthic habitats, flora and fauna from the physical disturbance of seabed during the construction of the pipeline.

<table>
<tr><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2">Sensitivity</th><th colspan="3">Magnitude of impact</th><th rowspan="2">Severity of impact</th><th rowspan="2">Significance</th></tr>
<tr><th>Intensity</th><th>Scale</th><th>Duration</th></tr>
<tr><td rowspan="2">Physical disturbance of seabed (trenching and tunnelling activities)</td><td>Flora (eel-grass)</td><td>High</td><td>Large</td><td>Local</td><td>Long-term</td><td>Moderate</td><td>Not significant</td></tr>
<tr><td>Fauna</td><td>Low to medium</td><td>Medium</td><td>Local</td><td>Short-term to medium</td><td>Minor</td><td>Not significant</td></tr>
<tr><td rowspan="2">Physical disturbance of seabed (anchor handling)</td><td>Flora (eel-grass)</td><td>High</td><td>Medium</td><td>Local</td><td>Long-term</td><td>Minor</td><td>Not significant</td></tr>
<tr><td>Fauna</td><td>Low to medium</td><td>Minor</td><td>Local</td><td>Short-term</td><td>Minor</td><td>Not significant</td></tr>
</table>

Suspended sediments

Increased SSC may impact benthic flora and fauna through reduced growth of benthic flora due to reduced light availability; and reduced food availability to benthic fauna due to blocking/closing of the feeding apparatus for filter-feeding species.

Most benthic habitats in shallow waters are accustomed to suspended particles as a natural, frequent occurrence due to wave action and current. Deep water habitats, however, are not adapted to high SSC to the same degree.

<u>Benthic flora</u>

The sensitivity of benthic flora to SSC is connected to the reduced availability of light to support growth. However, benthic flora are adapted to short periods with high SSC, especially eelgrass, which lives in the coastal zone, where the sediment dynamics are high, and hence their sensitivity to temporary increased SSC is low.

The impact from increased SSC will be highest in the shallow area near the landfall, as this is within the photic zone and where the recipient water mass volume for the sediment spill is restricted (due to the shallowness of the coastal zone). In addition, the highest concentrations of sediment spill will occur in the nearshore area due to back-hoe trenching (Section 5.1.1). The detectable changes in predicted SSC due to trenching close to the landfall site are simulated to be of both a short duration and of a limited spatial extent and is comparable to the natural SSC for exposed coastal waters during windy periods (Section 9.2). The duration of SSC exceeding 10 mg/l along the nearshore part of the pipeline route where eelgrass lives (2-7 m water depth) will generally be less than 12 hours. Only very close to the dredging activities at the exit hole (< 200 m distance) will the duration of elevated SSC (above 10 mg/l) be anticipated to last for more than 12 hours. Natural concentrations of suspended matter above 10 mg/l have been recorded in the coastal waters in the western Baltic Sea during periods of strong winds (above 10 m/s) (Håkanson & Eckhéll, 2005).

The intensity of the impact on the local growth conditions for eelgrass from the construction work is therefore assessed to be minor to medium and the impact is considered minor and not significant (Table 9-70).

Benthic fauna

Benthic fauna are adapted to live in areas where suspended particles are present. The sensitivity of benthic fauna to increased SSC is related to the suspension feeders, which retain suspended particles for consumption of organic matter. An increase in SSC can dilute the food intake. In general, most filtering species can survive for weeks without food, as may result from long-term exposure to elevated SSC. However, because of the metabolic requirement, their growth rates will be affected during periods of high turbidity. Nevertheless, as for benthic flora, their sensitivity to temporary increases in SSC is low.

As described above, suspended particles in the ambient water column are a natural feature of most shallow benthic habitats, which make the inhabitants of these areas quite resistant to recurring events of elevated SSC. Deeper open-water habitats, however, are not adapted to high SSC to the same degree. In particular, many forms of filtering echinoderms and anthozoans are sensitive to high concentrations of suspended minerals. Since most of these species do not live in the Baltic Sea (because of the low salinity), the deep-water habitats of the Baltic Sea are not as sensitive to high SSC as their counterparts in e.g. the Kattegat.

Offshore (> 12 m water depth), there will be an increase in SSC near trenching areas Figure 5-3 and Figure 5-4. Due to the deeper water depth, the natural variations in SSC will typically not be as large as in nearshore, shallower locations. Enhanced SSC due to trenching above 10 mg/l is expected to occur for less than 12 hours. The natural SSC variations for such areas is typically in the range of 1-5 mg/l (Håkanson & Eckhéell, 2015). Nearshore (0-12 m water depth), the duration of SSC above 10 mg/l will last from 1 hour to 4 days, depending on the distance to the trenching/dredging site (see Section 5.1.2).

In summary, because of the relatively short duration and the relatively small area to be affected, the impact of suspended matter on the living conditions for benthic flora and fauna is considered as not significant (Table 9-71).

Table 9-71 Impact significance on benthic habitats, flora and fauna from suspended sediment during the construction of the pipeline.

		Sensi-tivity	Magnitude of impact			Severity of impact	Signifi-cance
			Intensity	Scale	Duration		
Suspended sediments	Flora (eel-grass)	Medium	Medium	Local	Short-term	Moderate	Not significant
	Fauna	Low to medium	Minor	Local	Short-term	Minor	Not significant

Sedimentation

Suspended sediment will re-deposit on the seabed and potentially affect benthic flora and fauna through reduced viability due to smothering of flora and fauna. The following alteration of the composition of organisms may consequently change the food web structure of the ecosystem and thereby the living conditions in the habitat.

The impact magnitude is closely linked to the intensity and duration of the resulting re-sedimentation.

Benthic flora

The sensitivity of benthic flora to heavy sedimentation depends on the species and whether it lives at the border of its areal distribution. However, because re-suspension and sedimentation are natural occurrences, especially in shallow water, it is generally assumed that the sensitivity of benthic flora to sedimentation is low. Short-term sedimentation rates of less than 2 mm will usually not affect benthic algae species, and sedimentation of less than 1 cm will not affect flowering plants (FEMA, 2013a). Sedimentation of more than 1 mm due to trenching in the Danish sector is only foreseen nearshore (0-12 m water depth) and until a distance of up to 500 m from the pipeline where a backhoe dredger is used. Only very close (< 100 m distance) to the trenching site can re-sedimentation of up to 5 mm be anticipated. Practically no sedimentation of above 1 mm will take place along the offshore areas of trenching performed by ploughing. The sensitivity of benthic flora to sedimentation at rates relevant for the Baltic Pipe project is therefore low, which in combination with the medium intensity makes the impact severity minor not significant (Table 9-72).

<u>Benthic fauna</u>
As for suspended sediments, most benthic habitats in shallow waters are adapted to mineral sedimentation as a natural feature, whereas deep-water habitats are not, due to generally calm hydrological conditions and thereby lower sediment dynamics.

Sessile filtrating invertebrates living in deeper water are more sensitive than those inhabiting shallow regions, where re-suspension and sedimentation occur at naturally high rates. However, because of the continuous natural sedimentation in the sea, benthic fauna are generally considered able to manage high sedimentation rates. The sensitivity of benthic fauna to sedimentation at rates described for the flora above is therefore low which, in combination with the minor intensity, makes the impact severity minor and not significant (Table 9-72).

Table 9-72 Impact significance on benthic habitats, flora and fauna from sedimentation during the construction of the pipeline.

		Sensitivity	Magnitude of impact			Severity of impact	Signifi-cance
			Intensity	Scale	Duration		
Sedimen-tation	Flora (eelgrass)	Low	Medium	Local	Short-term	Minor	Not significant
	Fauna	Low	Minor	Local	Short-term	Minor	Not significant

Presence of pipeline
The pipeline presence on the seabed may on the one hand result in a loss of infauna seabed habitat from the project footprint. On the other hand, the introduction of the pipeline may represent a new hard substrate ("artificial reef") for sessile organisms.

In Danish waters, the pipeline will be buried and covered by the ambient substrate along most of the route (Chapter 3). The pipeline will remain emerged from the seabed after construction only at some of the deeper parts (>20 m) and in dense hard bottom areas. In addition, rock placement will be placed at cable crossings and to prevent free span of the pipeline (Section 5.1.1). Similar to the exposed parts of the pipeline, the rock piles will act as a hard bottom substrate and attract the same kind of organisms as natural reef structures.

The presence of the pipeline structures, including rock installations, will replace the existing benthic habitat within the footprint area. The following habitat types will be affected by the exposed pipeline structure or rock placement in the Danish sector (Figure 9-41):

- Hard bottom, Non-photic, 11 - 18 PSU;
- Hard bottom, Non-photic, 7.5 - 11 PSU;
- Hard bottom, Photic, 11 - 18 PSU;
- Sand, Non-photic, 7.5 - 11 PSU;
- Fine grained sediment (clay/silt), Non-photic, 11 - 18 PSU.

Where the pipeline is placed on sand or fine-grained sediment, the existing habitat will be altered and replaced by a hard bottom substrate. In some areas, though, the pipeline will sink into the seabed over time and eventually be covered with sand/mud. The ecological functioning of the hard bottom habitats will not be impaired by the presence of the pipeline or the artificial rocks. From a biological point of view, the artificial construction offers the same kind of physical properties as the natural existing solid surfaces.

Benthic flora

Hard bottom habitats dominated by benthic macroalgae will not be negatively impacted by the presence of the pipeline, as the benthic flora associated with hard substrates can re-establish on the new substrate created by the pipeline and supporting structures. There might even be a potential gain to these habitat types by an increase of solid surfaces, creating new artificial reef structures where benthic macroalgae can grow.

Coastal habitats inhabited by eelgrass (fine grained sediment in the photic zone) will be permanently lost by the introduction of a new hard substrate. However, in areas with eelgrass, the pipeline will be trenched into the seabed and backfilled with the trenched material. The habitat has the potential to again be inhabited by eelgrass. The presence of the pipeline in areas with the potential for eelgrass will have minor impact on their living conditions (Table 9-73).

Benthic fauna

Where the seabed consists of sand and fine-grained sediment, the detrimental impacts of the presence of the pipeline will primarily be linked to infauna. However, in areas with soft bottom, the pipeline will occupy a negligible proportion of the overall similar area, making the impact not significant. In areas of natural hard substrate, epifauna are expected to quickly establish on the solid pipeline structures. Overall, the sensitivity is assessed as low.

Even though there will be a small negative impact from the pipeline due to the loss of soft seabed habitat, the introduced artificial reefs will change the existing habitats with the potential for a minor degree of eventual positive impact. In conclusion, the impact of the presence of the pipeline on the local benthic communities is considered as not significant (Table 9-73).

Table 9-73 Impact significance on the benthic habitats, flora and fauna from the presence of the pipeline during the operational phase.

		Sensitivity	Magnitude of impact			Severity of impact	Significance
			Intensity	Scale	Duration		
Presence of pipeline	Flora (eel-grass)	High	Minor	Local	Long term	Negligible	Not significant
	Flora (macro algae)	Low	Minor	Local	Long term	Minor	Not significant
	Fauna	Low	Minor	Local	Long term	Minor	Not significant

9.11.3 Conclusion

The potential impacts on benthic habitats, flora and fauna resulting from construction activities and operation of the proposed pipeline within Danish waters are summarized in Table 9-74.

Table 9-74 Overall impact significance for benthic habitats, flora and fauna.

		Severity of impact	Significance	Transboundary
Physical disturbance of seabed (trenching and tunnelling activities)	Flora (eelgrass)	Moderate	Not significant	No
	Fauna	Minor	Not significant	No
Physical disturbance of seabed (anchor handling)	Flora (eelgrass)	Minor	Not significant	No
	Fauna	Minor	Not significant	No
Suspended sediment	Flora (eelgrass)	Moderate	Not significant	No
	Fauna	Minor	Not significant	No
Sedimentation	Flora (eelgrass)	Minor	Not significant	No
	Fauna	Minor	Not significant	No
Presence of pipeline	Flora (eelgrass)	Negligible	Not significant	No
	Flora (macroalgae)	Minor	Not significant	No
	Fauna	Minor	Not significant	No

9.12 Fish

In this section, the baseline for fish is described and the impacts from the project are assessed.

9.12.1 Baseline

The fish community in the Baltic Sea is greatly influenced by the hydrological uniqueness of the sea. The sea is semi-enclosed and surrounded by a large drainage basin. The ecosystem of the Baltic Sea is recognized by its lower biodiversity of both plants and animal species compared to more regular seas with normal (33-37 PSU) salinity (Ojaveer, 2017). The water is too fresh for most marine species, and too salty for most freshwater species. A more general description of the salinity regime in the project area can be found in Section 9.2. Approximately 100 fish species (excluding those within the Kattegat) are adapted to the Baltic Sea ecosystems (Ojaveer, 2017). Almost all these species can be found in the southwestern part of the Baltic Sea.

The Arkona Basin and the Bornholm Basin have approximately 110 and 105 species of fish and lamprey, respectively. Of the 110 species registered in the Arkona Basin, 22 different orders are present (HELCOM, 2012), where Perciformes (26.4%), Gadiformes (12.7%) and Cypriniformes (10.9%) dominate. The composition of orders in the Bornholm Basin is similar to the Arkona Basin, with dominance by Perciformes (22.9%), Cypriniformes (18.1%) and Gadiformes (10.5%) (HELCOM, 2012). The Perciformes order, meaning "perch-like", contains freshwater species including perch (*Perca fluviatilis*), pikeperch (*Sander lucioperca*) and ruffe (*Gymnocephalus cernua*), which naturally prefer less saline waters, i.e. mostly the coastal areas, but also marine species including greater sandeel (*Hyperoplus lanceolatus*), mackerel (*Scomber scombrus*) and the invasive round goby (*Neogobius melanostomus*). The gadiformes order includes the most commercially important species in the Baltic Sea for the Danish fleet, i.e. cod (*Gadus morhua*), but in general, most of the registered fishes of this order are noted as occurring temporarily and with no reproduction, e.g. haddock (*Melanogrammus aeglefinus*), pollack (*Pollachius pollachius*) and hake (*Merluccius merluccius*). Lastly, there are the ray-finned fishes i.e. cypriniformes, which includes bream (*Abramis brama*), roach (*Rutilus rutilus*) and the silver bream (*Blicca bjoerkna*).

The HELCOM checklist for Baltic Sea fish and lamprey species includes information on which species have regular reproduction (R), regular occurrence/no reproduction (X), temporary occurrence (T) and occurrence that is uncertain (U) (HELCOM, 2012).

Table 9-75 HELCOM checklist for fish and lamprey species. Species with regular production (R), regular occurrence/no reproduction (X), temporary occurrence (T) and occurrence uncertain (U) (HELCOM, 2012).

Basin	R	X	T	U
Arkona Basin	35%	17%	45%	3%
Bornholm Basin	37%	18%	43%	2%

The distribution seen in Table 9-75 is very similar for the two basins, despite the slight difference in the total number of species. Freshwater species with regular occurrence and reproduction encompass, *inter alia*, bream, roach, pike (*Esox lucius*), pikeperch and perch.

Several diadromous species are present in the Baltic Sea, e.g. eel (*Anguilla anguilla*), river lamprey (*Lampetra fluviatilis*), salmon (*Salmo salar*), smelt (*Osmerus eperlanus*), trout (*Salmo trutta*), vimba bream (*Vimba vimba*) and whitefish (*Coregonus maraenas*), all of which are regular occurring. Only smelt has reproduction in the Arkona Basin. Diadromous species are fish that undergo periodical migrations. They can be divided into anadromous and catadromous species. Anadromous species primarily live in the sea and migrate to freshwater to breed, whereas catadromous species do the exact opposite, e.g. live in either a river or a lake and migrate to breed in the sea (Muus & Nielsen, 1998). Migration can be hindered by obstacles e.g. weirs, dams and hydropower infrastructure (Travade *et al.*, 2010). Among the marine species that are classified as regular with reproduction are herring (*Clupea harengus*), sprat (*Sprattus sprattus*), cod, flounder (*Platichthys flesus*) and plaice (*Pleuronectes platessa*). The beforementioned species are important for the marine food web and the commercial fisheries in the Baltic Sea.

Fish play an important role in the Baltic Sea, as they are an essential link between planktonic production and higher trophic level predators. Forage fish are planktivorous pelagic species that transform the major part of zooplankton production into food available at higher trophic levels (Engelhard *et al.*, 2013). The breeding success, condition and reproductive capacity of predators are linked to fish as a food source for marine birds, mammals, and fish predators. Decreases in the abundance of forage fish may alter the food web, especially in a wasp-waist type ecosystem like the Baltic Sea, where a few forage fish dominate the intermediate trophic level. Alterations in abundance or distribution of these species can have large implications for higher trophic levels. During the last 30 years, such ecosystem restructuring has occurred, and the biomass of sprat has increased significantly as a consequence of the drop in the numbers of its main predator, cod (Eero *et al.*, 2012, Casini *et al.*, 2014).

The HELCOM Red List of Baltic Sea species in danger of becoming extinct is a threat assessment that includes fish species. The list follows the Red List criteria of the International Union for Conservation of Nature (IUCN). As for the Arkona and Bornholm Basins, the eel is the only fish with regular occurrence and an assessment as critically endangered (HELCOM, 2012). The eel is distributed in coastal areas and adjacent to freshwater rivers, streams, and lakes. The stock is considered panmitic, i.e. all individuals are potential partners (Muus & Nielsen, 1998). However, there are geographical differences in growth rates, sex ratios, rates of survival and productivity and thereby in fisheries. Historically, there has been a decline in the population over the last three decades, and only 1-5% of the former population resides in Europe today. In the Baltic Sea, the eel fishery consists of fishing for yellow eel (growing phase) and silver eel (migrating phase). In the period from 2010 to 2015, Danish fisheries landed 32.05 tonnes of eel.

Besides the eel, there are other species in the area surrounding the Baltic Pipe pipeline that are listed on the HELCOM and IUCN Red Lists. As the majority of these species are temporally occurring or have been assigned an IUCN status of vulnerable, they are judged as being of relatively low importance and will not be dealt with further.

Commercially important species
Commercial fishing is carried out in large parts of the Baltic Sea by all countries in the region. The fisheries target both marine and freshwater species, but approximately 95% of the total fish catch in terms of biomass consists of cod, sprat and herring (ICES, 2017). The catches are used for both human consumption and industrial use. The Baltic fisheries also target demersal species such as plaice and flounder, along with migratory species including trout and salmon. The following section includes a stock definition for commercially important species i.e. cod, sprat, herring, plaice, and flounder. Commercial fisheries as a receptor is dealt with in Section 9.25.

Cod, herring and sprat share interspecific interaction from the larval stage to the settling period. Sprat and herring prey on cod eggs in the Bornholm Basin, especially in the beginning of the cod spawning season. As cod mature, sprat and herring become their primary food items (HELCOM, 2008). Cannibalism exists between juvenile and adult cod, where the adult cod are likely to prey on juvenile cod, depending on the habitat volume and the overall abundance. Their interactions can periodically have an impact on the state of the fish stocks in the Baltic Sea (HELCOM, 2008). Estimating the total fish biomass in the Baltic Sea is difficult, as data and assessment on non-commercial species are rare. Available data generally represent the catch rather than the actual biomass, but the catches of less important fish species are small compared to commercially important species i.e. cod, herring and sprat.

<u>Cod</u>
Cod is a demersal species which is found throughout the Baltic Sea. Since 2003, the cod stock in the Baltic Sea has been managed as two separate stocks, i.e. the western and eastern Baltic cod. The stock is divided as there is evidence supporting a phenotypic and genetic difference between the two populations. In the Arkona Basin, there is co-existence among the western and eastern stocks. Studies suggest that cod exhibit natal homing for spawning, i.e. they spawn in the same place almost every year, and a difference of approximately 4 months in the timing of peak spawning season between the two stocks may add to the separation between them. The abundance of cod has increased lately, and recent studies show that a large part of cod in subdivision (SD) 24 is genetically eastern cod (ICES, 2015).

Figure 9-49 shows cod spawning and nursery areas in the southwestern part of the Baltic Sea. The reproductive cycle for the western Baltic cod starts in late October, and spawning begins approximately 4 months after. The spawning period is from the end of February to the beginning of June, in which the main spawning season is from March to April (ICES, 2015). Male cod tend to stay longer in the spawning area and they reach maturity earlier than females. Salinity > 15 PSU is a requirement for fertilization to occur, and more than 20 PSU is necessary to ensure the buoyancy of eggs (ICES, 2015). Spawning of the eastern stock differs, as it is confined to deeper areas where salinities are sufficiently high to allow egg fertilisation and buoyancy, i.e. 12-14 PSU. Historically, the eastern Baltic cod has had a spawning period that extends from March to September, but in the 2000s, spawning began to continue until as late as October/November (Köster *et al.*, 2016).

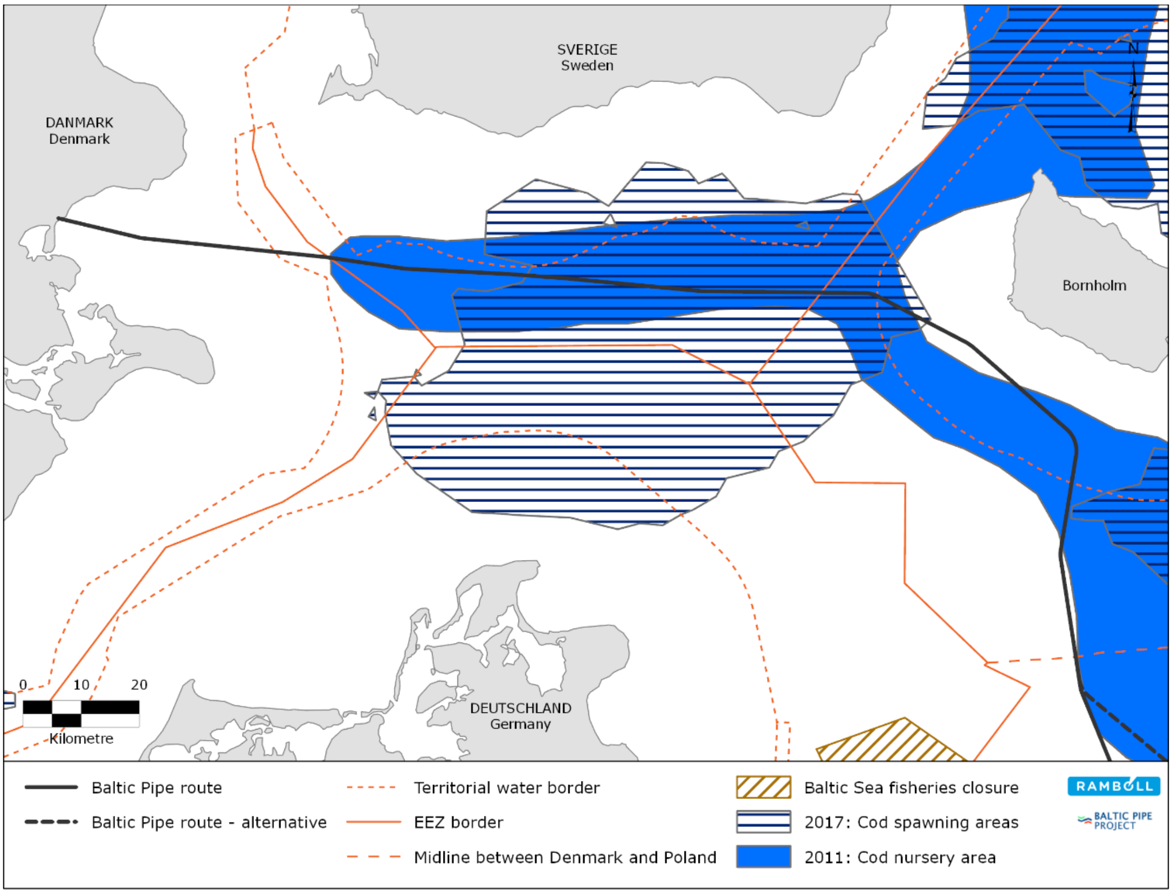

Figure 9-49 Cod spawning and nursery areas in the southwestern part of the Baltic Sea. The map also includes fisheries closure areas.

<u>Sprat</u>

Sprat is a pelagic species. The species is widely distributed in the open sea areas of the Baltic Sea, but high concentrations of young-of-the-year specimens are found in coastal areas (see Figure 9-50). The latter occurs in the autumn and first quarter of the year. In some years, juvenile herring tend to stay in the same areas as sprat, and shoals occur often in both open sea and coastal areas (ICES, 2008).

Sprat in the Baltic Sea are near the northern limit of the species' geographic distribution. Therefore, lower temperatures are detrimental to production and survival in the Baltic Sea, and laboratory experiments have shown that cold water prevents hatching of sprat eggs (ICES, 2008). In the Baltic Sea, the water temperature has increased over the last years. The effects of warmer temperatures on sprat biology has resulted in higher egg and larval survival, faster growth rates in larvae and adults, higher food supplies for larvae and adults, and increased / earlier egg production (i.e. faster gonadal development due to higher temperature and food supply) (ICES, 2008, Voss *et al.*, 2012). Historically, the peak spawning time for sprat in the Baltic Sea occurred in May. However, due to inter-annual variability in temperature, the timing of reproduction has changed. Spawning happens from January to July (Muus & Nielsen, 1998). During the summer, sprat spawning activity decreases, and they begin to migrate out of the deep basin towards the shallow feeding grounds.

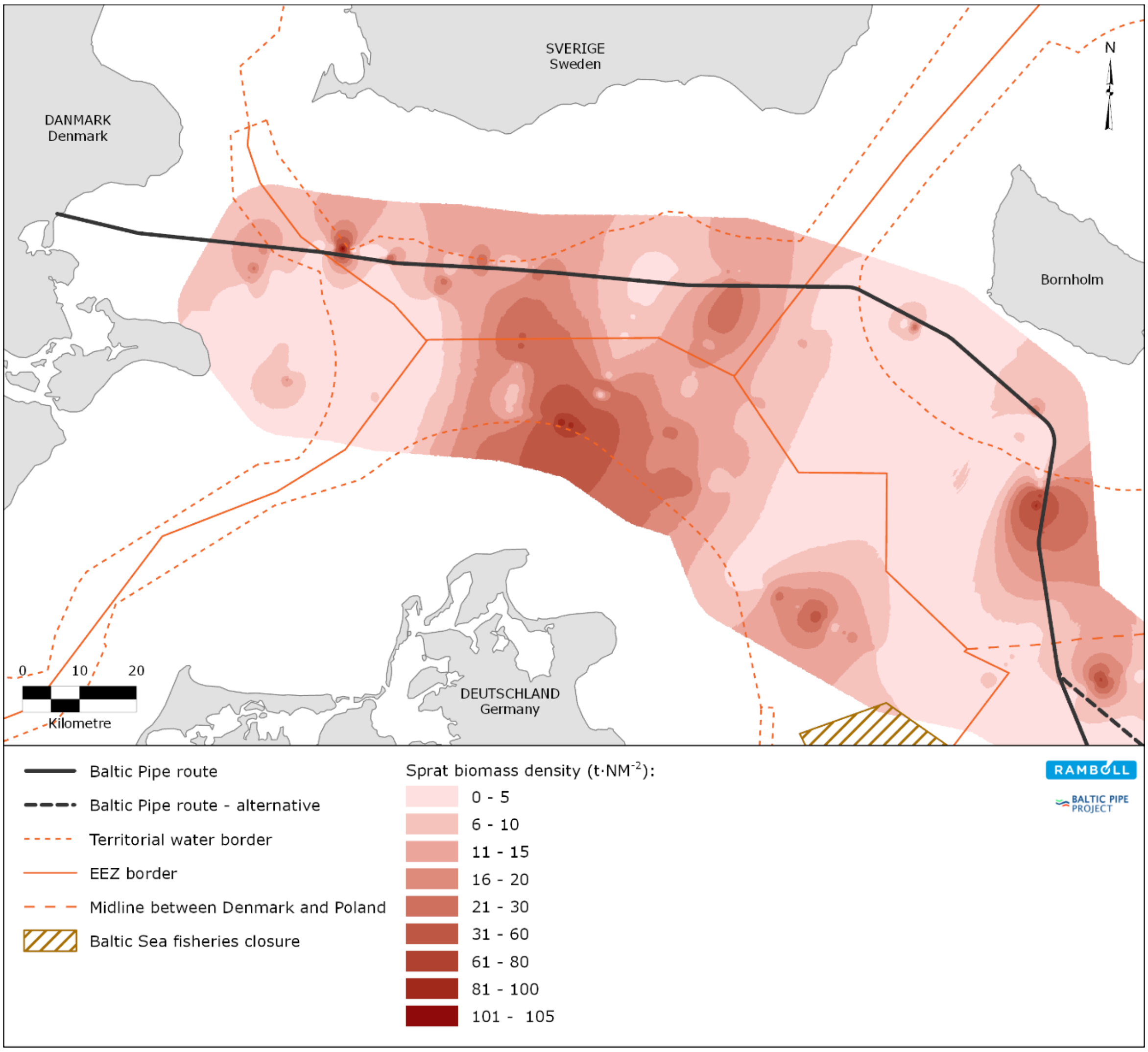

Figure 9-50 Surface biomass density for sprat [t·NM^{-2}], based on hydroacoustic surveys from the R/V Baltica (project area, January 2018). The map also includes general fisheries closures.

Herring

Herring are pelagic and distributed throughout the Baltic Sea. In management, two populations are identified, the western Baltic spring spawners and the central Baltic herring, where mixing occurs in the Arkona Basin (HELCOM, 2008). The western Baltic spring-spawners are migratory, travelling to more saline waters in the summer and then returning to the Kattegat and the Sound to overwinter before moving to spawning areas in March-May on the German Baltic coast. Herring spawning and nursery areas are typically located nearshore, and such areas are particularly vulnerable to anthropogenic influences, including extraction of raw materials, i.e. sand and gravel (Figure 9-51). The central Baltic stock comprises mainly a spring spawning herring population in the Bornholm Basin from April to May. Spring spawning occurs at the coast with a temporal gradient from south to north. When spawning is completed, the spawning individuals migrate to the deep basins to feed. There are no major important spawning grounds in the Arkona Basin for herring.

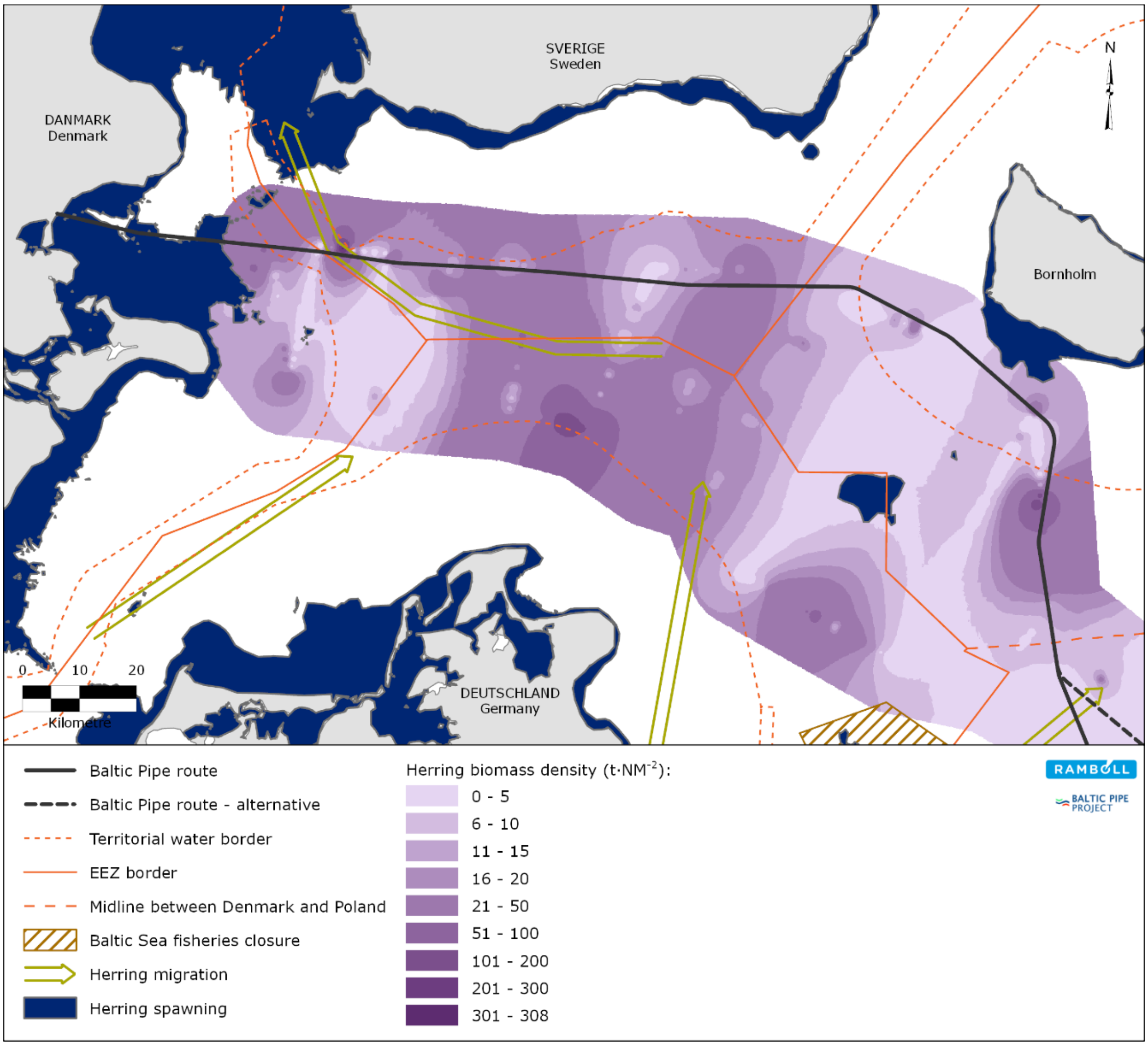

Figure 9-51 Herring spawning areas and migration patterns in the southwestern part of the Baltic Sea. The map also includes general fisheries closures and surface biomass density for herring [t·NM^{-2}] (project area, January 2018).

Plaice

Plaice is an important species that has been exploited for centuries in European waters. Plaice is a demersal species. The distribution of plaice in the Baltic Sea is dependent on salinity, and it extends from the Gulf of Gdansk to the Gotland area, but the species is also found sporadically further north. Plaice spawn in the Arkona Basin and the Bornholm Basin, and the nursery areas located in shallow waters down to 10 m depth (ICES, 2014). Juveniles are located in shallow coastal waters and outer estuaries. As plaice grow older, they move into deeper water. The abundance of plaice in the southern Baltic Sea is influenced by the migration of plaice from the Kattegat.

Plaice spawn in February-March in the beforementioned basins, and the eggs are pelagic (ICES, 2014). Spawning fails in brackish water if the salinity is below one third of the average sea salinity, as the eggs will sink to the bottom (Muus & Nielsen, 1998). Spawning of marine fishes with pelagic eggs in the Baltic Sea is, due to the low-salinity surface water, restricted to the deep basins.

Flounder

Flounder is the most widely distributed flatfish species in the Baltic Sea. There are two species of flounder in the Baltic Sea, the European flounder and the Baltic flounder (*Platichthys solemdali*), which appears to be near identical (Momigliano *et al.*, 2018). The two species can be distinguished by two methods, either genetically or by studying their eggs and sperm. The Baltic flounder lays sinking eggs on the seafloor in coastal areas, whereas the European flounder spawn buoyant eggs in deep areas. The Baltic flounder is more abundant in the Gulf of Finland, whilst the distribution of European flounder is centred in the central and southern Baltic Sea. Hence the European flounder is present in the Arkona and Bornholm Basins.

The volume of water suitable for reproduction among the European flounder population in the Arkona Basin is driven by salinity above 12 PSU and oxygen concentrations above 2 ml O_2/l. The recruitment success is therefore dependent on hydrological conditions at the spawning grounds i.e. the Arkona Basin and the Bornholm Basin (ICES, 2014). Spawning takes place from March to June and the nursery areas are located in shallow coastal waters (Table 9-76). The eggs of the European flounder are buoyant, unlike the sinking eggs of the Baltic flounder. The juveniles migrate offshore in the autumn.

Table 9-76 Spawning period for the commercially important species e.g. cod, sprat, herring, plaice, and flounder in the Arkona Basin and Bornholm Basin in the Baltic Sea (ICES, 2014; Bleil & Oeberst, 2012; Köster *et al.,* 2016). Bold E/W indicate main spawning period for cod.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cod			X[W]	X[W]	X[**WE**]	X[**WE**]	X[**WE**]	X[**E**]	X[E]	X[E]		
Sprat	X	X	X	X	X	X	X					
Herring			X	X	X							
Plaice		X	X									
Flounder			X	X	X	X						

9.12.2 Impact assessment

In relation to the construction and operation of the Baltic Pipe, the potential impacts outlined in Table 9-77 have been identified as relevant for the impact assessment on fish along the pipeline.

Table 9-77 Potential impacts on fish.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediments	X	
Sedimentation	X	
Underwater noise	X	

The following sources of impact have been screened out:

- **Presence of the pipeline (operation)**: The area of the seabed occupied by the pipeline will be negligible compared to the existing fish habitats in the southwestern Baltic Sea. As fish are highly mobile, the presence of pipeline structures will not impose any negative effect on fish populations. In some respect, the pipeline will act as an artificial reef structure, which actually may be regarded as advantageous for fish, due to an increased biomass of invertebrates.
- **Heat from the pipeline (operation)**: Simulations of temperature increase around the planned pipeline route in the Baltic Sea have shown that there will be no significant temperature difference between the pipeline and the marine environment (Section 5.2.3). Therefore, there will be no impact on fish.
- **Release of contaminants from anodes (operation)**: As clarified in Section 5.2.5, the concentrations of metal ions within the water column as a result of anode degradation during the operational phase will be indistinguishable from background concentrations. In addition, a

large part of the pipeline will be trenched, and most of the released metal ions will be bound to the sediment. Therefore, there will be no impact on fish.

- **Contaminants and nutrients (construction)**: As the sampling and analysis revealed in Section 5.1.3, there are no areas with concentrations of contaminants or nutrients that were higher than would be expected in the Baltic Sea, i.e. no contaminant "hot spots" were identified. Therefore, the release of contaminants and nutrients to the water column caused by the seabed interventions work is expected to be comparable with the release caused by natural re-suspension during rough weather, trawling, etc., per tonne of seabed sediments which have been spilled.

Physical disturbance of seabed

Several activities during the construction phase may physically disturb the seabed morphology. Seabed interventions and pipe-lay works comprise trenching, rock installation and DP-vessels/anchor handling, which may cause disturbance and change to benthic habitats. This impact can potentially disturb spawning and nursery areas.

The sensitivity of fish to physical disturbance of the seabed varies depending on biological circumstances i.e. the life stage of the fish (i.e. egg, larval, fry, juvenile or adult) and whether the fish is spawning (Kjelland *et al*., 2015). Also, the duration and impact magnitude of the physical disturbance is relevant to the sensitivity. Pelagic fish eggs (e.g. cod) that usually concentrate in the halocline due to the low salinity are less susceptible to physical disturbance of the seabed, whereas benthic fish eggs (e.g. herring) are known to be vulnerable to anthropogenic influences such as raw material extraction (Janßen & Schwarz, 2015; Sundby & Kristiansen, 2015). Despite the disturbance of the seabed, the period will be temporary and adult fish will return to the area shortly afterwards, making the time of disturbance of the spawning period and eggs immediate. Therefore, the sensitivity to physical disturbance of the seabed is regarded as low.

There are no known deep benthic spawning areas that will be affected by the physical disturbance of the seabed. This includes the autumn spawning herring in the Arkona Basin, whose spawning grounds are confined to areas of steep coastal slopes or banks with intense vertical mixing of water layers, and the demersal-egg spawning herring (i.e. the spring spawning populations) and Baltic flounder, which are known to spawn in many coastal areas around the Baltic Sea (Sundby & Kristiansen, 2015; Momigliano *et al*., 2018). However, no important spawning grounds are known along the planned pipeline route in the coastal area of the landfall at Faxe Bugt. Therefore, the intensity of the impact on fish spawning is assessed to be minor.

Initially, fish will be susceptible to showing avoidance behavior as a result of the physical disturbance of the seabed (Kjelland *et al*., 2015). However, since the area surrounding the pipeline is homogenous, i.e. the impact will have no spatial influence on the habitat availability (local impact) and the impact will be reversible. Once the activity has ceased, fish will return to the area; therefore, the duration is assessed to be short-term despite the fact that the impact is immediate. Therefore, the impact on fish habitats resulting from the construction work is assessed to be of negligible severity.

In summary, the physical disturbance of the seabed is assessed to have no significant impact on fish (Table 9-78).

Table 9-78 Impact significance on fish from the physical disturbance of seabed during the construction of the pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance of seabed	Low	Minor	Local	Short-term	Negligible	Not significant

Suspended sediments

The seabed intervention related to the construction works will cause resuspension of sediments to the water column, which may impact fish communities by provoking avoidance, clogging of gills, a reduction in feeding ability due to reduced visibility, and a reduction in the viability of pelagic fish eggs.

Modelling results of increased SSC can be seen in Section 5.1.2.

Because an increase in SSC in the water column is a regular feature of the sea (e.g. during stormy events), the vulnerability of fish to resuspended sediment spill depends entirely on the magnitude, composition and duration of the impact. Demersal fish are, generally, better adapted to elevated SSC and are less sensitive than pelagic species (Kjelland *et al*., 2015). Pelagic fish eggs are especially sensitive to high SSC, which can lead to egg abrasion (Berry *et al*., 2003). Therefore, the sensitivity is species specific and can be assessed as high.

Fish avoidance behavior can potentially be observed among individuals that are within the range of the construction site due to the increase in SSC. However, this impact is assessed as short-term because it will take time before fish resettle in the area. The expected avoidance behavior will also reduce the potential impact of clogging of fish gills. The quantitative knowledge about avoidance thresholds to sediment suspension is limited, but one study showed that 3 mg/l would result in avoidance behavior for both cod and herring (Westerberg, Rönnbäck & Frimansson, 1996). Further, the expected impacts on cod are likely similar for plaice and flounder, which have a similar spawning area and distribution of their eggs and larvae (Westerberg, Rönnbäck & Frimansson, 1996).

Sediment may adhere to pelagic eggs, such as cod or sprat eggs, causing them to sink to depths with oxygen deficiency. A critical SSC of 5 mg/l for cod eggs has been reported, and yolk-sack larvae show an increased mortality level at a sediment concentration of around 10 mg/l (Westerberg, Rönnbäck & Frimansson, 1996). As Figure 9-49 shows, the planned Baltic Pipe route crosses a cod spawning area in the Arkona Basin. However, since cod spawning occurs in the water column above the halocline, and the SSC increase will primarily take place in the bottom water, there will be no impact on cod eggs or fry. Turbulent mixing is suppressed by the halocline, meaning that sediment does not diffuse across the layer (Lee & Lam, 2004). Furthermore, the exceedance of threshold concentrations (5 mg/l) from trenching in hours is generally not located in cod spawning areas such as the Arkona Basin (see Figure 9-52).

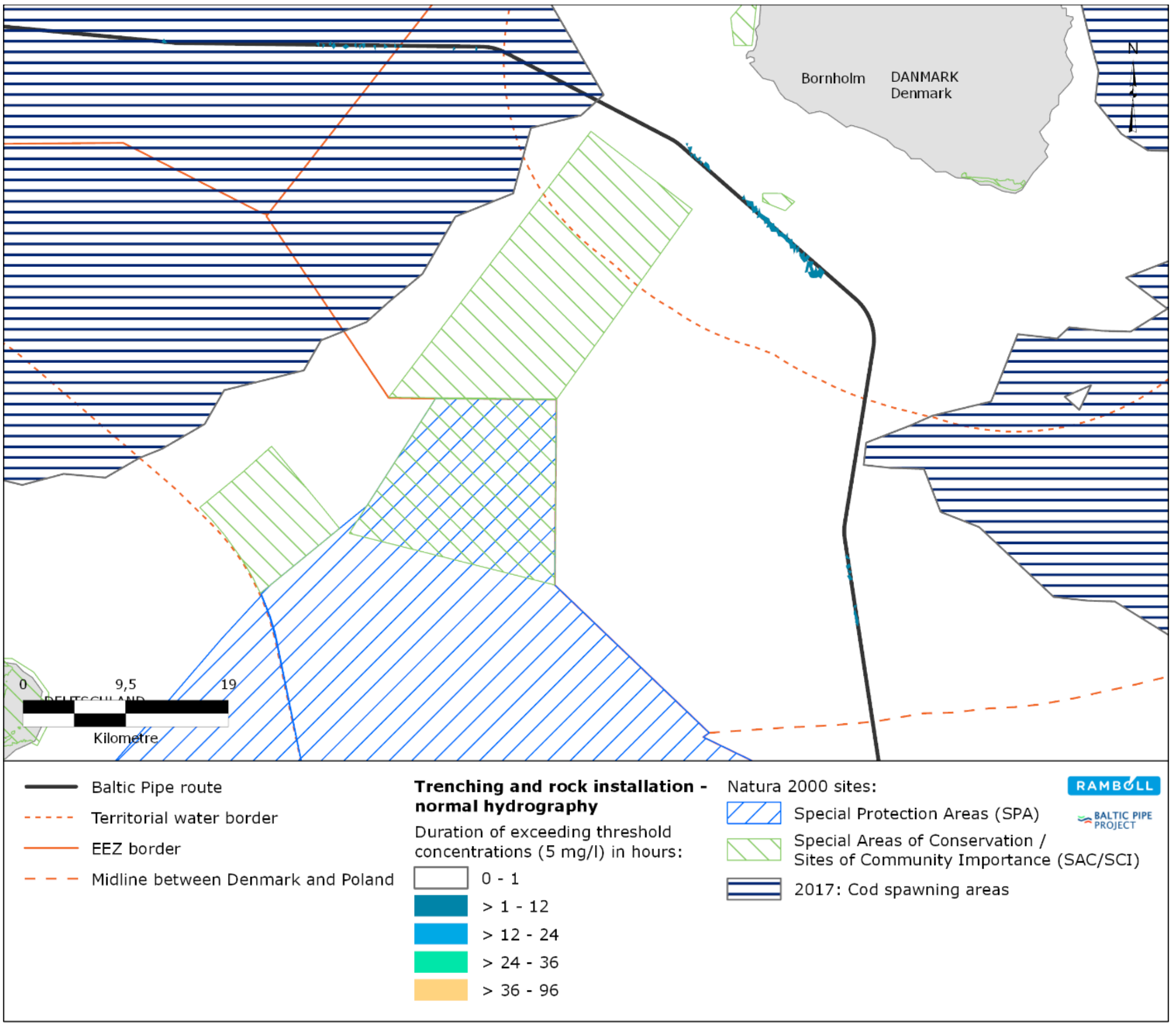

Figure 9-52 Trenching - normal hydrography, and cod spawning areas in the Arkona Basin.

In summary, fish and fish eggs are assessed to have a high sensitivity in relation to sediment spill, as the impact of elevated SSC is species-specific; however, the intensity is minor, as the dispersion caused by sediment spill will be close to natural conditions. The scale is evaluated to be regional, i.e. SSC in exceedance of threshold values will usually occur within a few kilometers of the construction work, see Section 5.1.2. The duration of the exceedance of threshold concentrations will, on average, last less than a day. Impact is not significant (Table 9-79).

Table 9-79 Impact significance on fish from suspended sediment during the construction of the pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Suspended sediments	High	Minor	Regional	Short-term	Minor	Not significant

Sedimentation

Suspended sediment made available due to construction will re-deposit on the seabed. This sedimentation may potentially affect fish populations by smothering larvae and eggs. There is no expected impact on pelagic fish from sedimentation.

Similarly, to the potential impact of suspended sediment, the magnitude of the impact is closely linked to the quantity, time and spatial scale of the re-sedimentation.

Demersal fish eggs and larvae may become critically covered by sediment (smothering) close to heavy intervention work (trenching areas) (Kjelland *et al*., 2015). Eggs and larvae of demersal spawning species, such as herring and the Baltic flounder, may be susceptible to smothering by sedimentation. Sedimentation can also influence the availability of food sources for fish by burying benthic fauna (Hutchison *et al*., 2016). Despite these potential impacts, the sensitivity is assessed to be medium as the state will revert naturally over time.

However, there will not be any significant impact from sedimentation on fish eggs in either coastal waters or offshore since no important demersal spawning grounds are found along the pipeline. Any potential impact would be within the immediate vicinity of the pipeline. The modelling results have shown that there will be a relatively large deposition of sediment at the temporary deposit area and at a small area within the vicinity of the exit point of the TBM, see Section 5.1.2. The deposition at the temporary deposit area corresponds to approximately 10-20 mm, and in the area close to the exit point of the TBM corresponds to approximately 1 mm. However, as stated above, there are no important demersal spawning grounds in these relatively small areas.

In summary, the magnitude of the impact from sedimentation on demersal fish larvae and eggs is assessed as minor due to the immediate duration, local impact and the reversibility of the impact (Table 9-80). Therefore, it is assessed that there will be no significant impact on fish from sedimentation.

Table 9-80 Impact significance on fish from the sedimentation of re-suspended matter during the construction of the pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Sedimentation	Medium	Minor	Local	Immediate	Minor	Not significant

Underwater noise

Anthropogenic underwater noise is potentially a threat to fish, and it has been recognized as a factor that may have implications (Slabbekoorn *et al*., 2010). Fish are exposed to moderate but widespread low-frequency noise, produced by various coastal activities, yet there is little insight to the nature and extent of the impact of sound on fish (Slabbekoorn *et al*., 2010). Underwater noise may impair the ability of fish to hear and use biologically relevant sounds, e.g. for acoustic communication, predator avoidance, prey detection and interpretation of the soundscape (Slabbekoorn *et al*., 2010). In general, there is a lack of studies within this field, and the majority of the available studies use captive fish (Graham & Cooke, 2008; Celi *et al*., 2016). However, there are indications that fish which are exposed to white noise or simulated boat noise have increased stress hormone (i.e. cortisol) levels (Celi *et al*., 2016). Other studies have shown increased heart rate and motility in relation to noise (Graham & Cooke, 2008). It is not possible to extrapolate such findings to free-swimming fish that are able to flee impacted areas, but the available information suggests that noise can have a potential impact on fish. Such impacts are also species-dependent, as they have different hearing abilities and dependency on sound (Slabbekoorn *et al*., 2010).

Fish have two sensory systems for detection of water motion, i.e. the inner ear and the lateral line system (Ladich & Schulz-Mirbach, 2016). Generally, fish hear best within 30 – 1,000 Hz, but there are species that can detect sounds up to 3,000 – 5,000 Hz, whereas other species are sensitive to infrasound or ultrasound (Slabbekoorn *et al*., 2010; Ladich & Schulz-Mirbach, 2016).

An example of the latter is the European eel, which is fished in Faxe Bugt and can detect and avoid infrasound (<20 Hz) produced by approaching predators.

The impact of underwater noise on fish can vary significantly, depending on the duration and the received level of the noise (see Table 9-81). Fish are known to respond differently to underwater noise (in experimental settings), which suggests that the reactions are likely dependent on variables such as location, temperature, physiological state, age, body size, and shoal/school size (Peng, Zhao and Liu, 2015).

Table 9-81 Potential impacts of underwater noise on fish.

Potential impact	Description of potential impact
Mortality	Several studies have reported mortality of fish exposed to blasts or other types of high-level sounds (Yelverton *et al.*, 1975; Popper & Hastings, 2009). Blast injuries can occur if munitions clearance takes place, whereas rock installation is incapable of producing noise with this type of impact. International guidance values regarding mortality from noise are shown in Table 9-82.
Physical injury	High-level acoustic exposures such as blasts can cause physical damage. There are no studies that have determined whether blasts that do not kill fish have had any impact on physiology (e.g. metabolic rate, stress). This type of impact can only occur in the close vicinity of the noise source (Peng, Zhao and Liu, 2015). International guidance values regarding physical injuries from noise are shown in Table 9-82.
Permanent threshold shift (PTS)	Permanent threshold shift can be caused by elevated noise resulting in auditory tissue damage. The hearing threshold does not recover after exposure (Andersson *et al.*, 2016). PTS values for cod and herring can be seen in Table 9-82.
Temporary threshold shift (TTS)	Temporal elevation of the hearing threshold can be caused by noise exposure. Hearing will recover with time, depending on the exposure, repetition rate, SPL, frequency and health of the fish (Andersson *et al.*, 2016). TTS can potentially occur at greater distances. International guidance values for TTS can be seen in Table 9-82, including specific values for cod and herring.
Masking of other sounds	Noise above the ambient level could cause masking, which interferes with the ability of fish to hear communication signals or other important sounds (Slabbekoorn *et al.*, 2010). No threshold values for masking of sounds are available in literature.
Behavioral response	Noise not resulting in PTS and TTS can cause avoidance, flight behavior, fright response, and altered swimming behavior (Slabbekoorn *et al.*, 2010; Andersson *et al.*, 2016). International guidance values for behavioral response are shown in Table 9-82, including specific values for cod and herring.

Table 9-82 International guidance values (IGV) for fish and cod/herring (Andersson *et al.*, 2016).

Guidance values for fish and cod/herring	Response	Sound Pressure Level (SPL=dB re 1 μPa/SEL=dB re 1 μPa²s)
Fish	Fatal injury	207 dB re 1 μPa²s (SEL)
Fish	Injury with recovery	203 dB re 1 μPa²s (SEL)
Fish	TTS	186 dB re 1 μPa²s (SEL)
Cod/Herring	PTS/TTS	205 dB re 1 μPa (SPL)
Cod/Herring	Mild behavioral response	75 – 125 dB re 1 μPa (SPL)
Cod/Herring	Strong behavioral response	125 – 165 dB re 1 μPa (SPL)
Cod/Herring	Strong escape response	165 dB re 1 μPa (SPL)

Construction activities

Construction activities, such as rock installations, trenching, pipe-lay, anchor handling, and ship traffic are characterized as continuous noise. As described in Section 5.1.5, the underwater noise generated from construction activities will not be distinguishable from the ambient noise levels, as the background levels in the Baltic Sea (with large volumes of ship traffic) are relatively high (Section 9.5). In addition, behavioral reactions to underwater noise from construction activities such as rock installation and ship traffic will occur near the pipeline and the construction vessels. The duration will be immediate and will cease after the activity has ended. It is not likely that there will be significant impacts on fish.

Unplanned event – munitions clearance

In connection with the risk assessments (Chapter 4), it has been identified that munitions clearance of UXO may pose a risk during the construction phase. Based on the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapters 4 and 5).

Impulsive noise emissions are relevant in relation to potential munitions clearance. The different threshold values are represented in Table 9-82. The potential impact distances for munitions clearance on fish is found in Table 9-83.

Table 9-83 Potential impact distances for munitions clearance on fish.

Distance [km]	Faxe Bugt								Bornholm			
Charge size	30 kg TNT				340 kg TNT				340 kg TNT			
Period	Summer		Winter		Summer		Winter		Summer		Winter	
max/avg	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg
Mortality	0.6	0.4	0.6	0.4	0.7	0.5	0.7	0.5	1.53	0.56	1.10	0.5
Injury	0.7	0.5	0.7	0.5	0.8	0.5	0.8	0.5	1.53	0.56	1.20	0.65

In a worst-case scenario, where munitions clearance is unavoidable, mortality can occur within a maximum distance of 0.7 km for Faxe Bugt and 1.5 km for Bornholm (Table 9-83). The worst-case scenario for injuries to fish at Bornholm is 1.4 km, and the maximum distance for Faxe Bugt is 0.8 km.

It is likely that it will be lethal for shoals or schools of fish that are present within the mentioned distances when munition clearances occur. The sensitivity to this impact on an *individual* level is high, due to the lethality and irreversibility, and the intensity is large for a regional area. Lastly, the duration of the impact is assessed to be immediate.

On a *population* level, the severity of the impact is minor. Munitions clearance will only present a lethal or injury risk for a few in larger populations. This means that the structure and function of the populations will remain unaffected.

Regarding behavioral response, fish are known to respond differently to tested noise, which suggests that reactions are likely dependent on variables including location, temperature, physiological state, age, body size, and shoal/school size. There will most likely be an immediate reaction to munitions clearance and the scale, which also is species-dependent, will range from local to regional in distance (Table 9-84).

Table 9-84 Impact significance on fish from underwater noise (unplanned event - munitions clearance) before mitigation measures.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Underwater noise (unplanned event - munitions clearance)	High	Large	Local/Regional	Immediate	Minor	Not significant

Mitigation measures

A ship-based sonar survey to identify shoaling or schooling fish in the area should be carried out to assess whether the timing of each munitions clearance is suitable or if the detonation should be postponed. This assessment can be helpful to protect shoals/schools of fish that may be present in the area.

Conclusion on mitigation measures

The application of mitigation measures will reduce the severity of the impact, as fewer individuals will be affected by munitions clearance. Still, the impact severity is assessed as minor because it is possible that there will be some variation within fish populations, but the severity will be closer to negligible than if no mitigation measures were used (Table 9-85).

Table 9-85 Impact significance on fish from underwater noise (unplanned event - munitions clearance) after implementation of mitigation measures.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Underwater noise (unplanned event - munitions clearance)	High	Large	Local/Regional	Immediate	Minor	Not significant

9.12.3 Conclusion

Table 9-86 presents the overall impact significance of the potential impacts on fish.

Table 9-86 Overall impact significance on fish.

Potential impact	Severity of impact	Significance	Transboundary
Physical disturbance of seabed	Negligible	Not significant	No
Suspended sediment	Minor	Not significant	No
Sedimentation	Minor	Not significant	No
Underwater noise (unplanned event)	Minor	Not significant	No

9.13 Marine mammals

In this section the baseline for marine mammals is described and the impacts from the project are assessed.

9.13.1 Baseline

Three species of marine mammals are resident in the western part of the Baltic Sea: harbour seal (*Phoca vitulina*), grey seal (*Halichoerus grypus*), and harbour porpoise (*Phocoena phocoena*). In addition, other marine mammals such as dolphins (e.g. *Stenella coeruleoalba)*, killer whale (*Orcinus orca*), beluga whale (*Delphinapterus leucas*) and others can be observed occasionally in the Baltic Sea, but these species are only rare visitors and will not be dealt with further herein.

Marine mammal surveys have been conducted as visual observations from shore and as aerial surveys along the planned route (Rambøll, 2018s). Three flights were performed: 7 November 2017, 8 January 2018, and 8 February 2018.

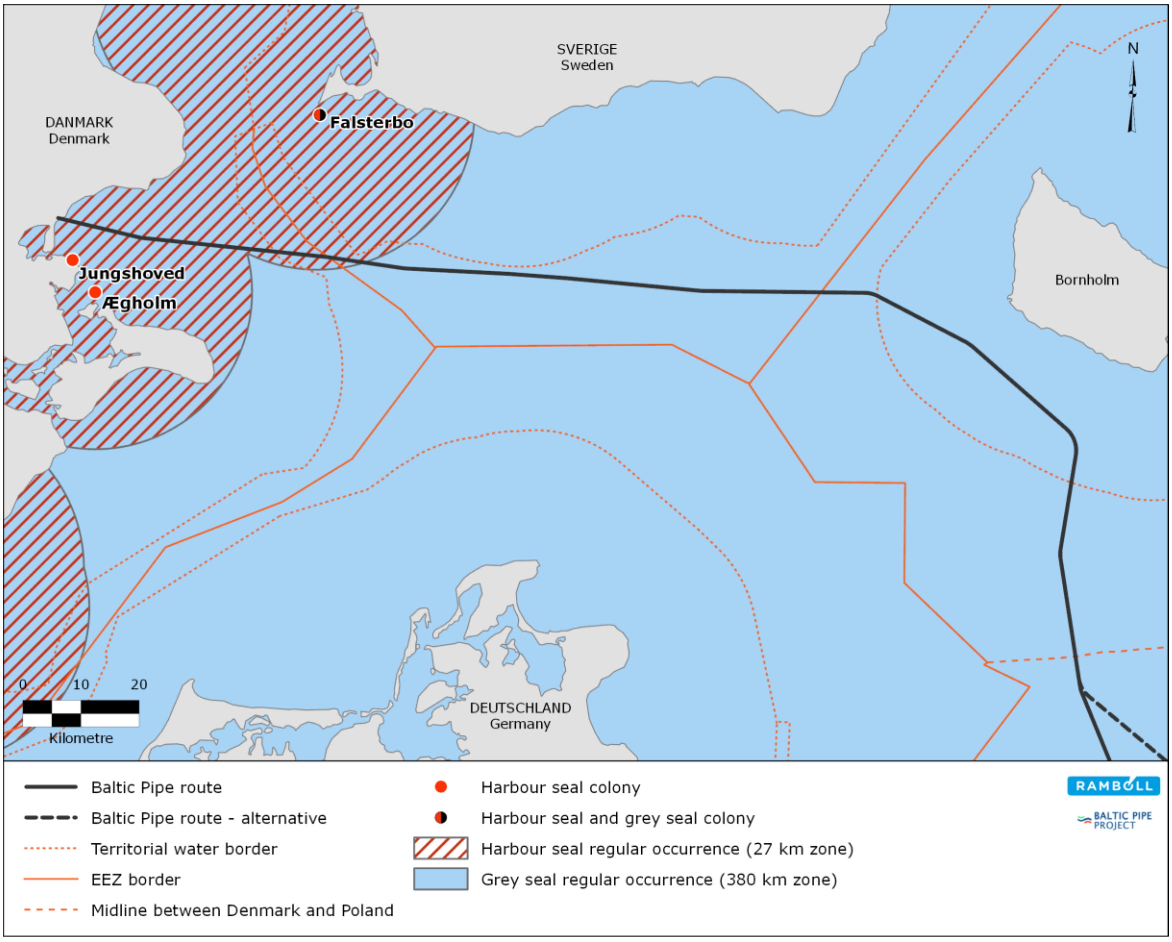

Figure 9-53 Grey and harbour seal colonies and zones of regular occurrence (Hansen *et al.*, 2018; Dietz *et al.*, 2015; Teilmann *et al.*, 2017). Grey seal occurs throughout the entire range of the project area, which is hence marked in blue.

Harbour seal

Harbour seal is the most common seal in Danish waters, with the highest densities in the Skagerrak, Kattegat, and Belt Seas. Further east, within the project area, the population is restricted to only a few colonies. The Baltic Sea population was estimated in 2016 to comprise 1,700 individuals (Hansen *et al.*, 2018).

The Baltic Sea population can be divided into two subpopulations, referred to as the Kalmarsund subpopulation and the southern Baltic subpopulation. Within the project area, only the southern Baltic subpopulation is present. Harbour seal colonies can be found at the small island Ægholm and at the northeastern part of Jungshoved in Faxe Bugt (more than 10.5 km from the planned route), at Saltholm and at Falsterbo (Sweden) (see Figure 9-53) (Naturstyrelsen, 2014b; Hansen *et al.*, 2018).

Survey campaigns have been done by observations from shore and as aerial surveys. During the aerial survey campaigns in November 2017 and February and March 2018 no harbour seals have been observed in Danish waters. Two dead harbour seals were observed during the onshore observations, one in January 2018 and one in February 2018 at the shore of Faxe Bugt.

In general, harbour seals are only swimming at limited distances from their colonies to seek food (less than 30 km, Dietz *et al.*, 2015), though further distances can be observed. Their food sources consist mainly of a large variety of fish species, but also squid and crustaceans. The vision of seals is adapted to function equally well both under and above water. Seals have whiskers, which have an equally high importance for food localization as vision (Denhardt *et al.*, 1998). In addition, harbour seal hearing is well-adapted for aquatic life. An audiogram for a particular species presents the underwater hearing range of the species. For harbour seals, the optimal hearing range is between a few hundred Hz to approximately 50 kHz (Figure 9-54). The audiogram shows the hearing threshold, which means that the species can only detect sound above the threshold for each frequency (frequencies above the shown line).

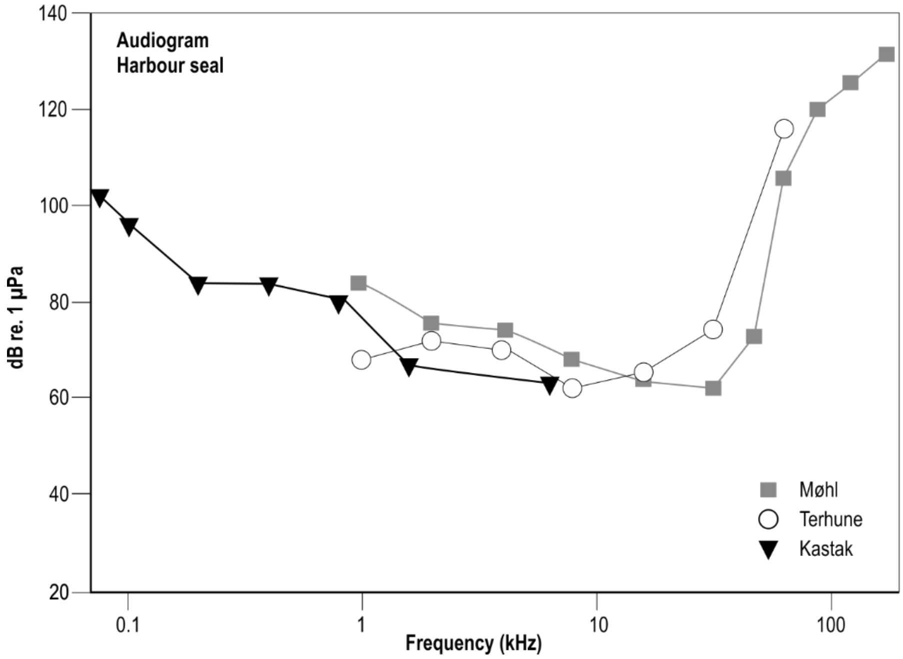

Figure 9-54 Audiogram for the harbour seal (quiet conditions) at a frequency range from 80 Hz to 150 kHz (Modified after Møhl, 1968; Terhune and Turnbull, 1995; Kastak and Schusterman, 1998).

Seals in general are not considered sensitive to disturbance (Blackwell *et al.*, 2004) except during breeding and moulting. In these periods, the species is sensitive to physical disturbance, especially from disturbance on land near colonies (Galatius, 2017). The harbour seal breeds in May/June and moults in August/September (Hansen *et al.*, 2018), which therefore are their most vulnerable periods. In addition, pups are sensitive to disturbance near colonies in June/July, as they depend on the resting sites for suckling.

The harbour seal is listed in Annex II and V of the Habitats Directive. The species is included on the designation basis for the Danish Natura 2000 site no. 168 - Havet og kysten mellem Præstø Fjord og Grønsund near the pipeline route (see Section 9.19). The southern Baltic Sea subpopulation is considered of least concern according to the HELCOM Red List and on a national level.

Grey seal

Grey seals can be observed throughout the Baltic Sea. The total size of the Baltic Sea population is estimated to be 40,000 individuals. In the Danish part of the Baltic Sea, 589 individuals were counted in 2016 (Hansen *et al.*, 2018), where the majority (468 individuals) were found at Christiansø, north of Bornholm. Colonies, also called haul-out sites, are places for resting, mating, breeding, and moulting. Colonies remain in the same location each year. Grey seal colonies can be found at Saltholm in Øresund and Rødsand at southern Lolland in Denmark and at Falsterbo in Sweden (Figure 9-53). Only Falsterbo has a relatively short distance (more than 25 km) to the proposed Baltic Pipe route.

Survey campaigns have been performed via observations from shore and as aerial surveys. During the November campaign, one grey seal was observed in the Danish territorial waters southwest of Bornholm. During the two aerial survey campaigns in February and March, no grey seals were observed in Danish waters. There have been no observations of grey seals during onshore surveys.

Grey seals travel far between resting spots and foraging sites (distances of up to 380 km have been registered, Dietz *et al.*, 2015). Grey seals feed on a wide variety of fish species. In the Baltic Sea, the main food source is herring, but sprat and Atlantic cod are also important food sources. Diving occurs at all water depths within the project area. Vision and hearing have not been researched for grey seals but are generally assumed to resemble the senses for harbour seal (see previous section).

Grey seals breed at undisturbed haul-out sites in February and March. In Denmark and the remaining part of the project area, Rødsand is the only grey seal breeding site, and here only a few pups have been born. Nursing takes place for 2-3 weeks. Moulting takes place on haul-out sites (or sea ice in the northern part of the Baltic Sea) in May/June (Hansen *et al.*, 2018).

Seals are generally not considered sensitive to disturbance (Blackwell *et al.*, 2004) except during breeding and moulting. In these periods, the species are sensitive to physical disturbance, especially from disturbance on land near colonies (Galatius, 2017). As there are no grey seal haul-out sites near the planned pipeline route, the grey seal is not considered sensitive to construction activities.

The grey seal is listed in Annex II and V of the Habitats Directive. The species is not included in Danish Natura 2000 sites along the pipeline route (see Section 9.19). It is considered of least concern on the HELCOM Red List, but as vulnerable on a national level in Denmark. In addition, the grey seal is included in Appendix II of the Bonn Convention[43].

Harbour porpoise

The harbour porpoise is the only cetacean species that lives in the Baltic Sea. Two populations of harbour porpoise can be found in the Baltic Sea; the Baltic Sea (or Baltic Proper) population and the Belt Sea population. The Baltic Sea population is an endangered population with only very few individuals (500 individuals). This population is only likely to occur during the winter period around Rønne Banke, as there is a clear distinction between the two populations during the summer period, with a population separation east of Bornholm (Figure 9-55, SAMBAH, 2016). The Belt Sea population size was estimated in 2012 to comprise approximately 18,500 individuals (Sveegaard *et al.*, 2013), and during the SAMBAH study, more than 20,000 individuals were observed (SAMBAH, 2016). During the summer period (May-October), only the Belt Sea population is expected to be present in the project area, whereas during the winter season (November to April) the overall presence will be lower but may consist of a mix of the two populations (SAMBAH, 2016). The highest concentration of harbour porpoises can be seen in the western part of the project area. Harbour porpoise distribution is shown in Figure 9-55. The

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[43] Bonn convention: Convention on the Conservation of Migratory Species of Wild Animals (CMS): The Convention provides a global platform for the conservation and sustainable use of migratory animals and their habitats. It brings together the States through which migratory animals pass (called the Range States) and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range.

Migratory species threatened with extinction are listed on Appendix I of the Convention. CMS Parties strive towards strictly protecting these animals, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might endanger them. Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention.

densities are, in general, smaller than in other parts of Danish waters (e.g. in the Storebælt and Lillebælt, Teilmann *et al.*, 2008). Densities are between 0 and 0.57 individuals/km^2 during the period of May to October, and 0 to 0.37 individuals/km^2 during the period November to April (SAMBAH, 2016; Teilmann *et al.*, 2017).

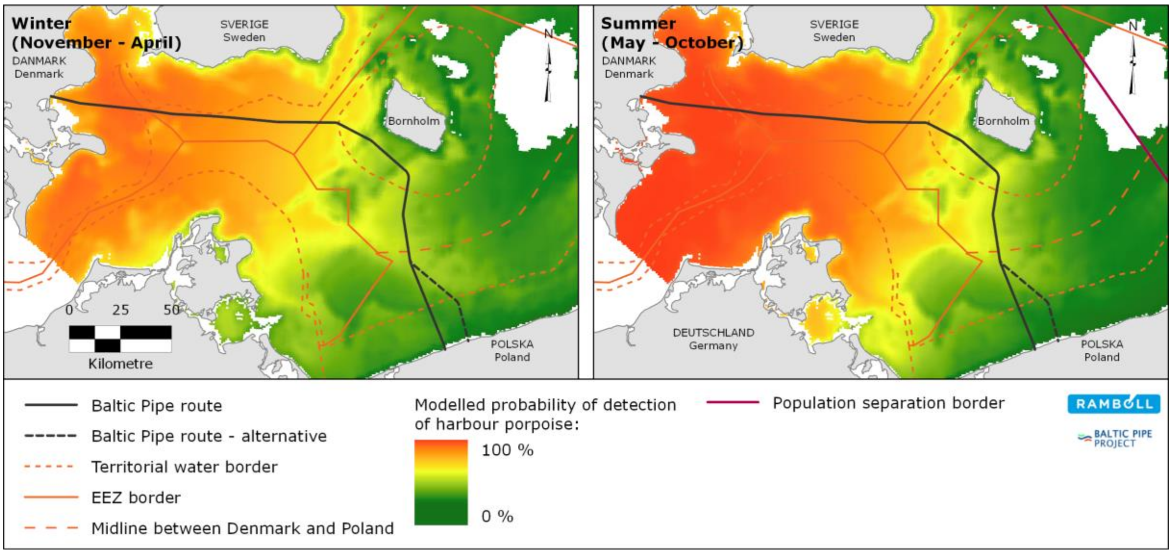

Figure 9-55 Harbour porpoise subpopulations and distribution for the period November to April and May to October (SAMBAH, 2016). The population separation border marks the border, where the Baltic Sea population are not found west of, during the summer period.

Survey campaigns have been performed as observations from shore and as aerial surveys. During the aerial campaign in November 2017, one harbour porpoise was observed approximately 25 km east of Møn. During the survey campaigns in February and March 2018, no harbour porpoises have been observed in Danish waters.

In addition, acoustic monitoring with C-PODs was executed from November 2017 to April 2018. In total, 10 C-PODs were deployed along the planned Baltic Pipe route, of which three were placed in Danish waters. Harbour porpoises were detected by all deployed C-PODs. In general, a higher detection (detection positive days, Table 9-87) was observed at the station closest to Faxe Bay (CPOD_01) than at the stations close to Bornholm (CPOD_13 and CPOD_15), Figure 9-56. Additional monitoring outside of Danish waters support these findings (Figure 9-56).

Table 9-87 C-PODs deployed in Danish waters. DPD: Detection Positive Days.

C-POD (DK waters)	Detection period	Comment
C-POD_01	14/11-2017 to 27/4-2018	Recorded according to plan. DPD in approx. 50-80% of the time.
C-POD_13	14/11-2017 to 25/3-2018	Shorter period due to recording failure. DPD in approx. 0-6% of the time.
C-POD_15	14/11-2017 to 21/4-2018	Recorded according to plan. DPD in approx. 0-10% of the time.

The harbour porpoise distribution based on C-POD DPD registrations during the survey period is shown in Figure 9-56.

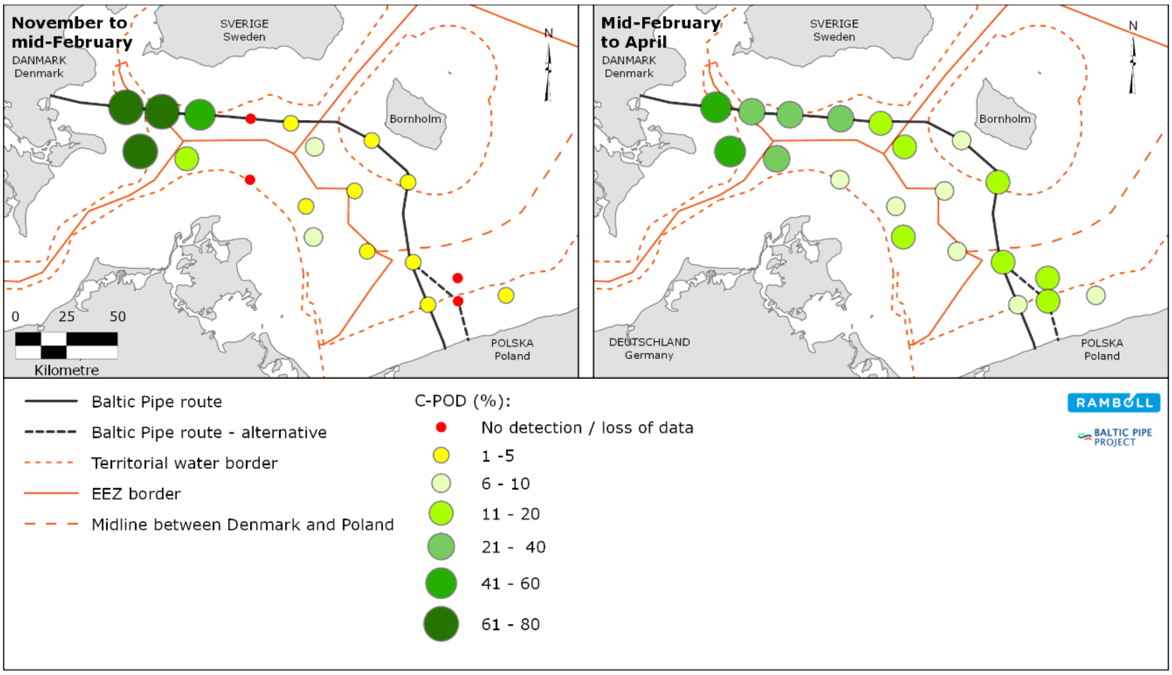

Figure 9-56 Harbour porpoise distribution presented as proportion of DPD based on acoustic monitoring (C-PODs) for the period November mid-February and from mid-February to April.

The survey results for the winter survey confirmed that harbour porpoises are observed in the Danish section of the project area and that there is a density gradient, where the density is higher in the western part of the Arkona Basin than in the eastern part near Bornholm during the winter period.

The main food source for the harbour porpoise consists of various fish species, especially cod, herring, and sprat (Börjesson & Berggren, 2003), but the species is an opportunistic feeder, adapting its feeding conditions towards available prey. Diving depth is usually no more than 50 m, which indicates that harbour porpoises dive at all water depths within the project area (Section 9.1).

Harbour porpoises use echo-localisation for foraging and navigation and are hence able to search for prey and navigate in complete darkness. A key feature of the species is its hearing capability, although harbour porpoises also have good vision underwater. The optimal hearing range is shown by the audiogram in Figure 9-57.

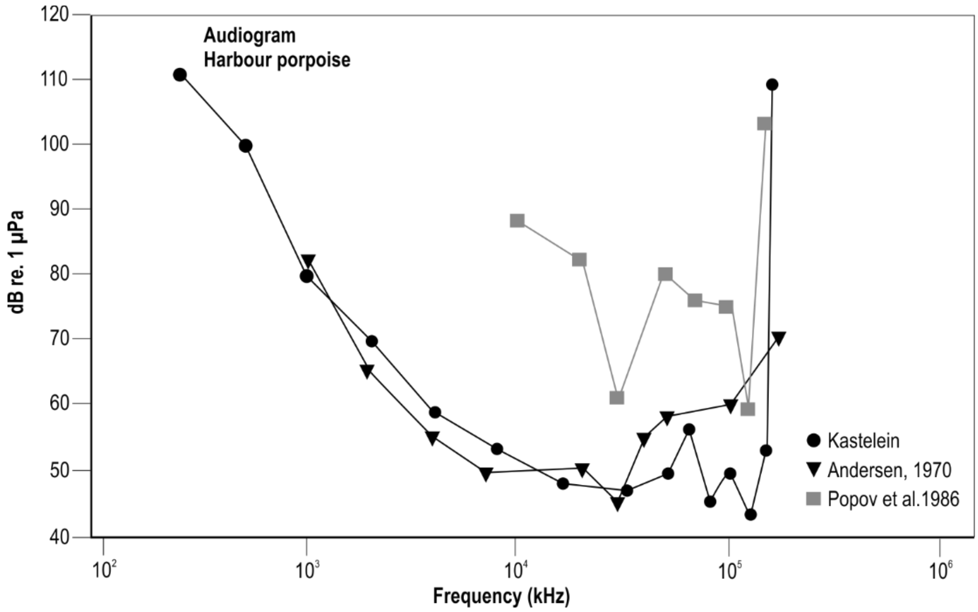

Figure 9-57 Audiogram for the harbour porpoise (modified from Kastelein *et al.* (2010), Andersen (1970) and Popov *et al.* (1986)). The audiogram shows the hearing threshold; harbour porpoises can detect sound levels above the threshold (the line) for each frequency. The best ability to detect sound is at frequencies with the lowest threshold.

Harbour porpoise breed from mid-June to late August in the Baltic Sea (SAMBAH, 2016). Females give birth to a single calf, which is dependent on its mother for the following year. There are no specific breeding areas identified in the Baltic Sea, but areas around the Midsjö Banks in Sweden are considered important (outside of the project area (SAMBAH, 2016)). It is assumed that harbour porpoises are especially sensitive during the breeding period, but the calves are considered vulnerable during the lactation period, which lasts 8-11 months.

The species is strictly protected under Annex IV of the Habitats Directive (EU Directive on the Conservation of Natural Habitats and Wild Flora and Fauna - 92/43/EEC). Furthermore, it is included on the Bonn Convention Appendix II[43]. The Baltic Sea population is assessed as Critically Endangered and the Belt Sea population as Vulnerable on the HELCOM Red List.

9.13.2 Impact assessment

In connection with the construction and operation of the Baltic Pipe, three potential sources of impact have been identified and are presented in Table 9-88.

Table 9-88 Potential sources of impact on marine mammals.

Potential source of impact	Construction	Operation
Suspended sediments	X	
Physical disturbance above water	X	
Underwater noise	X	

The following sources of impact have been screened out:

- **Contaminants and nutrients (construction):** Screened out due to extremely low exposure time and very low concentrations of bioavailable contaminants released to the water column from project-related activities (Section 9.2).
- **Presence of pipeline (operation):** The pipeline will occupy a very small part of the seabed (Box 5-5). In addition, introduction of new habitat (i.e., hard substrate) and habitat loss (due to the footprint of the pipeline), which could impact the availability of food sources (i.e., fish),

have been shown to be of negligible significance (Section 9.12); hence, no impact on marine mammals is foreseen.

- **Underwater noise from gas flow in the pipeline (operation):** Low-frequency noise from the pipeline will be audible for marine mammals very close to the pipeline. As the pipeline will occupy only a very limited space, and the range at which it will be audible will be strictly local, this is not likely to impact marine mammals.
- **Indirect impact by changes in food source (construction and operation):** As no significant impacts on fish are anticipated (Section 9.12), there will be no indirect impact on marine mammals.

Suspended sediments

Impacts on marine mammals from suspended sediment (increased SSC) dispersed from the construction works can including visual impairment and behavioural impacts, i.e., avoidance of sediment plumes.

Modelling results from increased SSC can be seen in Section 5.1.2.

Harbour porpoise

Harbour porpoises use echolocation for orientation and in the search for prey (Wisniewska *et al.*, 2016; Teilmann *et al.*, 2007). In addition, due to their high mobility and ability to avoid sediment plumes, the sensitivity to increases in SSC is low.

As the increase in SSC will be temporary (Section 5.1.2), with low concentrations outside the construction site, visual and behavioural changes, which can cause an impact, are not likely to occur. Thus, combined with the low sensitivity in relation to SSC, the impact severity is negligible and hence not significant.

Harbour seal and grey seal

Studies have shown that vision is not essential for seals to navigate and forage in water (Weiffen *et al.*, 2006), and as for harbour porpoises, seals are highly mobile; hence, their sensitivity in relation to SSC is low.

As the increase in SSC is temporary, with low concentrations outside the construction site, visual and behavioural changes, which can cause an impact, are not likely to occur. This combined with the low sensitivity yields a negligible impact severity, which is hence not significant, Table 9-89.

Table 9-89 Impact significance on marine mammals from suspended sediment.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Suspended sediments	Low	Minor	Local	Immediate	Negligible	Not significant

Physical disturbance above water

The physical disturbance from construction-related activities above water could potentially disturb seals (but not harbour porpoises), but seals in general are not considered sensitive to disturbance (Blackwell *et al.*, 2004). During periods of breeding and moulting, seals are sensitive to physical disturbance on land near colonies (Galatius, 2017). As the construction activities will not occur close to colonies (i.e., at a distance of less than 5 km, see Figure 9-53), impacts on breeding and moulting seals are not likely to occur.

The physical disturbance of marine mammals from the presence of vessels, which is relevant for both harbour porpoises and seals, is considered negligible compared to the disturbance from underwater noise. Underwater noise is therefore assessed as a worst-case scenario for disturbance (next paragraph), Table 9-90.

Table 9-90 Impact significance on marine mammals from physical disturbance above water.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance above water	Low	Minor	Local	Immediate	Negligible	Not significant

Underwater noise

Potential impacts on marine mammals from underwater noise range from physical injury to behavioural responses (Figure 9-58), characteristics of which are presented in Table 9-91.

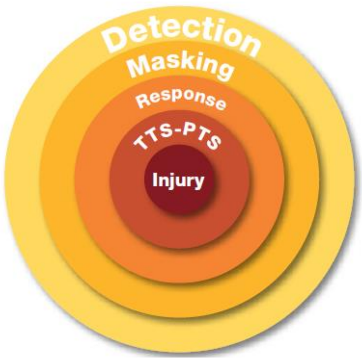

Figure 9-58 Zones of influence at various distances from an underwater noise source (WODA, 2013).

For marine mammals the auditory system is the most sensitive organ and the risk of damage to this system is higher than the risk of impacts on other organs. Following exposure to loud noise levels, threshold shifts are often observed. Threshold shifts are reductions in hearing sensitivity and can be either permanent or temporary, depending on the exposure levels and time. In terms of severity, the impact is gradual from blast injury to TTS (Sveegaard *et al.*, 2017).

Table 9-91 Potential impacts on marine mammals (Yelverton *et al.*, 1973; Southall *et al.*, 2007; Sveegaard *et al.*, 2017).

Potential impact	Description of potential impact
Physical injury (blast injury)	Tissue damage due to the shock wave. Measurements for threshold values have been taken for mammals with ear drums (Yelverton *et al.*, 1973). As harbour porpoise has no functional ear drum, this measured threshold value does not apply. The risk of tissue damage is measured in relation to the acoustic impulse (Pa·s): • 280 Pa·s: No mortality, but moderately severe blast injuries (including ear drum rupture) are frequently observed. Animals are capable of recovery.

Potential impact	Description of potential impact
	• 140 Pa·s: High risk of minor blast injuries, including ear drum rupture. • 70 Pa·s: Low risk of blast injuries. No ear drum rupture. • 35 Pa·s: Safe level Physical injury can imply insignificant bleeding to death of the affected species. Animals can recover quickly from small injuries, and no long-term effects are anticipated. More severe injuries can reduce viability and hinder reproductive ability.
Permanent threshold shift – PTS	Permanent hearing loss. Damage to the sensory organ. Hearing threshold does not recover after exposure. As most species are dependent on hearing ability, hearing loss will cause reduced viability and potential death, consequently. The impact severity is dependent on the level of PTS, where high PTS levels are more severe than small PTS (viability is not reduced significantly). Threshold values for harbour porpoise and seals can be seen in Table 9-94.
Temporary threshold shift – TTS	Temporary hearing loss. Hearing ability will recover with time, ranging from minutes to hours, depending on exposure level. As the impact is relatively short-term, the viability of the individual is not at high risk. Threshold values for harbour porpoise and seals can be seen in Table 9-94.
Avoidance behaviour	Underwater noise, which does not induce TTS or PTS, may still impact marine mammals by causing altered behaviour, which again can have implications for the long-term survival and reproductive success of individuals. Avoidance behaviour ranges from panic over flight to disturbance (Skjellerup *et al.*, 2015). Panic behaviour can cause severe impact by inducing by-catch, stranding etc., which in turn can cause mortality. Flight and disturbance behaviour can reduce foraging time, nursing time, which again can reduce the fitness of the species. No threshold values for construction activities or explosions have been determined in the literature.
Masking of other sounds	Masking is the situation where project-generated noise hinders the detection and identification of other sounds. Masking is relevant in connection with continuous noise (hence not munitions clearance) and must coincide in time and approximately be within the same frequency band. The impact of masking on marine mammals has not been assessed in the scientific literature. No threshold values for construction activities have been determined in the literature.
Behavioural response	Behavioural responses to noise (other than avoidance behaviour) can be e.g. altered swimming patterns. Behavioural responses are difficult to predict and therefore to assess. No threshold values for construction activities have been determined in the literature.

The sensitivity of marine mammals to underwater noise depends on the type of noise (e.g. level, frequency, single events from explosions vs. continuous noise such as rock installations), the threshold values, the vulnerability over the season (Table 9-92) and the species. In general, seals are considered less sensitive to disturbance by underwater noise than harbour porpoises (Blackwell *et al.*, 2004).

Table 9-92 Vulnerable periods (marked in grey) for marine mammals in the southern Baltic Sea in connection with abundance and key period (breeding, moulting and lactation as specified in the baseline sections) (Hansen *et al.*, 2018; SAMBAH, 2016).

Species/group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise – Belt Sea population[1]												
Harbour porpoise – Baltic Sea population[2]					3	3	3	3	3	3		
Harbour seal												
Grey seal												

[1]Adults are sensitive during the breeding period (June-August). Calves are sensitive 8-11 months after birth.
[2]Very vulnerable population.
[3]Very low abundance (if any present) in the project area (SAMBAH, 2016).

When defining the sensitivity of an activity, a combination of the activity and the seasonality have been taken into consideration.

<u>Construction activities</u>
Construction activities, such as rock installations, trenching, pipe-lay, anchor handling and ship traffic are characterised as a continuous noise. As described in Section 5.1.5, the underwater noise generated from the construction activities will not be distinguishable from the ambient noise levels, as the background levels in the Baltic Sea, where there are already large volumes of ship traffic, are relatively high (Section 9.5). In addition, behavioural reactions to underwater noise from construction activities such as rock installation and ship traffic will occur near the pipeline and the construction vessels. The duration will be immediate and will cease after the activity has ended.

It is not likely that there will be significant impacts on marine mammals (Table 9-93).

Table 9-93 Impact significance on marine mammals from underwater noise from rock installation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Underwater noise (construction activities)	High	Minor	Local	Immediate	Negligible	Not significant

<u>Unplanned events</u>
In connections with the risk assessments (Chapter 4), it has been identified that munitions clearance of UXO may pose a risk during the construction phase. Based on the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapter 4 and 5).

Underwater noise from munitions clearance will potentially create an impact on marine mammals. In the literature, a set of threshold values has been determined for TTS and PTS (Table 9-91), which is presented in Table 9-94.

Table 9-94 Threshold values for munitions clearance for marine mammals (Southall *et al.*, 2007; Sveegaard *et al.*, 2017).

Species/group	Munitions clearance	
	PTS	TTS
Harbour porpoise	179 dB SEL	164 dB SEL
Seal	179 dB SEL	164 dB SEL

Modelling methodology, choice of munition type and the results of the underwater noise propagation from munitions clearance are shown in Section 5.1.5. The propagation is modelled for winter and summer scenarios as well as for two munition types in Faxe Bugt and one in Bornholm. Modelling of the winter scenario is presented in Figure 9-59, Figure 9-60 and Table 9-95. PTS contours represent the physical and permanent injury to marine mammals, whereas TTS contours represent the area of TTS and avoidance behaviour.

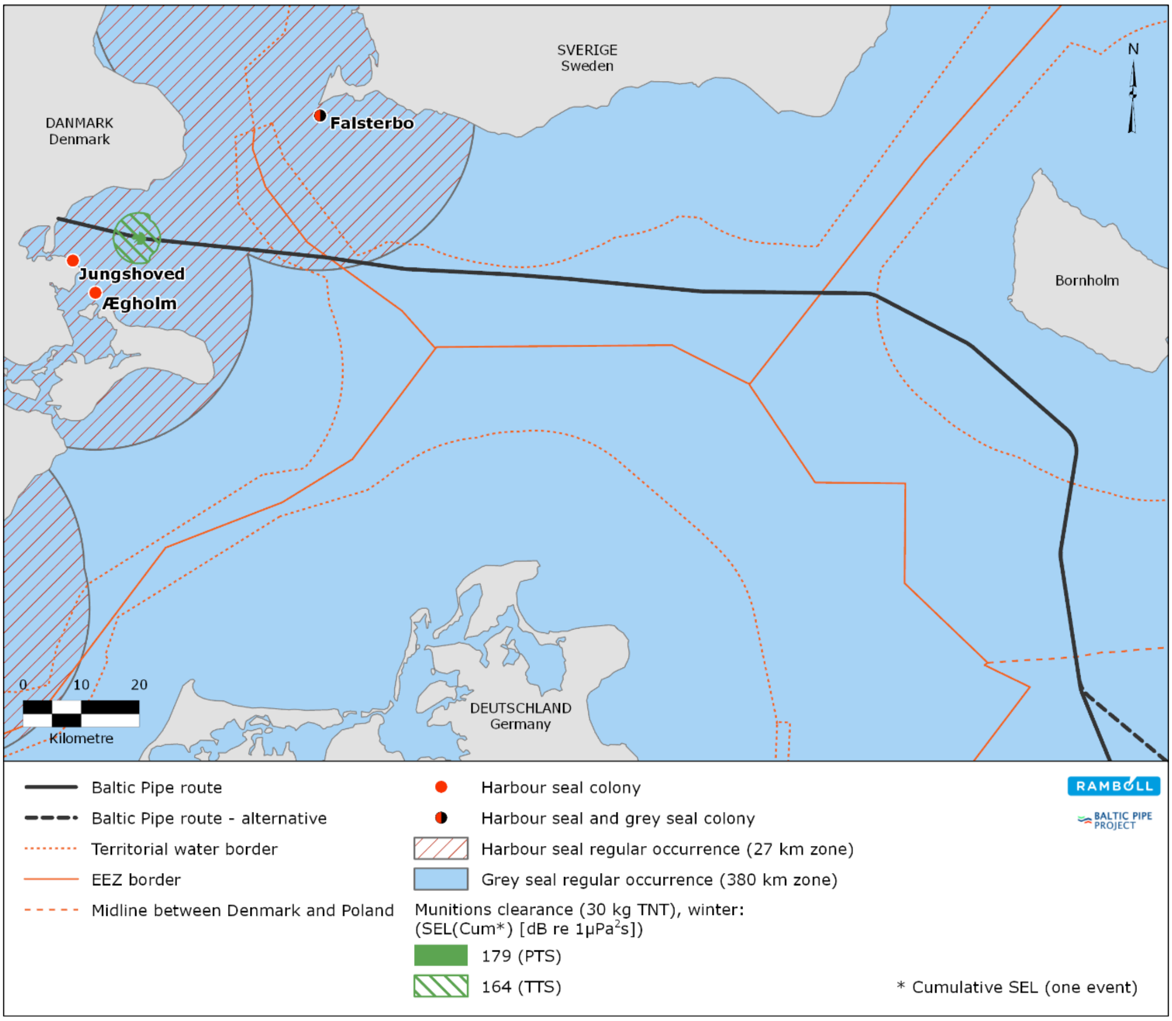

Figure 9-59 TTS and PTS for winter scenario for a 30 kg TNT.

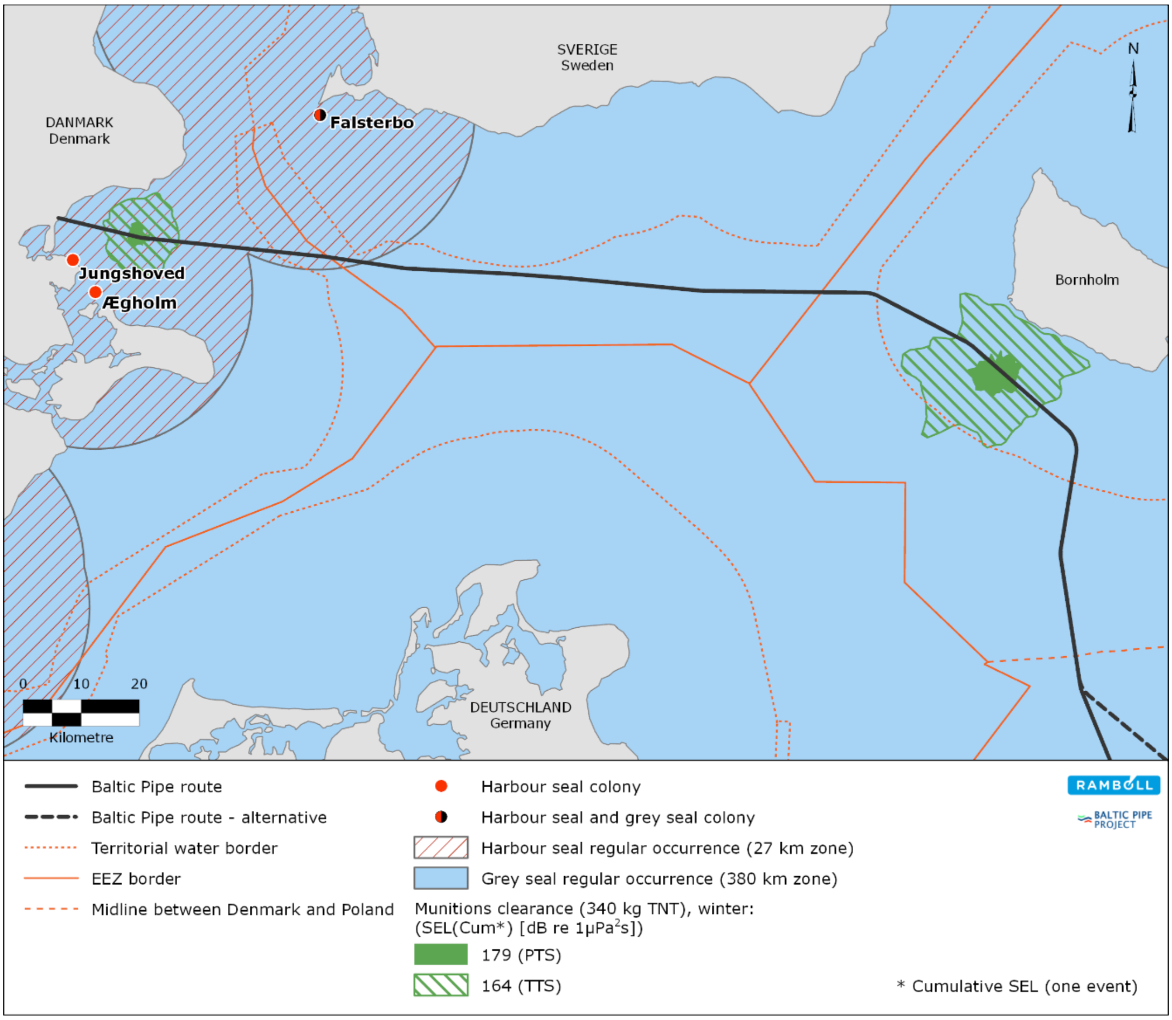

Figure 9-60 TTS and PTS for winter scenario for a 340 kg TNT.

Table 9-95 Potential impact distance for munitions clearance on marine mammals.

Distance [km]	Faxe Bugt								Bornholm			
Charge size	30 kg TNT				340 kg TNT				340 kg TNT			
Period	Summer		Winter		Summer		Winter		Summer		Winter	
max/avg	max	avg	max	avg	max	avg	max	avg	max	avg	max	avg
PTS	1.3	1	1.3	1	2.1	2	2.8	1.8	4.8	3.4	5.2	3.8
TTS	3.6	3.6	4.4	4.1	7.7	5.9	8.3	6.5	17.5	11.8	16.7	12

To assess the impact on marine mammals it is important to look at the impact both on an individual basis and on a population scale. The impact can also differ between species and populations. Below is the impact assessed for physical injury/PTS and TTS/avoidance behaviour for harbour porpoises and seals. The assessments are done without the use of mitigation measures (which is a hypothetical scenario as some or all of the suggested mitigation measures must be implemented) and with mitigation measures. Assessments without mitigation measures are done without considerations on season of construction works.

Physical injury and PTS

Harbour porpoise

The sensitivity for individual harbour porpoises of both populations to injury and PTS is high, as the impact is permanent and will most likely cause lowered fitness and potentially death as a consequence.

If munitions clearance is unavoidable in Faxe Bugt and/or near Bornholm, and based on a worst-case scenario, a risk of PTS would be present at a maximum distance of 2.8 km in Faxe Bugt and 5.2 km near Bornholm (Table 9-95). This means that if harbour porpoises are present in this area, injury and permanent hearing damage are likely to occur. The impact magnitude is high on an *individual* basis as the intensity of the impact is large and the impact will be long-term. The impact severity is hence considered major.

On a *population* level, the impact is different. For the Belt Sea population, the impact is not likely to be as severe, as only a few individuals out of a large population are likely to be impacted, and hence the impact on the structure and viability of the population will only be minor. The impact severity is assessed to be minor. The opposite is the case for the Baltic Sea population. If individuals from this very small and endangered population (< 500 individuals) are severely impacted, the impact magnitude on a population scale will also be high, as the viability of the population will be influenced. Taking a precautionary approach (not considering that the density of the species is low), the impact severity is assessed as major.

Seal

The sensitivity of individual seals to injury and PTS is high, as the impact is permanent and will most likely cause lowered fitness and potentially death as a consequence, similar to the harbour porpoise.

The impact range is identical as to that for the harbour porpoise (Table 9-95), see the above section.

On an *individual* scale, the risk of injury and PTS is present with a range of 2.8 km during the winter for both the harbour seal and grey seal (in Faxe Bugt), and 5.2 km for the grey seal near Bornholm (harbour seals are not present, Figure 9-53). The impact magnitude is high on an *individual* basis, as the intensity of the impact is large, and the impact is long-term. The impact severity is assessed as major.

On a *population* level the impact is not likely to be as severe, as only a few individuals out of a large population are likely to be impacted, and hence the impact severity on the population structure will be minor.

TTS and avoidance behaviour

The sensitivity to TTS and avoidance is low for both the harbour porpoise (both populations) and seals, as the impact will cease immediately (i.e., within minutes to hours) after the blast.

If munitions clearance is unavoidable in Faxe Bugt and/or near Bornholm, based on a worst-case scenario, a risk of TTS and avoidance reactions would be present within a maximum distance of 8.3 km in Faxe Bugt and 17.5 km near Bornholm (Table 9-95). It is expected that marine mammals will be able to hear the explosions at a very large distance (beyond the TTS zone) and are expected to react strongly within the TTS zone. Even though the intensity is large leading to a strong behavioural reaction and a risk of TTS, the impact magnitude is assessed as low, as the hearing ability and the reaction pattern will revert to normal after the impact has ceased. The impact severity will hence be minor and not significant (Table 9-96) for all species.

Table 9-96 Impact significance on marine mammals from underwater noise from munitions clearance (unplanned event) - before mitigation. PTS: Blast injury/PTS; TTS: TTS and avoidance behaviour.

Underwater noise - Munitions clearance			Sensitivity	Magnitude of impact			Severity of impact	Significance
				Intensity	Scale	Duration		
Harbour porpoise	Baltic Sea	PTS	High	Large	Regional	Long-term	Individual: Major Population: Major	Significant
		TTS	Low	Large	Regional	Immediate	Minor	Not significant
	Belt Sea	PTS	High	Large	Regional	Long-term	Individual: Major Population: Minor	Individual: Significant Population: Not significant
		TTS	Low	Large	Regional	Immediate	Minor	Not significant
Seal		PTS	High	Large	Regional	Long-term	Individual: Major Population: Minor	Individual: Significant Population: Not significant
		TTS	Low	Large	Regional	Immediate	Minor	Not significant

<u>Mitigation measures</u>

To reduce the impact from blast injury and PTS on individuals and at population level of the two populations of harbour porpoises and for the two species of seal, mitigation measures will be applied. The use of visual and passive acoustic monitoring by a marine mammal observer and seal scarers are common measures to reduce the impact from underwater noise. In addition, the choice of season for munition clearance can reduce the potential impact for the endangered Baltic Sea population of harbour porpoise.

Overall, the UXO specific marine mammal mitigation plan include mitigation measures such as the use of marine mammal observers (MMOs), Passive Acoustic Monitoring (PAM) and acoustic deterrent devices.

Visual observations and PAM

Visual monitoring by a MMO will be undertaken from the source vessel (on a suitable viewing platform). Visual monitoring should be restricted to periods of good visibility during daylight hours, as visibility decreases during poor weather or lighting conditions. If marine mammals are present prior to planned munition clearance, the detonation should be postponed. Visual observations prior to munitions clearance do not guarantee that marine mammals are not affected, as marine mammals may stay below the surface and hence remain undetected for long periods. However, a visual survey prior to clearance can help to protect animals, which are sighted. Acknowledged guidelines from JNCC should be applied as good practice for visual observation methodologies (JNCC, 2010; JNCC, 2017). PAMs are hydrophones deployed into the water column, and the detected sounds are processed using specialised software. PAM are implemented as a supplement to the visual observations done by the MMO.

Seal scarer

Seal scarers or seal scramers are acoustic deterrent devices, which can be used to deter seals and harbour porpoises from e.g. construction activities, fishing gear etc. The range, or the efficiency of the devices depends on the type of scarer and the setup. Harbour porpoises react stronger to seal scarers than seals (Hermannsen *et al,* 2015).

A review done by Centre for Environment and Energy for the Danish Energy Agency has summarised the deterrence range from several studies of scarers and has found that for harbour porpoises the most efficient seal scarer (Lofitech) has a range of 350-7,500 m. According to the review, all animals were deterred within 350 m, most animals at a range of 1-2,000 m, and the maximum reaction range was 7,500 m (Hermannsen *et al,* 2015).

A setup like the one suggested for NSP are suggested to be used for the Baltic Pipe project (Figure 9-61).

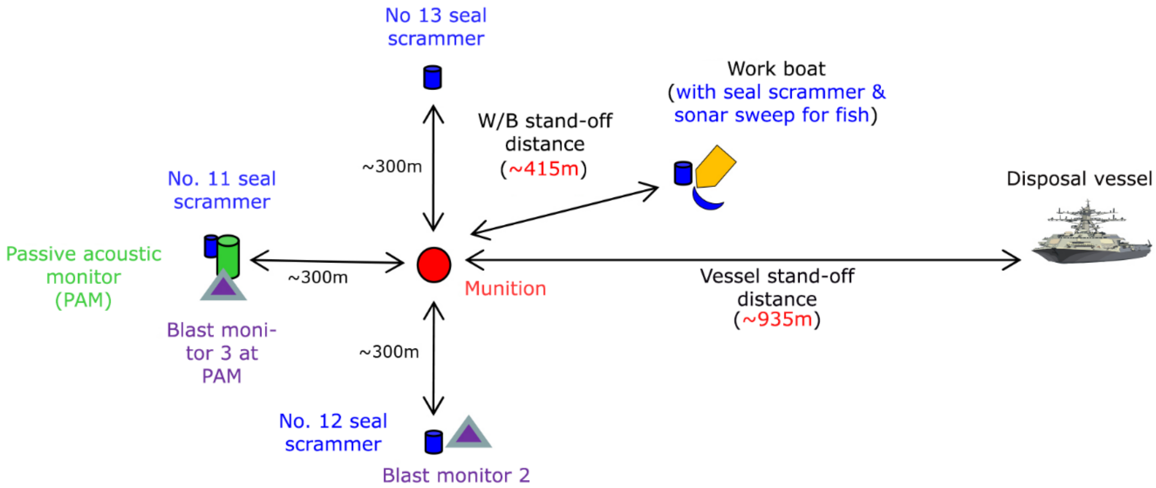

Figure 9-61 Setup for monitoring and mitigation equipment typically used during munitions clearance for the Nord Stream pipeline, from Rambøll (2017).

Application of seal scarers can reduce the risk of severe blast injury (non-recoverable injury, Table 9-91) to a negligible level, as no animals (harbour porpoises and seals) will be close to the detonation site.

For harbour porpoises, the PTS zone will also be reduced, as seal scarers are efficient to a distance of 1-2 km. Within Faxe Bugt the use of seal scarer will be very efficient. For a small detonation (30 kg TNT), the impact magnitude will be minor, and the severity will be negligible, as all harbour porpoises most likely will be scared out of the PTS zone.

For the large detonations (340 kg TNT), a PTS zone will remain as the seal scarer may not entirely deter all harbour porpoises within the zone. As the sound pressure level decrease exponentially from the munition site and as the severity of PTS decreases gradually (Table 9-91), it is assessed that severe PTS will be reduced to *minor to moderately severe injuries*, which corresponds to survivable injuries (Table 9-91). In Faxe Bugt the use of seal scarer is most efficient, compared to the area near Bornholm, due to the difference in noise propagation at the two sites. On the other hand, the density of harbour porpoises is higher in Faxe Bugt than farther to the east, so the risk of impacting individuals is higher in Faxe Bugt than near Bornholm. Therefore overall, the impact magnitude is assessed to be at the same level at the two sites.

As the most severe cases of PTS is reduced to a minor to moderately severe injury, the impact magnitude is assessed as medium and the severity as moderate for harbour porpoises on an *individual* level for both populations, but the impact as not significant, as the individuals can survive.

The impact severity on a *population* level of the Belt Sea population is assessed as minor, as only a few individuals out of a large population are likely to be impacted. Impact significance is assessed as not significant.

The impact severity on a *population* level of the Baltic Sea population is assessed as minor and not significant, as the likelihood of a PTS impact is very small due to the very low density of this population in the Arkona Basin and the likelihood of impact very small.

Seals may not be deterred due to their curious behaviour, but seals may seek to the surface due to the noise from seal scarers. In this way their heads remain out of the water and they are hence protected from hearing damages. The risk of blast injury and PTS is hence reduced. The impact magnitude is therefore assessed as medium and the severity as moderate for seals on an *individual* level. The impact severity on a *population* level is still assessed as minor.

Acoustic devices are hence the most effective to reduce the risk of PTS, as TTS goes beyond the efficiency of seal scarers. The assessment conclusions for TTS therefore remain unchanged.

Seasonality
To avoid impact on the endangered Baltic Sea harbour porpoise population, munition clearance could be done during the summer period, if reasonable practically. If this measure is added as a mitigation measure, the risk of impact (blast injury, PTS and TTS) for the Baltic Sea population is considered negligible, due to the insignificant density of the species during the summer period. It should be emphasized that seasonality as mitigation measure is only functional for the Baltic Sea population.

Conclusion on mitigation measures
A combination of the three proposed mitigation measures will significantly reduce the impact on harbour porpoises and seals. The most efficient is the protection of the endangered Baltic Sea population, for which impact can be avoided if munitions clearance only takes place during the summer period (May-October), and can be implemented if reasonable practically. It should be emphasised that the use of MMO, PAM and seal scarers must be implemented to protect marine mammals present in the area.

The impact on individual animals can be reduced to a negligible impact severity for blast injury, a moderate severity for PTS on an *individual* level, a minor impact severity on a *population* level and a minor impact severity for TTS and behavioural responses (Table 9-97).

Table 9-97 Impact significance on marine mammals from underwater noise from munitions clearance (unplanned event) - after mitigation. PTS: Blast injury/PTS; TTS: TTS and avoidance behaviour.

Underwater noise - Munitions clearance			Sensitivity	Magnitude of impact			Severity of impact	Significance
				Intensity	Scale	Duration		
Harbour porpoise	Baltic Sea	PTS	High	Low	Regional	Long-term	Negligible*	Not significant
		TTS	High	Low	Regional	Immediate	Negligible*	Not significant
	Belt Sea	PTS	High	Medium	Regional	Long-term	Individual: Moderate Population: Minor	Individual: Not significant Population: Not significant
		TTS	Low	Large	Regional	Immediate	Minor	Not significant
Seal		PTS	High	Medium	Regional	Long-term	Individual: Moderate Population: Minor	Individual: Not significant Population: Not significant
		TTS	Low	Large	Regional	Immediate	Minor	Not significant

*The species will present in the area in insignificant numbers during the summer period, hence the severity of impact is assessed as negligible.

<u>Transboundary</u>

Impacts from underwater noise in the event of munitions clearance can potentially be transboundary as the clearance site in Faxe Bugt is within a potential area of munition (Section 5.1.5). Therefore, the clearance site could potentially be closer to the Swedish border and hence the underwater propagation could go into Swedish waters. Assessments and conclusions are the same as the assessments for Danish waters.

9.13.3 Conclusion

The potential impacts on marine mammals resulting from construction of the planned pipeline within Danish waters are summarized in Table 9-98.

Table 9-98 Overall impact significance on marine mammals after implemented mitigation measures. Impacts are concluded on populations for planned events.

Potential impact	Severity of impact	Significance	Transboundary
Suspended sediments	Negligible	Not significant	No
Physical disturbance above water	Negligible	Not significant	No
Underwater noise (construction activities)	Negligible	Not significant	No
Underwater noise (unplanned event)	Minor	Not significant	Yes

9.14 Seabirds and migrating birds

In this section, the baseline for seabirds and migrating birds is described and the impacts from the project are assessed.

The Baltic Sea in general is an important area for birds, which can be found widespread in the area all year round. The shallow marine and coastal areas in Denmark are of significant international importance during winter, when the highest number of birds are found. Some Danish marine areas are of higher importance as feeding or staging areas for birds, as they concentrate here during winter; generally, the prevalence of wintering/staging birds can be correlated with food availability. When mapping birds in the Danish part of the Baltic Pipe project i.e. within Danish territorial waters and the Danish EEZ, Rønne Banke and Faxe Bugt are of specific interest in terms of wintering/staging seabirds, why this is focus for the following baseline.

9.14.1 Baseline

In the Danish offshore section of the project area, there are no suitable or important areas for breeding seabirds. Therefore, there is no risk of any physical disturbance from construction and operation of the planned pipeline for breeding birds. Consequently, this baseline description will focus on species of marine waterbirds, mainly seaducks, that winter/stage in Danish waters beginning in late autumn, with the majority of birds being present in winter (December – March).

The baseline description of birds is primarily based on monitoring results from National Programme for Monitoring of Water and Nature (Nationalt Overvågning af VAndmiljø og NAtur (NOVANA)) performed by Ministry of Environment and Food in cooperation with the University of Aarhus (DCE, Danish Centre for Environment and Energy) (Holm *et al* 2018*, Holm et al* 2016, Holm *et al* 2015). Typically, the regularly recurring wintering/staging birds are monitored, either through a nationwide census in the form of flight surveys, which applies to the Danish part of the Baltic Sea, or by counting in selected locations from ship or on foot. The baseline description will concentrate on the most prevailing (by numbers) bird species within the Danish territorial waters and EEZ in the Baltic Sea and by order of main feeding habitat. Information on the densities of seabirds will be given if available.

Surveys of seabirds have been performed in the form of aircraft surveys in November 2017, January 2018, February 2018, and March 2018. A ship survey covering Rønne Bank and the southern part of the Danish area was additionally conducted in February 2018. Faxe Bugt was not surveyed by ship. The surveys and results are reported in in details in the quarterly survey reports (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Migrating birds are presented on a general level, and in this context are constituted by birds that pass through the Danish part of the project area for the Baltic Pipe without breeding in the area.

Surveys of migratory birds were conducted during April, May and June 2018 by visual observations from vessels, observer-assisted radar and rangefinder tracking and automated radar recordings (Rambøll, 2018v).

Breeding birds in the landfall area are described in Section 9.20.

Bird species that are classified as Red Listed are included on Birdlife's *European Red List of Birds* (BirdLife International, 2015) and the HELCOM Red List (HELCOM Red List).

Seabirds

<u>Benthic feeders</u>

Benthic feeders feed on invertebrates (e.g. molluscs, echinoderms) at the seabed at variable water depths.

Long-tailed duck (Clangula hyemalis)

Long-tailed ducks in the Baltic Sea area come from breeding populations in northern Scandinavia, northern Russia and western Ireland. During the non-breeding season, long-tailed ducks prefer brackish and marine coastal areas as well as shallow offshore banks. Their occurrence in Danish waters is significantly affected by the winter weather conditions, with higher numbers of birds in cold winters. Long-tailed ducks are not present in Danish waters during the summer and the species does not moult in Danish waters (Petersen & Nielsen 2011).

Long-tailed duck is by far the most abundant species within the Danish section of the planned Baltic Pipe project, and the birds occur regularly at Rønne Banke, in the Baltic Sea east of Falster and Møn, including Faxe Bugt and Køge Bugt (see Figure 9-62), and at depths between 10 and 25 m (Durinck *et al.,* 1994). In 2016, the number of wintering long-tailed ducks was higher (7,299) than in recent nationwide midwinter censuses (Holm *et al.*, 2018; Petersen *et al.*, 2006; Petersen *et al.*, 2010; Pihl *et al.*, 2015). Mean densities at Rønne Bank (and Adler Grund) have been estimated at 10-20 bird/km^2 (Skov *et al.*, 2011; FEMA, 2013b).

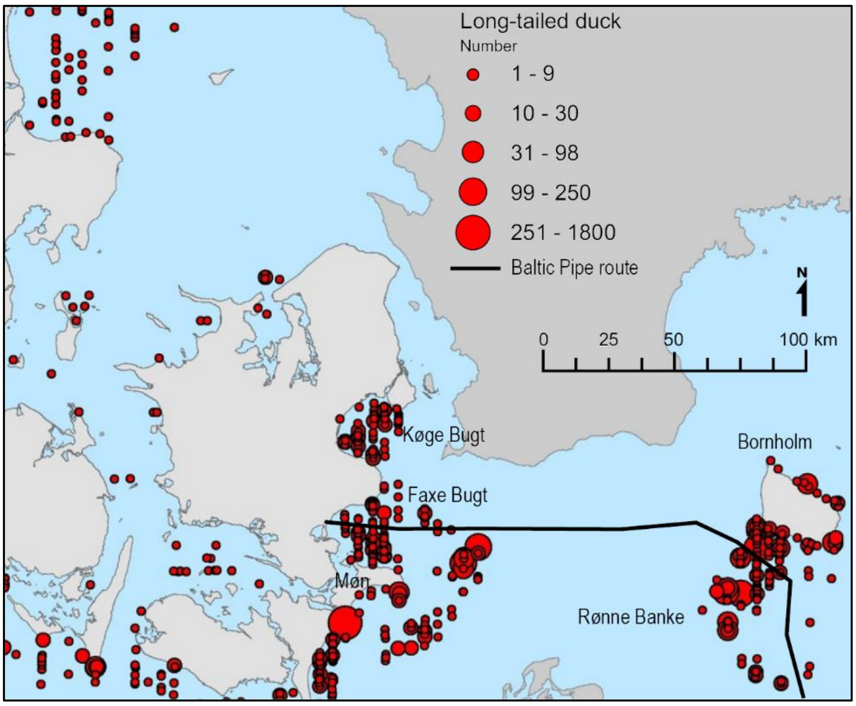

Figure 9-62 Distribution of long-tailed ducks, based on the 2016 midwinter bird census with a total of 7,299 individuals (based on Holm *et al.*, 2018).

The southwest of Rønne Banke is located on the border between Denmark and Germany, and the birds move around the bank, which is why the numbers in the Danish section vary from year to year.

For long-tailed duck, the wintering population is undergoing rapid population declines across Europe, although the population in Denmark is fluctuating. The population size in midwinter is estimated to have decreased by 30-49% over 27 years (three generations). Therefore, it is classified as Vulnerable (VU) (BirdLife International, 2015). According to the HELCOM Red List, wintering long-tailed ducks are listed as endangered (EN) (HELCOM Red List).

Survey results confirm the desktop study finding that long-tailed duck is by far the most prevalent species in the area. In Faxe Bugt and at Rønne Banke, the birds were observed from November to March, with the highest numbers in these Danish areas during February and March, which hence confirms the importance of these areas to this species (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Common scoter (Melanitta nigra)

During winter, the common scoter is prevalent in numbers of international importance in Danish waters, but usually in the more western parts of Denmark. However, at the last nationwide midwinter count in 2016, a larger number of common scoters were recorded in the more southern parts of the Kattegat; in the Storebælt; around Fyn, Langeland and Ærø; and in Faxe Bugt (Holm *et al.*, 2018) (see Figure 9-63).

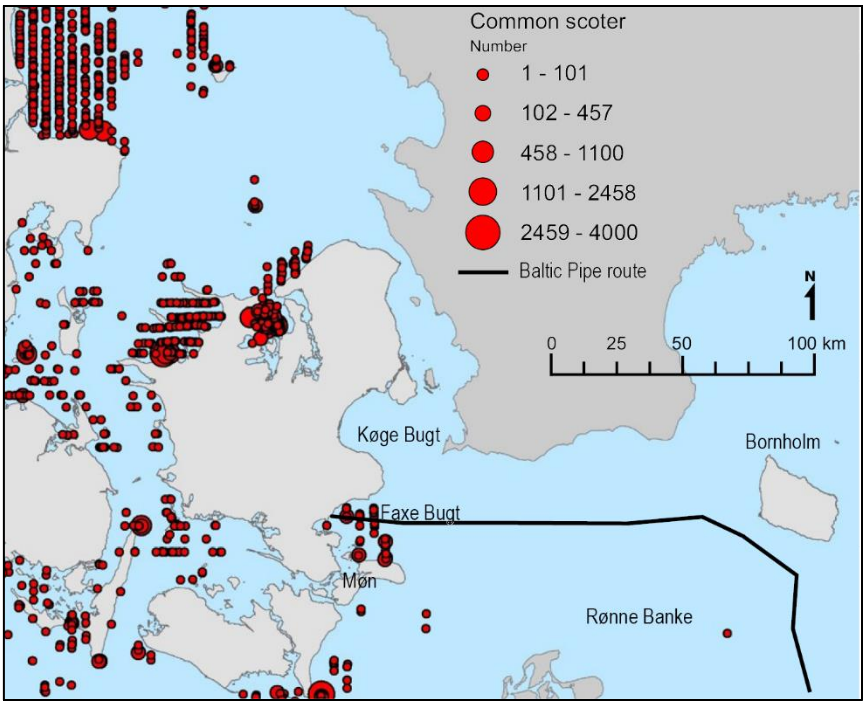

Figure 9-63 Distribution of common scoters, based on the 2016 midwinter bird census, with a total of 77,517 individuals (based on Holm *et al.*, 2018).

In Faxe Bugt, some hundred common scoter individuals are regularly and found at depths between 10 and 20 m (Durinck *et al.,* 1994). The mean density in Faxe Bugt has been estimated at 2.97 birds/km^2 (Skov *et al.*, 2011; FEMA, 2013b).

The common scoter stays in Danish waters from the time of moulting and throughout winter, although it does not breed in Denmark. In Danish waters, the birds originate from breeding populations in Scandinavia, northern Russia and western Siberia. During the moulting period, the birds mainly concentrate out of the Danish project area in the Baltic Sea.

In Denmark, the population of wintering common scoter is uncertain (fluctuating or decreasing), and a possible explanation is that a major re-distribution is under way (Asferg *et al.*, 2016). In Europe, the population trend is unknown, but the population is not believed to be decreasing sufficiently rapidly to approach the thresholds under the population trend criterion (30% decline over ten years or three generations). For these reasons, the species is evaluated as Least Concern (LC) in Europe (BirdLife International, 2015). Wintering common scoter is listed as endangered (EN) on the HELCOM Red List (HELCOM Red List).

Survey results confirm the desktop study findings that the common scoter is frequent in the area and is observed with the highest numbers during February and March in Faxe Bugt, as found during earlier observations (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Velvet scoter (Melanitta fusca)

The velvet scoter is a fairly common winter guest in Danish waters, primarily in the inner straits and the Kattegat and also regularly with some hundred birds in Faxe Bugt and the southern part of Rønne Banke (Holm *et al.,* 2018; Pihl *et al.,* 2015), see Figure 9-64. The mean densities in Faxe Bugt have been estimated at <0.1 bird/km^2 (Skov *et al*., 2011; FEMA, 2013b).

The birds originate from breeding populations in Scandinavia, north-western Russia and western Siberia. In Faxe Bugt, the velvet scoter is found at depths between 10 and 15 m (Durinck *et al.,* 1994).

The number of wintering velvet scoters in Denmark is decreasing or fluctuating, and it is not evident whether these changes in Danish waters are due to a decline in the population, or whether the birds are moulting and wintering further east and northeast than previously (Noer *et al.*, 2009). The population size in Europe is estimated to have decreased by 30-49% during 1991-2014 (three generations) but may now be fluctuating. Therefore, the species is still classified as Vulnerable (VU) (Birdlife International 2015). On the HELCOM Red List, the velvet scoter is listed as Vulnerable (VU)/Endangered (EN) (HELCOM Red List).

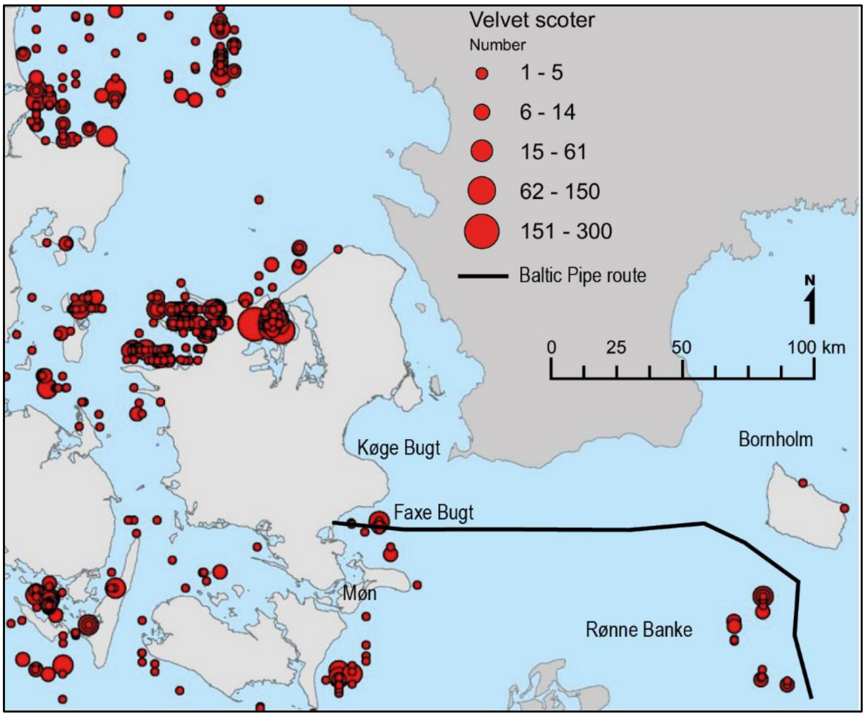

Figure 9-64 Distribution of velvet scoters based on the 2016 midwinter bird census, with a total of 3,682 individuals (based on Holm *et al*., 2018).

Survey results confirm the desktop study findings that velvet scoters concentrate and are found in highest numbers during February and March in Faxe Bugt (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Common goldeneye (*Bucephala clangula*)
The common goldeneye winters in Denmark in varying numbers, depending on the severity of the winter. Most individuals present in Denmark during the winter are migratory birds from the large populations in Scandinavia and western Norway, and the birds are present in most coastal areas, with regular and high concentrations in fjords and waters between Sjælland and Møn/Falster, including Præstø Fjord, west of Faxe Bugt and a with a few hundred birds in Faxe

Bugt itself, see Figure 9-65. The common goldeneye typically occurs at water depths less than 10 m (Durinck *et al.,* 1994).

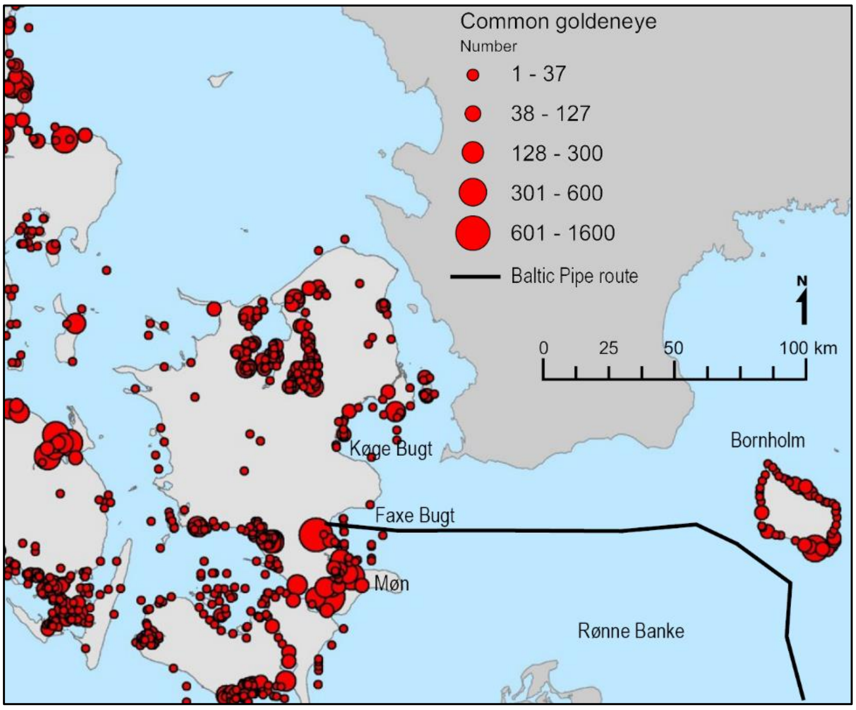

Figure 9-65 Distribution of common goldeneyes based on the 2016 midwinter bird census, with a total of 70,116 individuals (based on Holm *et al.*, 2018).

A small breeding population of some 100 pairs of common goldeneyes are found widespread in Denmark (Pihl *et al.*, 2015).

In Denmark, the population of wintering birds is stable, and so is the trend in Europe. Hence, the species does not approach the thresholds for Vulnerable under the population trend criterion (30% decline over ten years or three generations). For these reasons, the species is evaluated as Least Concern (LC) in Europe (Birdlife International 2015). The species is also listed as of Least Concern (LC) on the HELCOM Red List (HELCOM Red List).

Survey results show that common goldeneyes were present and in small numbers during January, February, and March 2018 (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Common eider (Somateria mollissima)
The common eider occurs in Denmark as a breeding, migrating and wintering bird. The Danish breeding birds as well as the staging birds from the Baltic Sea area winter in the inner Danish waters, with the central Kattegat, the straits and the waters around Fyn being the most important, and thus outside the Danish section of the Baltic Pipe project area (Figure 9-66). There is only a small, but regular occurrence in the project area, with some hundred birds occurring in Faxe Bugt during winter (Holm *et al.*, 2018, Pihl *et al.*, 2013). The birds are typical at water depths of less than 10 - 15 m (Durinck *et al.,* 1994).

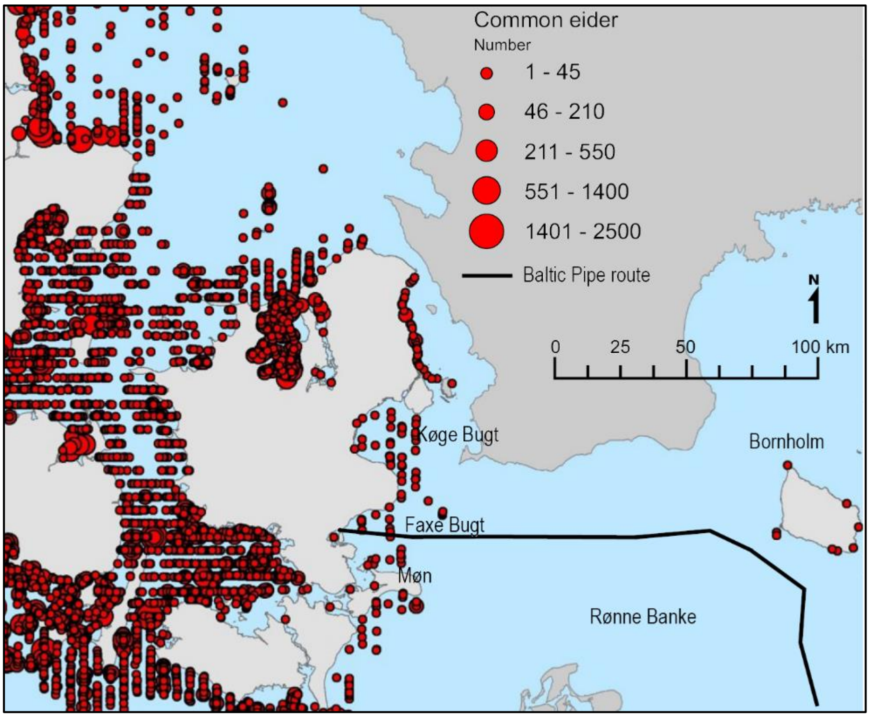

Figure 9-66 Distribution of common eiders based on the 2016 midwinter bird census, with a total of 168,949 individuals (based on Holm *et al.*, 2018).

The total breeding population in Denmark has been stable from 1990 to 2010, although there have been significant regional fluctuations due to increased mortality among females and a general decline in reproduction. As a breeding bird in Denmark, the common eider is widespread with a population of about 25,000 pairs (Christensen & Bregnballe, 2011). However, all breeding localities are outside the Danish section of the project area. The mean densities in Faxe Bugt have been estimated to constitute approximately 3-5 birds/km^2 (Skov *et al.*, 2011; FEMA, 2013b).

In Denmark, the breeding population is stable, but the wintering population is declining, and generally, in Europe, the population size is estimated to decrease by 30-49% over the period from 2000, when the declines were estimated to have begun, to 2027 (three generations), resulting in its classification as Vulnerable (VU) (BirdLife International 2015). Wintering common eider is listed as Vulnerable (VU)/Endangered (EN) on the HELCOM Red List (HELCOM Red List).

The survey results showed that the common eider was present in small numbers in November, January and March 2018 (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

<u>Water column feeders</u>
Water column feeders feed at a broad depth range in the water column on pelagic and demersal fish, zooplankton, and invertebrates.

Common merganser (goosander) (Mergus merganser)
During winter, the common merganser migrates to Danish waters from the breeding localities in Norway, Sweden, and Finland. The number of overwintering common mergansers is highly dependent on the winter weather, with most birds occurring during cold winters. The birds concentrate in fjords and sheltered coastal areas at shallow water depths of less than 10 m (Durinck *et al.,* 1994). They are regularly present during winter in high numbers in Storstrømmen and Præstø Bugt, west of Faxe Bugt, and with a few hundred birds in Faxe Bugt itself (Figure 9-67) (Holm *et al.*, 2018).

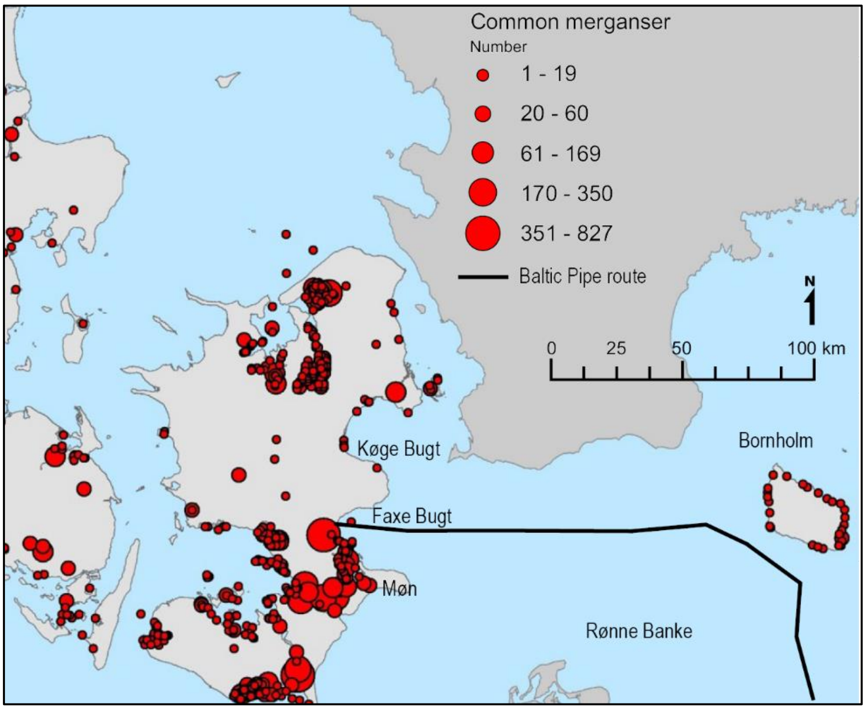

Figure 9-67 Distribution of common mergansers (goosanders) based on the 2016 midwinter bird census, with a total of 16,253 individuals (based on Holm *et al.*, 2018).

The common merganser is rare as a breeding bird in Denmark and the small Danish breeding population is found in southern Sjælland, Lolland-Falster and Møn, as well as on Bornholm[44] (see Section 9.20).

The trend for the wintering population in Europe appears to be stable, and hence the species does not approach the thresholds for classification as Vulnerable (VU) under the population trend criterion (30% decline over ten years or three generations). For these reasons, the species is evaluated as Least Concern (LC) in Europe (Birdlife International 2015). The common merganser is listed as Least Concern (LC) on the HELCOM Red List (HELCOM Red List).

Survey results show that the common merganser is observed in low numbers in Faxe Bugt, with the highest numbers counted during surveys in February and March, similar to earlier observations (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Red-breasted merganser (Mergus serrator)
During winter, the red-breasted merganser is widespread in shallow and more sheltered coastal areas in the inner Danish waters at water depths of less than 20 m, as shown in Figure 9-68, which also shows that a large number of birds winter in especially in Præstø Fjord (west of Faxe Bugt), south of Sjælland and with some hundred birds in Faxe Bugt itself. The migrating and overwintering birds come from the NV European population.

[44] https://dofbasen.dk/ART/art.php.

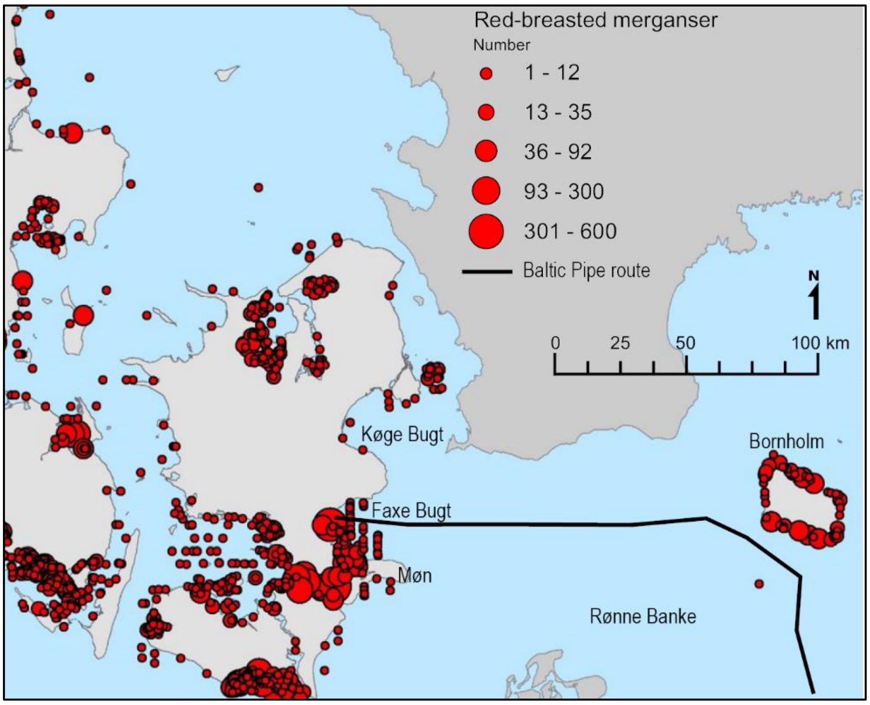

Figure 9-68 Distribution of red-breasted mergansers based on the 2016 midwinter bird census, with a total of 16,353 individuals (based on Holm *et al*, 2018).

The red-breasted merganser breeds along all Danish shores except for the west coast of Jutland.

Although the Danish wintering population seems stable, the population size in Europe is estimated to be decreasing at a rate approaching 30% in 21.9 years (three generations) and is classified as *near threatened* (NT) (Birdlife International 2015). Red breasted merganser is listed Vulnerable (VU) on the HELCOM Red List (HELCOM Red List).

Survey results shows that red-breasted merganser is observed in few numbers in Faxe Bugt with highest numbers during survey in March (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Divers

The red-throated diver *(Gavia stellata)* and black-throated diver *(G. arctica)* overwinter primarily in shallow waters at sea and at water depths of 10-22 m (Durinck *et al.,* 1994). Most of the black-throated divers are found in the eastern part of Denmark (Figure 9-69). The birds congregate at Rønne Banke and with a minor proportion in Faxe Bugt. In 2016, the occurrence of the black-throated diver was observed around Bornholm, which was mainly due to a detailed bird census with counting undertaken around the coast of the island. The populations are generally estimated to be of low density, with 0.1–0.2 birds/km^2 found in all other areas with sandy sediments and a water depth shallower than 30 m (Skov *et al*., 2011; FEMA, 2013b) and relevant for Rønne Banke (northern part) and Faxe Bugt.

Neither of the diver species breed in Denmark.

Even though the population trend for both species of divers appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for the population trend criterion Vulnerable (VU) (30% decline over ten years or three generations). For these reasons, the species is evaluated as Least Concern (LC) in Europe (Birdlife International 2015). Wintering populations of both species of divers are evaluated critically endangered (CR) according to the HELCOM Red List (HELCOM Red List).

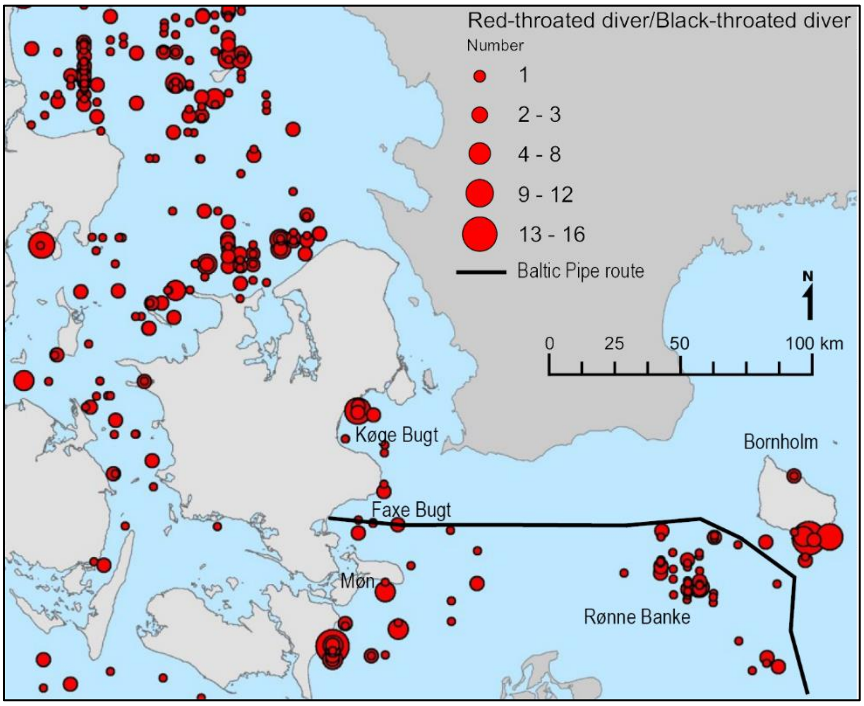

Figure 9-69 Distribution of red-throated divers and black-throated divers based on the 2016 midwinter bird census, with a total of 740 individuals (based on Holm *et al.*, 2018).

The survey results confirm that both species of divers are present in low numbers and with the highest numbers occurring during January and February (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

Alcidae

Five species of alcidae winter in varying numbers in Danish waters and especially in the Kattegat; these include the razorbill (*Alca torda*), common guillemot (*Uria aalge*), black guillemot (*Cepphus grylle*), Atlantic puffin (*Fratercula arctica*) and little auk (*Alle alle*).

Most of the observed birds are razorbills and common guillemots, which occur in relative steady numbers in inner Danish waters, concentrating in the Kattegat, and with annual, regional fluctuations depending on the occurrence of food (fish shoals). Several birds have been observed at Rønne Banke and around Bornholm, especially near Ertholmene (Figure 9-70). The birds are generally found at depths of 20–40 m (Durinck *et al.,* 1994).

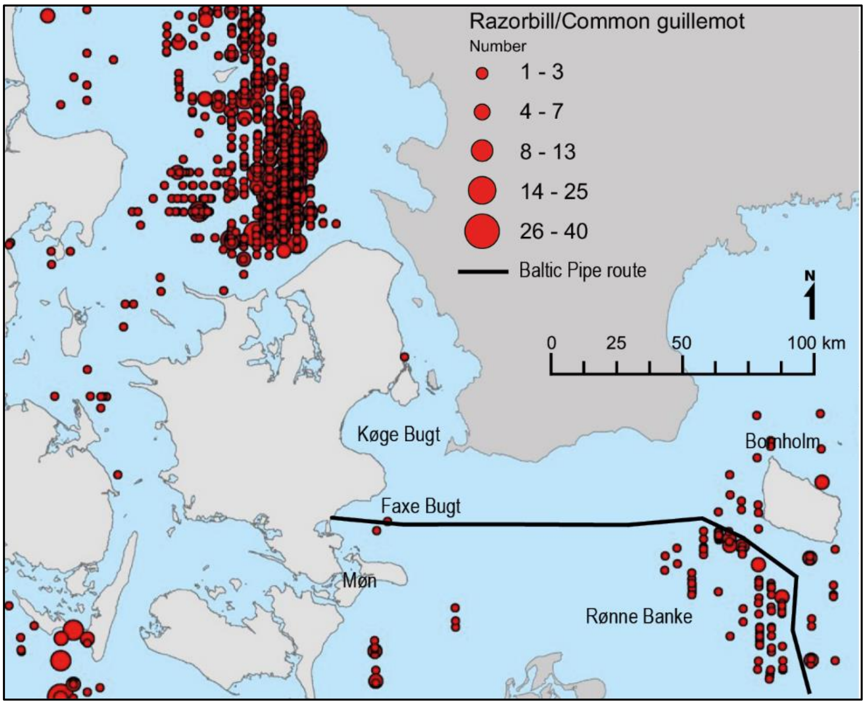

Figure 9-70 Distribution of alcidae (razorbills/common guillemots) based on the 2016 midwinter bird census, with a total of 4,228 individuals (based on Holm *et al.*, 2018).

Razorbills and guillemots have their prime breeding site north-east of Bornholm (Christiansø) where approx. 3,000 pairs of guillemots and 1,200 pairs of razorbills breed[45].

Based on ship surveys during June and July 2007, adult-chick associations of guillemots were observed in the southern part of Rønne Banke, whereas razorbills were absent (Rambøll / Nord Stream 2 AG, 2017b). The birds are assumed to come from the colony near Christiansø.

The Danish population of razorbills tends to be stable to increasing, but at EU-level there is a decline (primarily in Iceland) over a three-generation length (GL 13.6 years) period (41 years), estimated to be in the range of 20-29%, and resulting in its classification as Near Threatened (NT) (Birdlife International, 2015). The species is listed Least Concern (LC) on the HELCOM Red List (HELCOM Red List).

For common guillemots, the population in Denmark is increasing; however, the trend on an EU-level appears to be decreasing. The decline is not believed to be sufficiently rapid to approach the thresholds for the population trend criterion Vulnerable (>30% decline over ten years or three generations). For these reasons the species is evaluated as Least Concern (LC) in Europe (Birdlife International 2015). On the HELCOM Red List, the species is listed Least Concern (LC) (HELCOM Red List).

Survey results confirm that auks are widespread at greater water depths in the area, with some concentrations in the outer Faxe Bugt, as previously observed. The birds were observed with the highest numbers during March (Rambøll, 2018t; Rambøll, 2018u; Rambøll, 2018v).

[45] http://www.chnf.dk/index.php

Great cormorant (Phalacrocorax carbo sinensis/ P. c. carbo)
In Denmark, there are two subspecies of great cormorant, *Phalacrocorax carbo sinensis* and *P. c. Carbo*. The birds feed mainly on fish.

The great cormorant*, P. c. sinensis*, breeds in Denmark as well as in all other countries surrounding the Baltic Sea. After the breeding season, the great cormorant spreads out along the coast until August/September, at which time they migrate to wintering areas in the Mediterranean. Lately, the mild winters have led to an increase in the proportion of great cormorants wintering in Denmark.

Larger concentrations of cormorants were recorded in the regions of Falster-Sydsjælland, south of Faxe Bugt, and the distribution of cormorants was very similar to that seen in previous midwinter counts (Holm et al., 2018), see Figure 9-71.

P. c. Carbo breeds along the coasts of the United Kingdom and Norway, from where they migrate to Denmark to stay during winter (i.e. from August until April). During winter, the birds are found widespread along the coasts, near greater lakes, and along streams (Bregnballe & Nitschke, 2016).

In general, the population of breeding great cormorants is slowly recovering from a period of decreasing numbers and holds approximately 31,700 pairs. The nearest breeding population in the Danish EEZ is found south of the landfall area at Faxe South near Møn, some 15 km away.

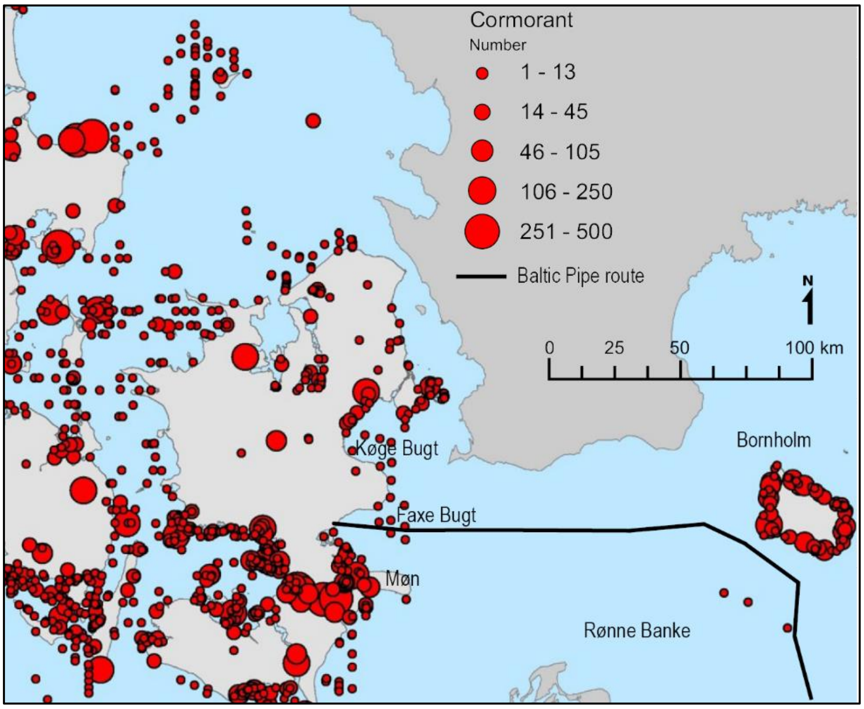

Figure 9-71 Distribution of cormorants based on the 2016 midwinter bird census, with a total of 15,345 individuals (based on Holm et al, 2018).

The population trend appears to be increasing, and hence the species is not approaching the thresholds for the population trend criterion Vulnerable (VU) (30% decline over ten years or three generations). For these reasons, the species is evaluated as Least Concern (LC) in Europe (Birdlife International, 2015). On the HELCOM Red List, the species is also listed as Least Concern (LC) (HELCOM Red List).

Migrating birds
Migratory birds in this context are considered birds that pass the Danish project area for the Baltic Pipe without breeding or overwintering/staging in the area and are so-called long-distance migrants. These migrants comprise large numbers of different species (e.g. waders, passerines, raptors, terns, pigeons, cranes etc.) that are passing over the Baltic Sea both during spring and autumn. This means that large numbers of migrants arrive to Scandinavia from southerly and south-westerly winter quarters in spring, and that even higher numbers as more birds – adults and first-year birds – depart from Scandinavia over this area in autumn (Nilsson & Green, 2011).

Migration routes vary between routes with the shortest distances over water e.g. across the Belts and Øresund, where birds use the coasts/land masses as guiding lines and therefore often concentrate at endpoints, and on the other hand, routes that show variability in location and direction and represent broad-front migratory birds, which move independently of coastal topography and predominantly during night-time (FEBI, 2013a; Energinet.dk, 2015; Nilsson & Green, 2011). A large part of the daytime migration takes place at altitudes below 200 m, whereas most of the nighttime migration takes place at altitudes above 200 m (Energinet.dk, 2015; Sweden Offshore Wind AB, 2004).

From studies of migrating birds related to the wind farms on Krieger's Flak, the timing and intensity of bird migration through the Arkona Basin and at Rønne Banke have been identified. The diversity of bird migration can be quite high, as shown by visual counts of migration at Krieger's Flak (surveyed for 65 days in the German part), during which 116 species were observed. The vertical distribution of migrating birds showed the same general trends documented by other studies that birds tend to fly at lower altitudes during head winds and at lower altitudes during the day as compared to during the night. Overall, most bird echoes recorded during the night were in the lower 200 m. The data collected on flight patterns documented from migration directions at the southern Swedish coast and from the numbers of birds observed at the FINO 2 platform showed that small numbers of raptors actually cross the Arkona Basin. During an average autumn, 40,000-50,000 raptors of various species and 84,000 common cranes (*Grus grus)* leave Skåne on their southward migration. For most species of raptors, fewer than 10% of the birds leaving Skåne cross the Arkona Basin. However, slightly larger proportions are seen for osprey, harriers and falcons. The results indicate that the flight altitudes close to the coast are largely dependent on the weather conditions, with most species reducing altitude closer to the coast during poor visibility and head winds, whereas at greater distances from the coast, the vast majority of raptors and common cranes fly at relatively low altitudes (< 200 m) during all weather conditions when they cross Krieger's Flak (Energinet.dk, 2015).

Feddet, south of the landfall at Faxe S, is of some interest as an exit point for migrating raptors in spring, as several species have been observed for over a period of 9 years during April and May[46]. The birds are presumably heading for the southern coast of Sweden and Falsterbo and pass via Stevns Klint, 24 km north of the landfall at Faxe, as these birds in general do not move long distances across water. Møns Klint, 37 km south of the landfall at Faxe, is another point for migrating birds to exit/arrive.

<u>Surveys</u>
Surveys of migrating birds have been performed during spring, specifically in March, April, and May 2018 (Rambøll, 2018v), and confirm this general springtime migration pattern.

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[46] http://faxefugle.blogspot.com/#!/2018/06/trkkende-rovfugle-pa-feddet-forar-2018.html.

Most of the observations in March related to seaduck migration, mainly common eiders, and, to a lesser extent, geese and swans (Rambøll, 2018v).

In April 2018, close to the Danish coast, intensive migration of geese was recorded, the key species being barnacle goose, brent goose (*Branta b. bernicla*) and greylag goose (*Anser anser*). Offshore movements of common scoters dominated in April. Some movements of land bird species such as raptors and passerines were only recorded in low to moderate densities (Rambøll, 2018v).

In May, the common crane, black-headed gull (*Chroicocephalus ridibundus*), black tern (*Chlidonias niger*), common tern (*Sterna* hirundo), European honey buzzard (Pernis apivorus), common swift (Apus apus), barn swallow (Hirundo rustica) and Eurasian curlew (Numenius arquata) were observed close to the Danish coast. The bird migration recorded at the offshore stations was very low, with some movements of little gulls (*Hydrocoloeus minutus)* and honey buzzards (*Pernis apivorus*) being the most noteworthy (Rambøll, 2018v).

9.14.2 Impact assessment

In connection with the construction and operation of the Baltic Pipe, two potential impact has been identified (Table 9-99).

Table 9-99 Potential impact on wintering birds.

Potential impact	Construction	Operation
Physical disturbance above water	X	X

Experience from the Nord Stream pipeline and the results of bird monitoring showed that the construction and operation of the NSP did not have a negative impact on water birds in the regions (Germany, Russia) where the monitoring of birds took place (Rambøll O&G / Nord Stream AG, 2013a; Rambøll O&G / Nord Stream AG, 2014a), and therefore the following impacts have been screened out:

- **Contaminants and nutrients (construction):** Screened out due to the extremely low exposure time and very low concentrations of bioavailable contaminants released to the water column from project-related activities (Section 9.3).
- **Presence of pipeline (operation):** The pipeline will occupy a very small part of the seabed (Box 5-5). In addition, the introduction of a new habitat (i.e. new hard substrate) and habitat loss (i.e. from the footprint of the pipeline and support structures), which could impact the availability of the food source (fish), have shown to be negligible (Section 9.12); hence, no impact on marine birds is foreseen.
- **Indirect impact from changes in food source (construction and operation):** As no significant impacts on fish or benthic flora and fauna are anticipated (Sections 9.11 and 9.12), there will be no indirect impact on the marine birds that feed on these organisms.
- **Suspended sediments (construction):** As increased SSC dispersed from the construction works above 10 mg/l is generally expected to last less than one day, and as SSC will not occur in any area above 10 mg/l for a period of more than 4 days (Section 5.1.2), no impact in the form of decreased water transparency or reduced visibility and feeding efficiency for marine birds is foreseen.

Physical disturbance above water

Physical disturbance above water is the identified as a potentially impact on wintering birds from the project. It will originate from the presence of vessels (i.e. the lay barge and support vessels); from excavating the exit point for the tunnel activities in Faxe Bugt at the landfall during construction; and from the presence of vessels operating along the pipeline route during planned inspections and maintenance activities in the operational phase.

Seabirds respond to the visual presence of moving vessels as well as the resulting noise. Some species, e.g. common eider, long-tailed duck and divers, seem to habituate to maritime traffic, which takes place at the same location and with the same timing pattern, such as shipping lanes and regular ferries (Schwemmer *et al.,* 2011).

More random sailing and sailing through areas not normally exposed to it may introduce disturbance to seabirds. For wintering birds, this may cause an energetic cost, as the birds will have to move away (i.e. by swimming, diving, and/or flying) and, therefore, lose essential time for foraging and resting. As an example, the common scoter has been observed to be very reluctant about returning to its former position and resuming its previous activities, after a given disturbance has ceased (Schwemmer *et al.,* 2011).

Several studies demonstrate bird avoidance (i.e. diving, swimming) and flush distances from 200 m to more than 2,000 m from ships. In general, the common eider, guillemot and razorbill respond less to disturbance from ships, with flush distances of approx. 200 m; the long-tailed duck shows a flush distance of 400 m; divers and the common goldeneye have flush distances of up to 1,000 m (Skei, 2014; Garthe and Hüppop*,* 2004; Schwemmer *et al.,* 2011 and Topping *et al.,* 2011). The common scoter responds to disturbance with a flush distance of up to 1,000 m, and when in large flocks, the flush distance is up to 2,000 m from the vessel (Schwemmer *et al.,* 2011). So, the flush distance depends on the specific bird species; but it is also influenced by the time of year, vessel speed, wind speed, wave height (i.e. the higher the wind speed and wave height, the shorter the flush distance). Furthermore, the behavior of birds is also influenced by flock size; the larger the flock, the greater the flush distance (Schwemmer *et al.,* 2011).

<u>Presence of vessels (offshore construction)</u>
In general, seabirds in the Baltic Sea are widely dispersed most of the year, and there is a high seasonal variability in the occurrences of seabirds in the Danish offshore area for the Baltic Pipe. During winter, some seabirds concentrate in specific areas such as Rønne Banke and Faxe Bugt. Therefore, the potential impact will depend on the timing of construction activities, prevalent bird species, densities and season.

When pipe-lay takes place at water depths > 20 m, the lay barge and supporting vessels will have a speed of 2.5-4 km/day, resulting in an hourly speed of about 160 m, and at water depths < 20 m, the speed of the lay barge and support vessels is expected to be 0.5 km/day (see Section 5.1.6), resulting in an hourly speed of approx. 20 m.

The construction works related to the offshore pipeline construction will be within a zone of 1,000 - 1,500 m around pipeline, including involved vessels, accompanying ships, anchors, and anchor chains.

As the numbers of seabirds at Rønne Banke have a strong seasonal variability, disturbance from the construction activities (i.e. pipe-lay) will, if the construction period coincides with the wintering period (November – April), impact birds within the construction corridor (up to 1,500 m around the lay barge) and potentially within a wider corridor, depending on the species/flush distance.

Seabirds at Rønne Banke that may potentially be impacted include wintering/staging red-throated divers and black-throated divers, long-tailed ducks, common scoters and auks (razorbills/common guillemots). Of these species, the prevalence of long-tailed ducks is the most

important at Rønne Banke, with a density of 10-20 birds/km^2 as described above, whereas all other birds in this area are found in much lower densities. Outside of the winter period, birds at Rønne Banke are widely dispersed.
Due to the response to disturbance from the presence of vessels and construction activities, the sensitivity of seabirds is high. However, as the presence of vessels will have a short duration within any given location, the disturbance of birds will be of minor intensity, temporary, i.e. immediate, and local to regional in scale. The severity of the impact is minor and the resulting disturbance of wintering birds from the presence of vessels during pipe-lay is assessed to be not significant.

Presence of vessels (nearshore construction and pipe-lay)
Vessels will be present at the nearshore landfall in connection with excavation of the exit point for the tunnel in Faxe Bugt at a water depth of about 4 m, dredging of material at a water depth of 7 m, restoration activities and pipe-lay nearshore, all of which will cause disturbance. The planned timing for this part of the construction works is April-September (approx. 5 months). By this time, the majority of wintering birds have moved away from Faxe Bugt, e.g. to breeding grounds, and therefore the sensitivity of wintering birds is evaluated as low, and no impact on wintering seabirds from construction activities related to the nearshore tunnel activities is foreseen.

For the pipe-lay activities in Faxe Bugt, a barge with backhoe dredgers will be used, as the water depth is less than 12 m; the speed will depend on the task, seabed conditions etc. but is expected to be less than 0.5 km/day. As the numbers of seabirds at Rønne Banke have a strong seasonal variability, disturbance from pipe-lay will, if the time for construction coincides with the wintering period (November–April), impact birds within the construction corridor (up to 1,500 m around the lay barge) as well as in a wider corridor.

As the numbers of seabirds in Faxe Bugt have a strong seasonal variability, disturbance from the pipe-lay activities will, if the construction period coincides with the wintering period (November–April), impact birds within the construction corridor (up to 1,500 m around the laybarge) as well as in a wider corridor, depending on species/flush distance.

Potentially impacted seabirds at Faxe Bugt include the long-tailed duck, common eider, common scoter, velvet scoter, common goldeneye, common merganser, red-breasted merganser, divers, auks and great cormorant. Of these species, the long-tailed duck is by far the most prevalent, although the density is lower than at Rønne Banke; this applies to all aforementioned species. Outside the winter period, birds in Faxe Bugt are widely dispersed.

Due to the response from seabirds to disturbance from the presence of vessels and construction activities, the sensitivity of birds is high. However, as the presence of vessels will have a short duration within any given location, the disturbance of birds will be of minor intensity, temporary, i.e. short term, and local to regional in scale. The severity of the impact is minor and the resulting disturbance of wintering birds from the presence of vessels during pipe-lay is assessed to be not significant.

Risk of collision
For migratory birds, there is a general risk of collision in connection with offshore construction activities, as birds may be attracted to the artificial lights from the lay barge and accompanying ships. The risk of collision is especially pronounced during bad weather conditions with low visibility, and during the night, when land bird species such as passerines migrate. For birds that migrate during the daytime, the collision risk is lower, in part because these birds often travel close to land as they prefer the shortest distances over water and in part because vessels will be

more visible during the daytime. Staging waterbirds are mostly active during daytime, though some species may move between resting and foraging habitats during twilight. However, considering the low densities of birds in the area and low activities during night time, all relevant wintering/staging bird species are considered to be at a low risk of collision with the lay barge and other construction vessels.

The sensitivity of birds to risk of collision is considered high; however, as the lay barge and other vessels will occupy a relatively small area at any given time during construction, in relation to the total area available for migratory bird species in the Danish area of the Baltic Pipe route, and as the monitoring during construction of the NSP confirmed that very few migrating birds were observed to have collided with construction vessels (Rambøll O&G / Nord Stream AG, 2013a), it is therefore expected that the risk of bird collision will be quite small and will not impact migratory populations. The severity of the impact is negligible, and the risk of collision is assessed to be not significant.

Presence of vessels (operation)

During operation, vessels will be involved in the supervision of the pipeline, with an expected frequency of surveys and maintenance being 1-2 times per year during the first years and once every 5 years thereafter. The disturbance of wintering birds by the presence of vessels during operation will be almost identical to the disturbance during pipe-lay and will thus be dependent on the time of year. However, the higher speed of inspection vessels may cause even more birds to fly off compared to the situation during pipe-lay.

Due to the response of birds to disturbance from the presence of vessels during operational phase inspection and maintenance of the pipeline, the sensitivity of birds is high. However, as vessels will be present at any given location for a short duration, the disturbance of birds will be of minor intensity, temporary, i.e. short term, and local to regional in scale. The severity of the impact is minor and the resulting disturbance of wintering birds from the presence of vessels is assessed to be not significant.

Summary of physical disturbance above water

A summary of the magnitude of impact and the impact significance is presented in Table 9-100.

Table 9-100 Impact significance on staging/wintering seabirds from physical disturbance above water.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance above water (offshore construction)	High	Minor	Local/regional	Immediate	Negligible - Minor	Not significant
Physical disturbance above water (nearshore construction)	Low	Minor	Local/regional	Immediate	Negligible	Not significant
Risk of collision (offshore construction)	High	Minor	Local/regional	Immediate	Negligible	Not significant
Physical disturbance above water (operation)	High	Minor	Local/regional	Immediate	Negligible	Not significant

9.14.3 Conclusion

The potential impacts on wintering (staging) seabirds and migrating birds resulting from construction and operation activities of the proposed pipeline within Danish waters are summarized in Table 9-101.

Table 9-101 Overall impact significance on seabirds (wintering and migrating).

Potential impact	Severity of impact	Significance	Transboundary
Physical disturbance above water (offshore construction)	Negligible - Minor	Not significant	No
Physical disturbance above water (nearshore construction)	Negligible	Not significant	No
Physical disturbance above water (risk of collision)	Negligible	Not significant	No
Physical disturbance above water (operation)	Negligible	Not significant	No

9.15 Migrating bats

In this section, the baseline for migrating bats is described and the impacts from the project are assessed.

9.15.1 Baseline

Studies have revealed that bats migrate across the Baltic Sea (Energistyrelsen og Naturstyrelsen, 2015) and species such as Nathusius' pipistrelle (*Pipistrellus nathusii*), common noctule (*Nyctalus noctula*), parti-coloured bat (*Vespertilio murinus*) and the serotine bat (*Eptesicus serotinus*), have been registered. Other bat migration studies have revealed similar observations and additional species (Bach *et al.,* 2014). There are conflicting opinions on migrating patterns and whether migrations occur seasonally (Bach *et al.,* 2014; Rydell *et al.,* 2014). Nevertheless, there is no doubt that the entire coastline and islands of the Baltic Sea are of potential importance to migrating bats in the spring (April-May) and autumn (August-September) (Rydell *et al.,* 2014).

All bat species in Denmark are nationally protected. Additionally, all bat species in Denmark are protected under Annex IV of the EU Habitats Directive, implemented in Danish legislation[47, 48]. This means that damaging or destroying areas where the bats breed or rest must not adversely affect the living conditions for the animals. Some of the bat species are also Annex II species of the EU Habitats Directive and as such should be protected in designated as Sites of Community Importance (SCI) under the Natura 2000 network.

9.15.2 Impact assessment

The current literature does not indicate a collision risk for bats with vessels; bats in offshore areas use echolocation; therefore, it can be expected that bats are able to detect and avoid obstacles such as stationary or slow-moving construction vessels (FEBI, 2013b; Energinet.dk, 2015; Rydell, 2014). Bats (as well as their insect prey) may be attracted to light on construction vessels. However, the magnitude of such an effect has not been documented. Decreasing illumination and restricting the spectrum of light may reduce the impact (Longcore & Rich, 2017, Stone *et al*., 2015).

Due to the unlikely significant impact on migrating bats from physical disturbance above water and the low risk of collision with vessels during construction and operation of the pipeline, this subject will not be considered further.

Furthermore, this subject has been scoped out of further consideration according to the Danish authority scoping decision (Energistyrelsen, 2018).

9.16 Annex IV species

In this section the baseline for Annex IV species in the area is described and the impact from the project is assessed.

9.16.1 Baseline

The harbour porpoise (*P. phocoena*) is the only Annex IV species found in the Danish offshore section of the Baltic Sea. Details about this small marine mammal, its distribution, and key biological features are described in Section 9.13.

Assessments of impacts on Annex IV species will be performed regarding the deliberate killing and the ecological functionality in breeding and resting areas; as such, breeding and resting areas are specified below.

It can be seen in Figure 9-55 in Section 9.13 that within the Danish section of the Baltic Sea, the highest probability of detecting harbour porpoises is found in the westernmost part (SAMBAH, 2016). No specific areas of reproduction are known for harbour porpoises within the project area. Harbour porpoises are continuously swimming and have no specific resting sites. Two populations of harbour porpoise can be seen in the western Baltic Sea; Belt Sea population, which is present in the Arkona Basin year-round, and the Baltic Sea population, which is present in the Arkona Basin during the winter period (November to April) (SAMBAH, 2016).

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[47] Administrative Order no. 926 of 27/06/2016 on appointment and administration of international nature protection sites and protection of certain species *(bekendtgørelse om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter)*.

[48] Administrative Order no. 434 of 02/05/2017 on Impact Assessment of International Nature Protection Sites and Protection of Certain Species at Preliminary Studies, Investigation and Extraction of Hydrocarbon, Storage in the Underground, Pipelines, etc. off-shore *(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).*

9.16.2 Impact assessment

The methodology for the impact assessment for Annex IV species is described in Section 8.4.

In accordance with the Directive, the following is prohibited for strictly protected species (emphasis added):

- *All forms of deliberate capture and keeping and deliberate killing;*
- Deliberate damage to or destruction of breeding or resting sites;
- *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;*
- Deliberate destruction or taking of eggs from the wild or keeping these eggs even if empty;
- 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.

Planned project activities will not cause intentional or deliberate capture or killing of harbour porpoises, hence an assessment is not relevant for the planned project activities.

Deliberate disturbance of wild fauna, as listed above, can be of concern with respect to the planned pipeline, as activities from the construction and operation of the pipeline may cause disturbance. The remaining prohibited actions listed above are not a concern for this project.

As mentioned above, a key issue in the assessments for Annex IV species is the ecological functionality of breeding and resting areas. Ecological functionality means the ability of the population to reach or sustain a viable population size, with the potential to reach or maintain favourable conservation status within the entire range of the species, hence the maintenance of the breeding and resting areas. Thus, Article 12(1)(d) of the Habitats Directive ensures that such sites and areas are not damaged or destroyed by human activities.

Potential impacts on harbour porpoises have been identified in the marine mammals section of this report, Section 9.13 and only negligible and not significant impacts have been identified for the planned project activities. In addition, as specified in the marine mammals section, there are no specific breeding areas identified in the Baltic Sea, although areas around the Midsjö Banks in Sweden are considered important (SAMBAH, 2016). The Midsjö Bank in Sweden is outside of the project area (the distance from pipeline is more than 120 km), see Section 9.13.1.

Based on this, it is not likely that there will be significant impact on the two harbour porpoise populations and the ecological functionality of the species will therefore not be impaired.

Unplanned events – munitions clearance

Underwater noise from the *unplanned event* of potential munitions clearance have been addressed in Section 9.13 and it has identified that impacts can occur on harbour porpoises.

<u>Deliberate killing</u>

Assessment for the munition clearance including visual observations and seal scarers as mitigation measures conclude that on an *individual* scale, there will be a moderate impact on harbour porpoises. Due to the reduced risk of blast injury and severe PTS, the impact is assessed as not significant for harbour porpoises both individual and population level, hence the project will not lead to deliberate killing of specimens.

Deliberate disturbance and impact on ecological functionality

Munition clearance will be temporary and as key breeding sites for harbour porpoises are outside the zone of potential impact (the maximum distance at which animals may experience TTS from underwater noise is 17.5 km, west of Bornholm, Figure 9-60), and because there are no significant impacts on a population level (when seal scarers are applied as a mitigation measure), it is not likely that there will be significant impact on the two harbour porpoise populations. The ecological functionality of the species will therefore not be impaired.

9.17 Biodiversity

Biodiversity generally refers to the variety and variability of life in an area. According to the United Nations Environment Programme (UNEP), biodiversity typically measures variation at the genetic, species, and ecosystem levels. The biodiversity indicates the environmental status of the habitats and degree of species richness within an area.

Denmark has signed the UN Biodiversity Convention (Order of Convention no. 142 of 21th of November 1996), adopted at the Rio World Summit in 1992, together with 189 other countries and the EU (October 2008). The purpose of this Convention is to preserve biodiversity, promote the sustainable exploitation of natural resources and ensure a fair distribution of the yield from exploiting genetic resources.

The offshore biodiversity is the sum of all the trophic levels in the marine ecosystem, from phytoplankton to top-predators as marine mammals, together with the different marine pelagic and benthic habitats.

In this section, the baseline for biodiversity in the project area is described and impacts from the Baltic Pipe project are assessed.

9.17.1 Baseline

The Baltic Sea holds a unique and diverse composition of species (plankton, benthic flora and fauna, fish, marine mammals and seabirds) and habitats and includes marine protected areas and marine Natura 2000 sites. Together these species and habitats comprise the offshore biodiversity of the Baltic Sea.

As outlined in Section 9.11, 18 habitat types can be identified in the region of the Baltic Pipe project, of which 15 are found near the pipeline route in Danish waters. The predominant seabed habitat type along the pipeline route consists of soft sediments (clay, silt, sand sand) at depths below the photic zone (non-photic zone) (Figure 9-41 in Section 9.11.). Many different species of benthic flora, fauna and fish are connected to these benthic habitats, together with marine mammals and seabirds. The baseline for all these components of the offshore biodiversity is described in Sections 9.10 to 9.14 and 9.16 to 9.19.

According to the Baltic Sea Action Plan (HELCOM, 2007), the target for good environmental status for biodiversity in the Baltic Sea is to reach a favourable status of Baltic Sea biodiversity. This is done by securing the natural marine and coastal landscapes, thriving and balanced communities of plants and animals, and viable populations of species.

In HOLAS I (Holistic Assessment of the Ecosystem Health of the Baltic Sea), an assessment of the biodiversity status was made in 2010 for 22 areas in the Baltic Sea. Assessments was based on the ecological objectives of landscapes, communities and species, which structures the biodiversity (HELCOM, 2010b). The ecological objective was classified as high to low (Figure

9-72he interpolated[49] biodiversity status in the part of the Arkona Basin where the Baltic Pipe project is planned ranged from low to medium (HELCOM, 2018c).

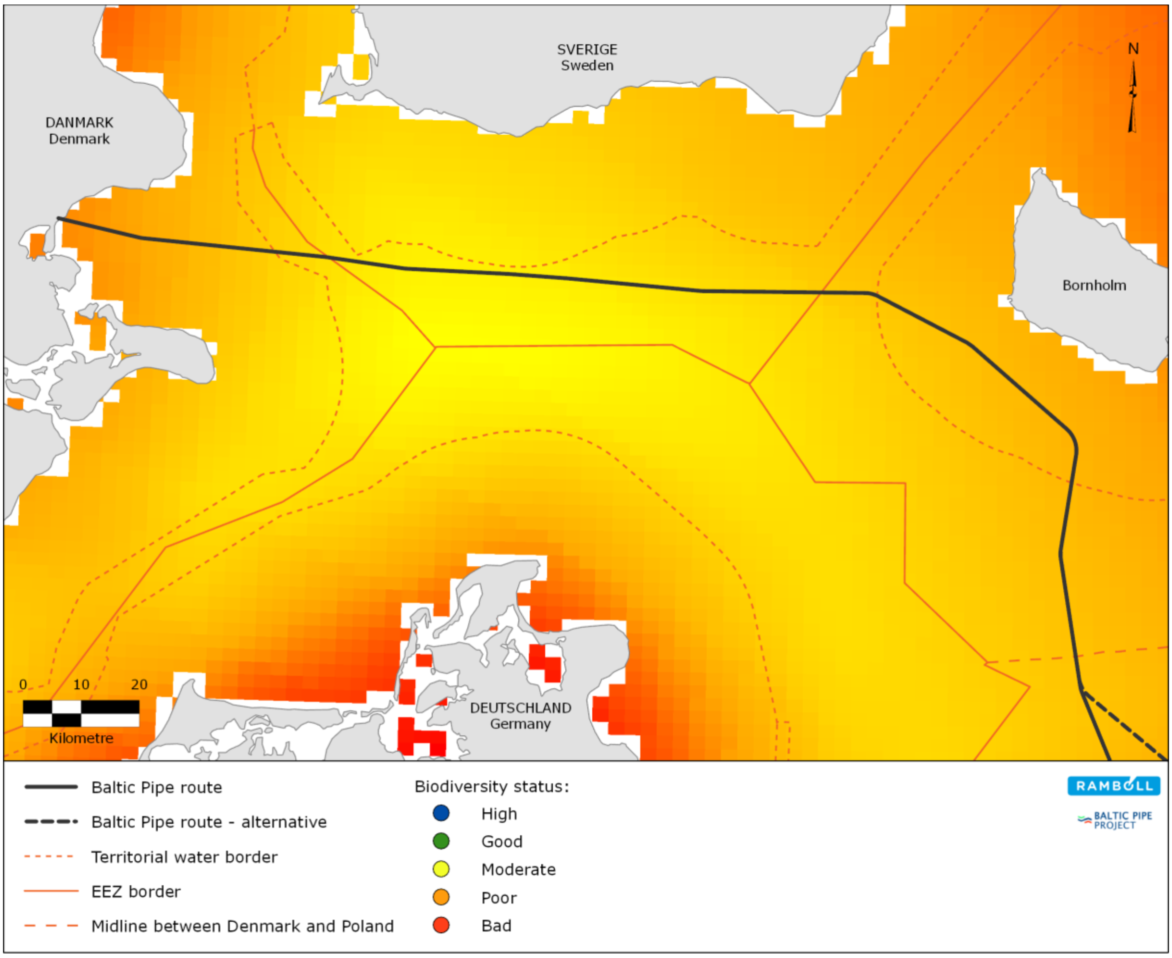

Figure 9-72 Interpolated biodiversity status in the Baltic Sea based on surveys during HOLAS I in 2010 (HELCOM, 2018c).

In HOLAS II, which covered the period from 2011-2015, assessment of the biodiversity in the Baltic Sea has been made for the following receptors: benthic habitats, pelagic habitats, fish, and seals. However, none of these receptors were found to have a Biological Quality Ratio (BQR)[50] over 0.6, which is the ratio that corresponds to good biodiversity status (HELCOM, 2018c).

The biodiversity of the Danish part of the Baltic Sea is low (Figure 9-72), as a result of both abiotic and biotic conditions as well as existing pressures from eutrophication, exploitation of resources, contaminants, non-indigenous species, etc. However, the low biodiversity makes each species in the different marine habitats equally important due to their trophic interactions in the marine food webs (HELCOM, 2010b).

9.17.2 Impact assessment

To assess potential impacts on the offshore biodiversity, it is important to look at both direct and indirect impacts on species and habitats that comprise the marine ecosystem, and to consider possible cumulative effects. This can be done by assessing whether there will be:

[49] Interpolation between assessment areas.

[50] Biodiversity Quality Ratio (BQR) is comparable with the Ecological Quality Ratio principle defined in the Water Framework Directive.

- Loss or fragmentation of habitats;
- Significant impacts at the individual level for vulnerable species;
- Significant impacts at the population level for more common species;
- Additional pressure from already existing pressures, e.g. eutrophication or contaminants;
- Cumulative effects from other projects or cumulative effects within the project.

The sensitivity of biodiversity is high, and areas with low biodiversity will be more sensitive to impacts than areas with high biodiversity.

The list of potential impacts on offshore biodiversity relates to impacts on pelagic and benthic habitats, and the species living in these habitats. Based on the impact assessment of descriptor D1 Biodiversity in the Marine Strategy Framework Directive (Section 10.1.2) and the impact assessment on protected areas offshore (Section 9.18) and Natura 2000 sites offshore (Section 9.19), the potential impacts on offshore biodiversity from the Baltic Pipe project are listed in Table 9-102.

Table 9-102 Potential impacts on offshore biodiversity.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediments	X	
Sedimentation	X	
Contaminants and nutrients	X	
Underwater noise	X	
Physical disturbance above water	X	X
Presence of pipeline		X
Non-indigenous species	X	

In the Sections 9.10 to 9.14 and 9.16 to 9.19, impact assessments have been conducted for phytoplankton, benthic flora and fauna, fish, marine mammals, seabirds, Annex IV species, protected areas and Natura 2000 areas, together with an assessment for the descriptor D1 Biodiversity in the Marine Strategy Framework Directive (Section 10.1.2).

No significant impacts on marine habitats and species have been identified in these assessments.

Transboundary impacts

A transboundary impact is an impact caused by the project, which extends across national borders. Within the project area, Denmark shares borders with Sweden, Germany and Poland, which are the countries in which a potential transboundary impact are most likely to occur. In Chapter 12 potential transboundary impacts have been assessed, and during the construction and operational phase there has been identified potential transboundary impacts on climate and air quality from emissions of CO_2 and potential impacts on commercial fisheries from e.g. safety and restriction zones. However, none of these potential transboundary impacts have been assessed to be significant, and thus, no significant impacts will be anticipated on the offshore biodiversity.

Unplanned event – underwater noise

In connection with the risk assessments undertaken (Chapter 4), it has been identified that clearance of UXO may pose a risk during the construction phase. Based on the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapters 4 and 5). In the unlikely event of munitions clearance, there could potentially be an effect on fish and marine mammals at the individual level (Sections 9.12 and 9.13). In addition, there could be possible transboundary impacts from underwater noise in the event of munitions clearance, depending on the location of a potential clearance site in Faxe Bugt (Section 5.1.5). Therefore, the clearance site could potentially be close to the Swedish border and hence the underwater propagation could cross into Swedish waters (Chapter 12).

To protect fish from significant impacts, the following mitigation measures will be applied:

- A sonar survey to identify shoaling or schooling fish in the area to assess whether the timing of the munitions clearances is suitable or if the detonation should be postponed.

To protect marine mammals from significant impacts, the following mitigation measures will be applied:

- Visual and passive acoustic observations – to ensure no marine mammals are close to the munition area;
- Seal scarers – to scare away marine mammals near the munition area;
- Seasonality - to ensure that munition clearance is conducted at a time when the fewest individuals of the endangered Baltic Sea population of harbour porpoise could potentially be affected.

The mitigation measures are described in detail in Sections 9.12 and 9.13. By using this combination of mitigation measures, the impact on *individuals* and *populations* of fish and marine mammals in the event of munition clearance is reduced to not significant.

9.17.3 Conclusion

Based on the above, the direct impacts (Table 9-102) from the construction and operation of the Baltic Pipe project on the offshore biodiversity in the Baltic Sea will not be significant. There will be no significant loss of or changes to benthic and pelagic habitats and no significant effects at the population level for marine species, Table 9-103.

Table 9-103 Impact significance from the potential impacts described in Table 9-102 during the construction and operation of the pipeline and after mitigation measures.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance of sediment	High	Moderate	Local	Long-term	Minor	Not significant
Suspended sediments	High	Minor	Local	Immediate	Negligible	Not significant
Sedimentation	High	Minor	Local	Short-term	Minor	Not significant
Underwater noise (construction activities)	High	Low	Regional	Immediate	Negligible	Not significant
Underwater noise (unplanned event)	High	Low	Regional	Immediate	Negligible	Not significant
Physical disturbance above water	High	Minor	Regional	Immediate	Negligible	Not significant
Presence of pipeline	High	High	Local	Long-term	Negligible	Not significant
Non-indigenous species	High	Minor	Local to regional	Long-term	Negligible	Not significant

When looking at possible cumulative effects with other projects (Chapter 11) or within the project, several existing and planned activities could potentially have a cumulative impact. However, based on the assessments performed in Section 11.1-11.4, there will be no significant impacts from cumulative activities on the marine environment (Section 11.5) and hence no significant impact on biodiversity. The Baltic Pipe project will not add to the degree of eutrophication or levels of contaminants in the Baltic Sea, which are the main pressures on the benthic environments that form the basis of the different marine habitats in the Baltic Sea.

9.17.4 Overall conclusion

The Baltic Pipe project will not result in significant impacts on biodiversity and will not enhance the existing main pressures on biodiversity from eutrophication or contaminants. The Baltic Pipe project will not significantly impact the goal in the Baltic Sea Action Plan of reaching a favourable status for Baltic Sea biodiversity (HELCOM, 2007).

9.18 Protected areas

In this section, the baseline for protected areas within the project area is described and the potential impacts of the project are assessed.

9.18.1 Baseline

Within the Danish project area, the only marine protected areas (in addition to Natura 2000 and Ramsar sites) are HELCOM marine protected areas (HELCOM MPAs) and Shellfish waters.

HELCOM MPAs

HELCOM has established coastal and marine MPAs according to HELCOM Recommendation 35-1 to protect valuable marine and coastal habitats in the Baltic Sea. Today, there are 176 HELCOM MPAs in the entire Baltic Sea, most of which are located nearshore. Six MPAs are located in the vicinity of the pipeline. Each HELCOM MPA should have a unique management plan or management measures drafted for the area in question, which regulates or compensates for harmful human activities through various actions.

All HELCOM MPAs in Denmark overlap with designated Natura 2000 sites. The Natura 2000 network protects natural habitats and species deemed important at the EU level, whereas the HELCOM MPAs network aims to protect marine and coastal habitats and species specific to the Baltic Sea.

In Table 9-104 and Figure 9-73, HELCOM MPAs along or in the vicinity of the Danish section of the pipeline route are presented.

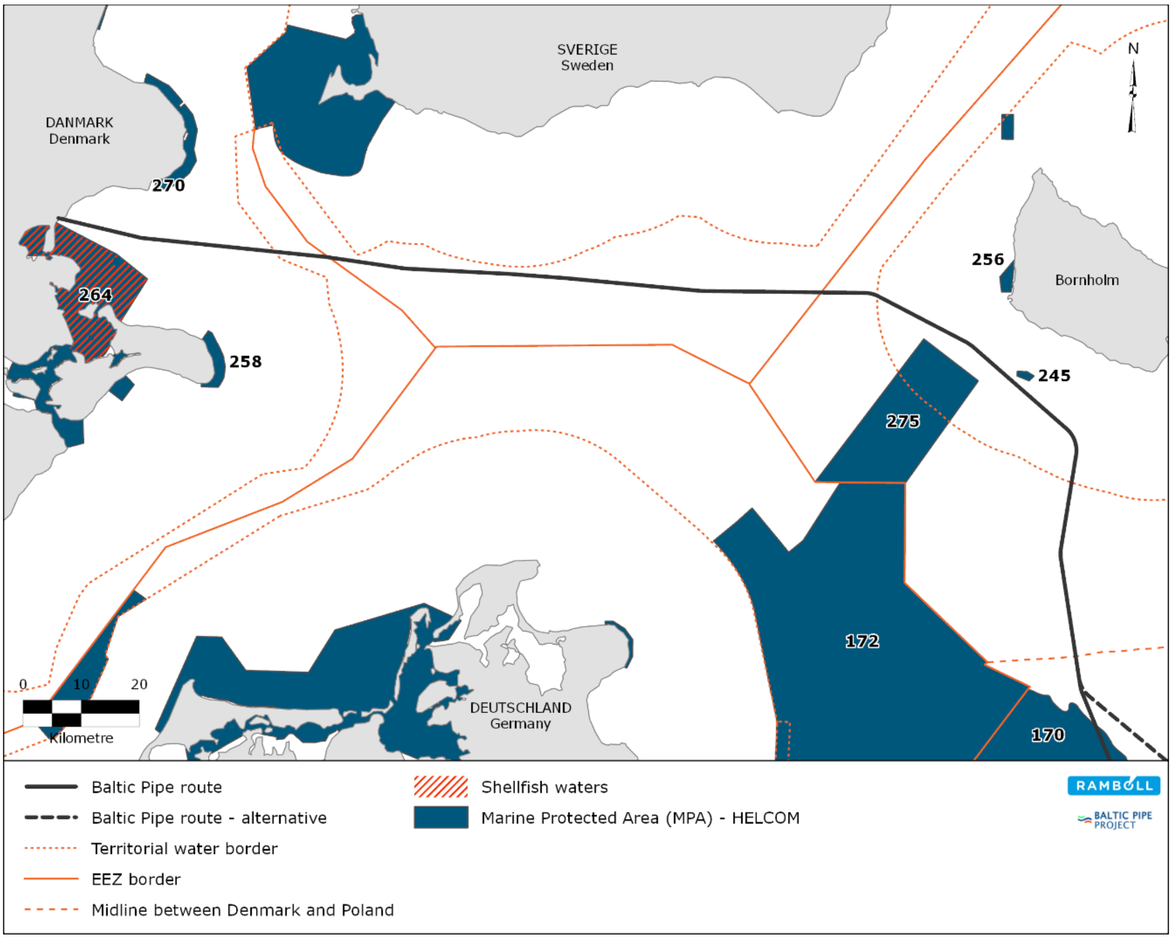

Figure 9-73 HELCOM MPAs in the Arkona Basin (HELCOM, 2018e) and designated shellfish waters in Denmark (Styrelsen for Vand- og Naturforvaltning, 2016). Relevant MPAs for the Danish route of Baltic Pipe are presented in Table 9-104.

Table 9-104 HELCOM MPAs along the Danish route for Baltic Pipe, with status for management plans are according to HELCOM (HELCOM, 2018e).

HELCOM MPA site	Status for management plans	Description	Pressures to the MPA	Distance to pipeline
Denmark				
#270 Stevns rev	Designated & managed (Natura 2000 management plan)	**Size:** 46.67 km^2 **Biotopes:** Reefs Sandbanks which are slightly covered by seawater all the time **Species:** Mew gull (*Larus canus*) Common eider (*Somateria mollissima*) **Selection criteria:** Area with high natural biodiversity, ecologically significant habitats, representative area, geological, biological, and marine values.	Disturbance of or damage to seabed Input of nutrients and organic matter	8.2 km
#264 Havet og kysten mellem Præstø Fjord og Grønsund	Designated & managed (Natura 2000 management plan)*	**Size:** 329.65 km^2 (marine 288.03) **Biotopes (marine):** Sandbanks which are slightly covered by seawater all the time Mudflats and sandflats not covered by seawater at low tide Coastal lagoons Large shallow inlets and bays Reefs **Species:** Shoveler (*Anas clypeata*) Greylag goose (*Anser anser*) Tufted duck (*Aythya fuligula*) Barnacle goose (*Branta leucopsis*) Goldeneye (*Bucephala clangula*) Mute swan (*Cygnus olor*) White-tailed sea-eagle (*Haliaeetus albicilla*) Common merganser (*Mergus merganser*) Red-breasted merganser (*M. serrator*) Great cormorant (Continental) (*Phalacrocorax carbo sinensis*) Pied avocet (*Recurvirostra avosetta*) Common tern (*Sterna hirundo*) Arctic tern (*S. paradisaea*) Sandwich tern (*Thalasseus sandvicensis*) Little tern (*Sternula albifrons*) Harbour porpoise - Western Baltic subpop (*Phocoena phocoena*) **Selection criteria:** Important feeding area for species, important migration route and resting area for species, important reproduction area for species, ecologically significant	Disturbance of or damage to seabed Input of nutrients and organic matter Introduction or spread of non-indigenous species	1.1 km

HELCOM MPA site	Status for management plans	Description	Pressures to the MPA	Distance to pipeline
		habitats, biological, marine and terrestrial values		
#258 Klinteskov Kalkgrund	Designated & managed (Natura 2000 management plan)	**Size:** 30.08 km^2 (marine 20.86 km^2) **Biotopes:** Reefs Sandbanks which are slightly covered by seawater all the time **Selection criteria:** Area with high natural biodiversity, ecologically significant habitats, representative area, geological, biological and marine values	Input of nutrients and organic matter	14.7 km
#256 Hvideodde Rev	Designated & managed (Natura 2000 management plan)	**Size:** 8.34 km^2 **Biotopes:** Reefs **Selection criteria:** Area with high natural biodiversity, ecologically significant habitats, representative area, geological, biological and marine values	Introduction or spread of non-indigenous species	10.5 km
#275 Adler Grund og Rønne Banke	Designated & managed (Natura 2000 management plan)	**Size:** 320.54 km^2 **Biotopes:** Reefs Sandbanks **Selection criteria:** Rarity and sensitivity of species or habitats, area with high natural biodiversity, ecologically significant habitats, representative area, marine values	Disturbance of or damage to seabed Input of nutrients and organic matter Introduction or spread of non-indigenous species	3 km
#245 Bakkebrædt og Bakkegrund	Designated & managed (Natura 2000 management plan)	**Size:** 3 km^2 **Biotopes:** Reefs Sandbanks **Selection criteria:** Area with high natural biodiversity, ecologically significant habitats, representative area, geological, biological, and marine values.	Input of nutrients and organic matter	1.1 km
Germany				
#172 Pommersche Bucht-Rönnebank	Under development	**Size:** 2089.45 km^2 **Biotopes:** Reefs Sandbanks **Species:** Gulf sturgeon *(Acipenser oxyrinchus)* Twaite shad *(Alosa fallax)*	Disturbance of or damage to seabed Extraction of seabed or subsoil Input of sound	9 km

HELCOM MPA site	Status for management plans	Description	Pressures to the MPA	Distance to pipeline
		Razorbill *(Alca torda)* Black guillemot *(Cepphus grylle arcticus)* Black guillemot *(C. grylle grylle)* Long-tailed duck *(Clangula hyemalis)* Black-throated diver *(Gavia arctica)* Red-throated diver *(G. stellata)* Little gull *(Hydrocoloeus minutus)* Herring gull *(Larus argentatus)* Mew gull *(L. canus)* Lesser black-backed gull *(L. fuscus fuscus)* Greater black-backed gull *(L. marinus)* Velvet scoter *(Melanitta fusca)* Common scoter *(M. nigra)* Long-tailed cormorant *(Phalacrocorax carbo sinensis)* Horned grebe *(Podiceps auritus)* Great-crested grebe *(P. cristatus)* Red-necked grebe (*P. grisegena)* Common eider *(Somateria mollissima)* Guillemot *(Uria aalge)* Harbour porpoise *(Phocoena phocoena* (Baltic Sea sub. pop)) Harbour porpoise (*P. phocoena* (Western Baltic sub. pop)) Grey seal *(Halichoerus grypus)* **Selection criteria:** Important feeding area and important migration route and resting area for species. Area with biological and marine values. Designated to protect natural habitat types listed in Habitats Directive Annex I and species listed in Annex II. Designated to protect special protection areas classified by Member States under the Birds Directive.	Input of nutrients and organic matter Input of contaminants Extraction or mortality/injury to species Disturbance of species	
Poland				
#170 Zatoka Pomorska	Under development	**Size:** 3117.87 km^2 (0.37 km^2 is terrestrial) **Biotopes:** Sandbanks **Species:** Razorbill (*Alca torda*) Black guillemot (*Cepphus grylle grylle*) Long-tailed duck (*Clangula hyemalis*) Black-throated diver (*Gavia arctica*) Red-throated diver (*G. stellata*) Velvet scoter (*Melanitta fusca*) Common scoter (*M. nigra*) Red-breasted merganser (*Mergus serrator*) Horned grebe (*Podiceps auritus*) Great-crested grebe (*P. cristatus*)	Input of litter (solid waste matter, including micro-size litter)	8 km

HELCOM MPA site	Status for management plans	Description	Pressures to the MPA	Distance to pipeline
		Red-necked grebe (*P. grisegena*) Twaite shad (*Alosa fallax*) Grey seal (*Halichoerus grypus*) Harbour porpoise (*Phocoena phocoena* (Baltic Sea subpop)) Vendace (*Coregonus albula*)**		

*It should be noted that the harbour porpoise is not managed under this Natura 2000 plan, as it is not a part of the designation basis for the Natura 2000 site.
**Freshwater species.

Shellfish waters
Shellfish waters are areas designated under the Order on quality requirements for shellfish waters (BEK 840 of 27/06/2016)[51] and an EU Directive regarding the quality of shellfish waters[52]. The areas are appointed to protect water quality, so that the waters are suitable for the development of shellfish (e.g. bivalves, gastropods and crustaceans). The target is mainly to increase the potential production of shellfish for human consumption, but also to protect the food source for shellfish eating birds. The southern area of Faxe Bugt is a designated shellfish area (Figure 9-73) (Styrelsen for Vand- og Naturforvaltning, 2016). The site overlaps with the SPA F89 Præstø Fjord, Ulvshale, Nyord og Jungshoved Nor (Section 9.19).

9.18.2 Impact assessment

The construction and operation of the Baltic Pipe in Danish waters may impact the designations of the protected areas along the route in the Arkona Basin. See Table 9-105 for an overview of these potential impacts.

Table 9-105 Potential impacts on protected areas.

Potential impact	Construction	Operation
Underwater noise	X	
Physical disturbance above water	X	X

The following sources of impact have been screened out:

- **Physical disturbance of seabed (construction):** As the pipeline does not cross protected areas, there will be no impact on protected areas.
- **Suspended sediment and sedimentation (construction):** Modelling results show that suspended sediment will not be dispersed into protected areas, and hence no impact on the designation basis is likely to occur. Shellfish waters will therefore not be impacted.
- **Release of contaminants from anodes (operation):** Most of the pipeline will be trenched, hence the total amount of metals released from anodes will be marginal (Section 5.2.5 and 9.2.2). In combination with the distance from the pipeline route to the sites, significant impacts are not likely to occur on protected areas.
- **Contaminants and nutrients (construction):** Screened out due to the extremely low exposure time for marine life and very low concentrations of bioavailable contaminants released to the water column from project-related activities (Section 9.3). Impact on the designation basis within the protected area is not likely to occur. Shellfish waters will as such not be impacted.

[51] Bekendtgørelse 840 af 27/06/2016 om kvalitetskrav for skaldyrvande, https://www.retsinformation.dk/Forms/R0710.aspx?id=181975.
[52] Directive 2006/113/EC on the environmental quality of shellfish waters.

- **Discharges to sea (construction):** As impacts on water quality will be restricted to 10-30 m from the discharge point (Section 9.2.2), impacts on the designation basis for the protected areas are not likely to occur, and hence the impact is screened out. Shellfish waters will as such not be impacted.
- **Presence of pipeline (operation):** As the pipeline does not cross protected areas, there will be no impact on protected areas.

Due to the distance from the pipeline route and the propagation of the potential impacts (Chapter 5), impacts on the designation basis of Stevns rev, Klinteskov Kalkgrund, Hvideodde Rev, Adler Grund og Rønne Banke, Bakkebrædt og Bakkegrund, Pommersche Bucht-Rönnebank and Zatoka Pomorska, are not likely to occur.

Underwater noise
Modelling results show that the only site which could potentially be impacted by underwater noise is:

- Havet og kysten mellem Præstø Fjord og Grønsund.

Underwater noise can potentially impact harbour porpoises (specifically, the western Baltic population, also called the Belt Sea population), which are on the designation basis for this site.

Assessments of the impact on harbour porpoises have been performed in Section 9.13.2. The conclusions in this section are that underwater noise from construction activities can potentially lead to an impact on marine mammals. As the level of noise from construction activities will be within the same levels as or less than the already existing underwater noise levels in the Arkona Basin, impacts due to underwater noise from construction activities are not likely to be significant.

Unplanned event – underwater noise
Impacts from underwater noise in the event of munitions clearance (dealt with as an *unplanned event*) have been assessed in Section 9.13 on marine mammals. Modelling of potential munitions clearance in Faxe Bugt shows that there is a risk of harbour porpoise experiencing TTS in a small portion of the protected area (Figure 9-60 marine mammals munitions in Faxe 340 kg TNT). As specified in the assessment, the sensitivity to TTS and avoidance behaviour in general is low for seals, as the impact will cease immediately (minutes to hours) after the blast, although there will be a strong behavioural reaction. Even though the reaction will be strong and there is a risk of TTS, the impact magnitude is assessed to be low, as the hearing ability and the reaction pattern will revert to normal after the impact (minutes to hours) has ceased. The impact is therefore assessed as not significant (Table 9-106). There is no risk of PTS for harbour porpoises within the protected area.

Table 9-106 Impact significance on protected areas from underwater noise.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Underwater noise (construction activities)	Low	Low	Regional	Immediate	Minor	Not significant
Underwater noise (unplanned events)	Low	Low	Regional	Immediate	Minor	Not significant

Physical disturbance above water

The following site may be impacted by physical disturbance above water:

- Havet og kysten mellem Præstø Fjord og Grønsund.

As none of the sites will be directly impacted (Figure 9-73), and as the sediment spill is limited to a spatial extent that does not reach inside protected areas, potential impacts are only related to underwater noise and physical disturbance of species (birds and seals).

<u>Birds</u>

Due to the relatively limited size of the expected construction area, the birds on the designation basis for the four sites can easily find alternative areas for foraging and resting. In addition, the construction period will be short-term. As assessed in Section 9.14, the impact on birds from physical disturbance above water from both construction and operation of the Baltic Pipe is considered to be not significant for the nearshore areas. Offshore, the density and prevalence of birds is very low, and disturbance from activities is of minor intensity, local and short term. Based on this assessment for birds, no impacts on birds in nearby protected areas are expected.

<u>Marine mammals</u>

The physical disturbance from construction related activities above water could potentially disturb seals (but not harbour porpoises), but seals in general are not considered sensitive to disturbance (Blackwell *et al.*, 2004). During periods of breeding and moulting, seals are sensitive to physical disturbance on land near colonies (Galatius, 2017). As the construction activities are not close to colonies (more than 5 km in Faxe Bugt, Figure 9-60), impacts on breeding and moulting seals are not likely to occur.

Table 9-107 Impact significance on protected areas from physical disturbance above water.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance above water	Low	Low	Local	Immediate	Negligible	Not significant

9.18.3 Conclusion

Based on the above, the conclusion of the assessments is the impacts on the offshore HELCOM MPAs in the Baltic Sea will not be significant (Table 9-108).

Table 9-108 Overall impact significance on HELCOM MPAs.

HELCOM MPA site	Severity of impact	Impact significance	Transboundary
#270 Stevns rev	None	-	No
#264 Havet og kysten mellem Præstø Fjord og Grønsund	Minor	Not significant	No
#258 Klinteskov Kalkgrund	None	-	No
#256 Hvideodde Rev	None	-	No
#275 Adler Grund og Rønne Banke	None	-	No
#245 Bakkebrædt og Bakkegrund	None	-	No
#172 Pommersche Bucht-Rönnebank	None	-	No
#170 Zatoka Pomorska	None	-	No

There will be no impacts on shellfish waters from the project.

9.19 Natura 2000

This chapter introduces the Natura 2000 sites that can be impacted by construction and operation of the Baltic Pipe in the Danish offshore section of the project. A separate Natura 2000 screening document based on two route alternatives (see Chapter 6) has been prepared and submitted to the Danish authorities (Rambøll, 2018x).

In an official statement regarding the Natura 2000 screening, the Danish Energy Agency has stated that it agrees to the screening conclusion, namely that the Natura 2000 site Adler Grund and Rønne Banke must be subject to an Appropriate Assessment as a significant impact cannot be ruled out, should the route be planned to pass through this Natura 2000 site.

Pipeline route optimisations have changed the preferred route since the Natura 2000 screening was submitted. The new route is presented in Figure 9-74. This route does not cross the Adler Grund and Rønne Banke Natura 2000 site. The construction method has additionally been optimised since the initial Natura 2000 screening, and the Natura 2000 screening is therefore updated in Section 9.19.2 below.

Natura 2000 sites that have been considered but excluded in the screening are also presented (Table 9-109).

Along with the Danish Natura 2000 screening, Swedish[53], German and Polish[54] Natura 2000 screening procedures have been prepared (Rambøll, 2018y; SMDI, 2017). A short summary of the sites which have been included in these Natura 2000 screenings is presented (Table 9-110).

[53] The Swedish Natura 2000 procedure has to date involved a Natura 2000 scoping, but not a full screening procedure. The Swedish Natura 2000 permitting process includes a notification and scoping process according to Chapter 6 of the Environmental Code (Ds 2000:61). The Natura 2000 screening/appropriate assessment will be included in the Swedish EIA.

[54] The Polish Natura 2000 process was initiated in the PIC, The Project Information Card.

9.19.1 Baseline

Along the preferred route, no Danish Natura 2000 sites will be crossed. Several Danish, Swedish, German, and Polish sites are, however, found in the near vicinity of the preferred route (Figure 9-74, Table 9-109).

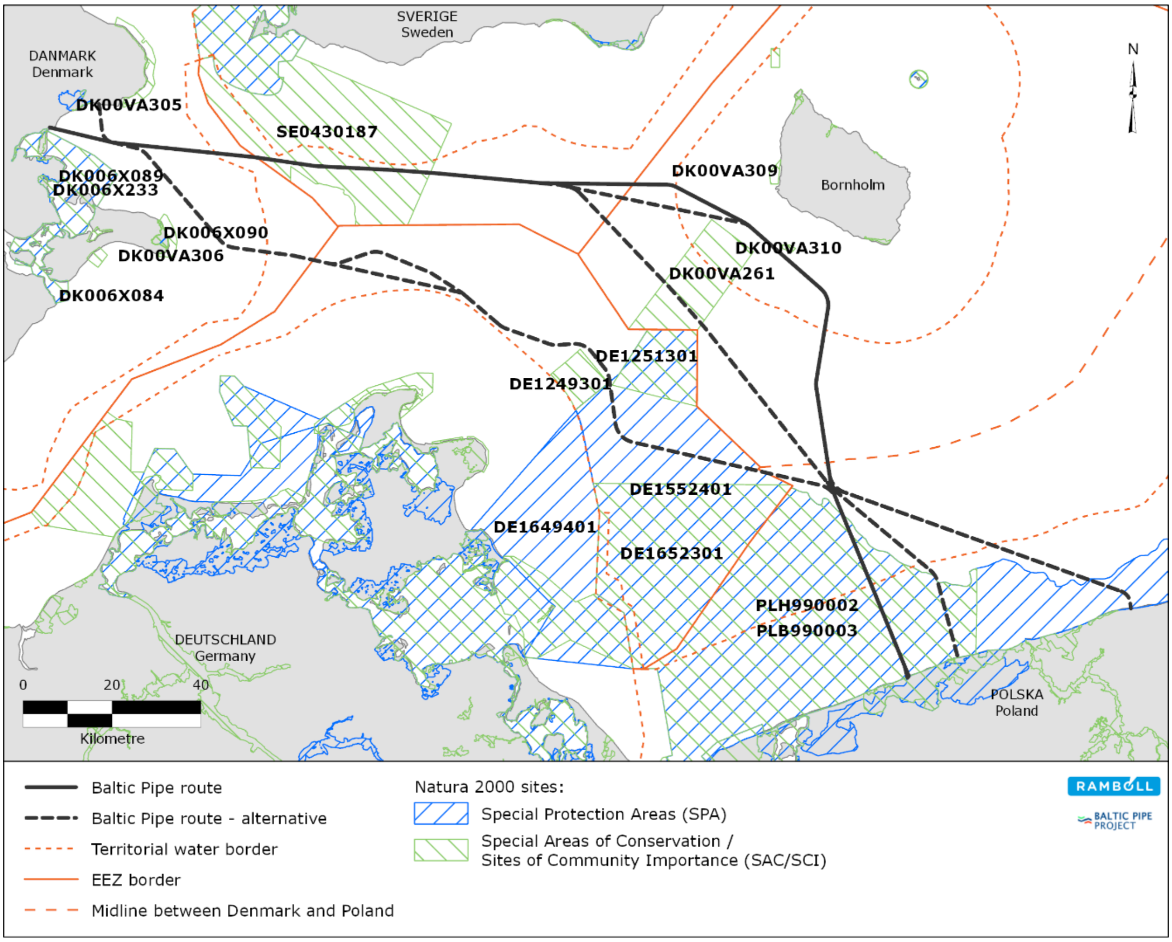

Figure 9-74 Natura 2000 sites in the vicinity of the planned Baltic Pipe route variants. EU Natura 2000 codes are presented on the map (see also Table 9-109).

Table 9-109 Natura 2000 sites in the vicinity of the planned Baltic Pipe route in Danish waters. The national number refers to the Natura 2000 national administrative plan for the site. SAC: Special Areas of Conservation, SPA: Special Protection Areas.

Natura 2000 site (national #)	Site type with EU Natura 2000 code	Name	Designation basis	Dist. km*	Included in the Natura 2000 screening
Denmark					
#206 Stevns Rev	SAC DK00VA305	Stevns Rev (H206)	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110)	8.2	Yes
#168 Havet og kysten mellem Præstø Fjord og Grønsund	SAC DK006X233	Havet og kysten mellem Præstø Fjord og Grønsund (H147)	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110) Mudflats and sandflats not covered by seawater at low tide (1140) Coastal lagoons (1150) Large shallow inlets and bays (1160) Harbour seal (*Phoca vitulia*) (1365)	1.1	Yes
	SPA DK006X089	Præstø Fjord, Ulvshale, Nyord og Jungshoved Nor (F89) Ramsar site	Annex I**: Bewick's Swan (*Cygnus columbianus*) Whooper swan (*C. cygnus*) Barnacle goose (*Branta leucopsis*) Smew (*Mergellus albellus*) White-tailed eagle (*Haliaeetus albicilla*) Western marsh harrier (*Circus aeruginosus*) Peregrine falcon (*Falco peregrinus*) Spotted crake (*Porzana porzana*) Pied avocet (*Recurvirostra avosetta*) European golden plover (*Pluvialis apricaria*) Ruff (*Calidris pugnax*) Sandwich tern (*Sterna sandvicensis*)	1.1	Yes*** Most species on the designation basis are associated with land or close to shore within the Natura 2000 site. Great cormorant, common goldeneye, red-breasted merganser and goosander could potentially be impacted by construction activities when foraging, and hence not in the Natura 2000 site itself. Due to the relatively limited size of the expected construction site and the size of Faxe Bugt, the birds can easily find alternative areas for foraging. In addition, the construction period will be short. Significant impacts on these species are therefore not likely and the Bird protection site F89 and the Ramsar site will not be considered further.

Natura 2000 site (national #)	Site type with EU Natura 2000 code	Name	Designation basis	Dist. km*	Included in the Natura 2000 screening
			Common tern (*S. hirundo*) Arctic tern (*S. paradisaea*) Little tern (*Sternula albifrons*) Annex 2**: Great cormorant (*Phalacrocorax carbo*) Mute swan (*Cygnus olor*) Greylag goose (*Anser anser*) Eurasian wigeon (*Mareca penelope*) Northern pintail (*Anas acuta*) Northern shoveler (*Spatula clypeata*) Tufted duck (*Aythya fuligula*) Common goldeneye (*Bucephala clangula*) Red-breasted merganser (*Mergus serrator*) Goosander (*M. merganser*) Eurasian coot (*Fulica atra*)		
	SPA DK006X084	Ulvsund, Grønsund og Farø Fjord (F84)	Numerous bird species****	21.2	No Due to distance and the location of this site, which is outside the project area (in an enclosed bay), impacts are unlikely. Therefore, this site is not expected to be influenced by any project-related activities during construction and will not be considered further.
#171 Klinteskoven og Klinteskov Kalkgrund	SAC DK00VA306	Klinteskov Kalkgrund (H207)	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110)	14.7	No The site was included in the initial Natura 2000 screening, which included all route alternatives. Due to the distance between the chosen pipeline route and the Natura 2000 site, and the identified potential impacts (Chapter 5) significant impacts are not likely to occur. The site will not be considered further.
	SPA and SAC DK006X090	Klinte-skoven (F90 and H150)	Numerous habitats and species	16.4	No Habitats and species are strictly terrestrial, and impact is unlikely. Therefore, this site is not expected to be influenced by any project-

Natura 2000 site (national #)	Site type with EU Natura 2000 code	Name	Designation basis	Dist. km*	Included in the Natura 2000 screening
					related activities during construction and will not be considered further.
#211 Hvideodde Rev	SAC DK00VA309	Hvideodde Rev (H211)	Reefs (1170)	10.5	No Due to the distance and expected dispersion of sediment, which could impact flora/fauna on the reef habitat, see Section 5.1.2, this site is not expected to be influenced by any project-related activities during construction and will not be considered further.
#252 Adler Grund og Rønne Banke	SAC DK00VA261	Adler Grund og Rønne Banke (H261)	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110)	3	Yes
#212 Bakkebrædt og Bakkegrund	SAC DK00VA310	Bakkebrædt og Bakkegrund (H212)	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110)	1.1	Yes
Sweden					
#SE0430187 Sydväst-skånes utsjövatten	SCI SE0430187	Sydväst-skånes utsjövatten	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110) Grey seal (*Halichoerus grypus*) (1364) Harbour seal (*P. vitulina*) (1365) Harbour porpoise (*Phocoena phocoena*) (1351)	0	Yes
Germany					
#DE1251-301 Adlergrund	SCI DE1251301	Adlergrund	Reefs (1170) Sandbanks which are slightly covered by seawater at all times (1110) Harbour porpoise (*P. phocoena*) (1351) Grey seal (*H. grypus*) (1364)	25.1	No A German Natura 2000 screening has been prepared based on a German route alternative (Rambøll, 2018y). As the preferred route has changed since the screening and hence the distance to the Natura 2000 site has increased from 0 to 25.1 km, significant impacts on habitats and species from construction and operation are not likely to occur due to the distance and the identified potential impacts (Chapter 5).
#DE1652-301 Pommersche	SCI DE1652301	Pommer-sche Bucht mit Oderbank	Sandbanks which are slightly covered by seawater at all times (1110)	9.2	Yes

Natura 2000 site (national #)	Site type with EU Natura 2000 code	Name	Designation basis	Dist. km*	Included in the Natura 2000 screening
Bucht mit Oderbank			Harbour porpoise (*P. phocoena*) (1351) Twaite shad (*Alosa fallax)* (1103)		
#DE1552-401 Pommersche Bucht	SPA DE1552401	Pommer-sche Bucht	Numerous bird species****	9.2	No A German Natura 2000 screening has been prepared based on a German route alternative (Rambøll, 2018y). The preferred route has changed since the screening and hence the distance to the Natura 2000 site has increased from 0 to 9.2 km. Significant impacts on designated bird species are not likely to occur due to the identified potential impacts (Chapter 5, Section 9.14) and the distance.
Poland					
#PLB990003 Zatoka Pomorska	SPA PLB990003	Zatoka Pomorska	Numerous bird species****	7.6	No Due to the distance and the identified potential impacts (Chapter 5, Section 9.14), designated bird species are not likely to be significantly impacted by the construction or operation activities in Danish waters.
#PLH990002 Ostoja na Zatoce Pomorskiej	SCI PLH990002	Ostoja na Zatoce Pomorskiej	Sandbanks which are slightly covered by seawater at all times (1110) Harbour porpoise (*P. phocoena*) (1351) Twaite shad (*A. fallax)* (1103)	7.6	Yes

*Shortest distance to survey corridor (km), **Birds Directive, ***Included in the baseline description of the screening but excluded after species identification and description of key features, ****As the site is not likely to be impacted, species are not listed.

Natura 2000 site #206 - Stevns Rev

The Natura 2000 site no. 206 - Stevns Rev (Stevns Reef) is a habitat site situated more than 8 km from the Baltic Pipe (Table 9-109) in the western Baltic Sea. The designation basis is reefs (1170) and sandbanks which are slightly covered by seawater at all times (1110). Sandbanks are present at the northernmost side (more than 30 km from the construction site) of the habitat site and outside potential area of influence.

The size of the site is 4,640 ha, of which 2,546 ha are mapped as reef, 87 ha as sandbanks and 52 ha as biogene reefs (Table 9-109, Naturstyrelsen, 2014a). The reef is covered in macroalgae (Naturstyrelsen, 2016a).

See a general description of the habitats in the paragraph *Relevant habitat types,* below.

In the Natura 2000 management plans for 2016-2021, there are no assessment systems for marine habitat types, but the overall goal is to reach favourable conservation status (Naturstyrelsen, 2016a). Commercial fisheries are allowed and occur at the southernmost parts of the site and are not currently identified as a threat to the designated habitat types (Naturstyrelsen, 2014a).

Natura 2000 site #168 - Havet og kysten mellem Præstø Fjord og Grønsund
Only the habitat site (SAC) Havet og kysten mellem Præstø Fjord og Grønsund (H147) is included below as the SPAs have been screened out (Table 9-109).

<u>Havet og kysten mellem Præstø Fjord og Grønsund (H147)</u>
Havet og kysten mellem Præstø Fjord og Grønsund (The sea and the coast between Præstø Fjord and Grønsund) is a habitat site covering a 32,972 ha area, of which approximately 87% is marine. The marine site covering Ulvsund and Grønsund is not relevant for the current project, as the distance is too far and in an enclosed bay. Multiple habitats have been designated for the site (Figure 9-75 and Table 9-109), as well as one species, the harbour seal (1365). The site is situated approximately 1 km from the pipeline (Table 9-109). As seen from Figure 9-75, the habitat type Coastal lagoons (1150) is not likely to be impacted by the project due to its enclosed nature and distance from project site (more than 6 km).

Harbour seals breed in the area (fewer than 40 individuals) and two seal colonies are situated at the small island Ægholm and at the north-eastern part of Jungshoved, Figure 9-75 (Naturstyrelsen, 2014b). For more details on the harbour seal, see Section 9.13.

See a general description of habitats in the paragraph *Relevant habitat types*.

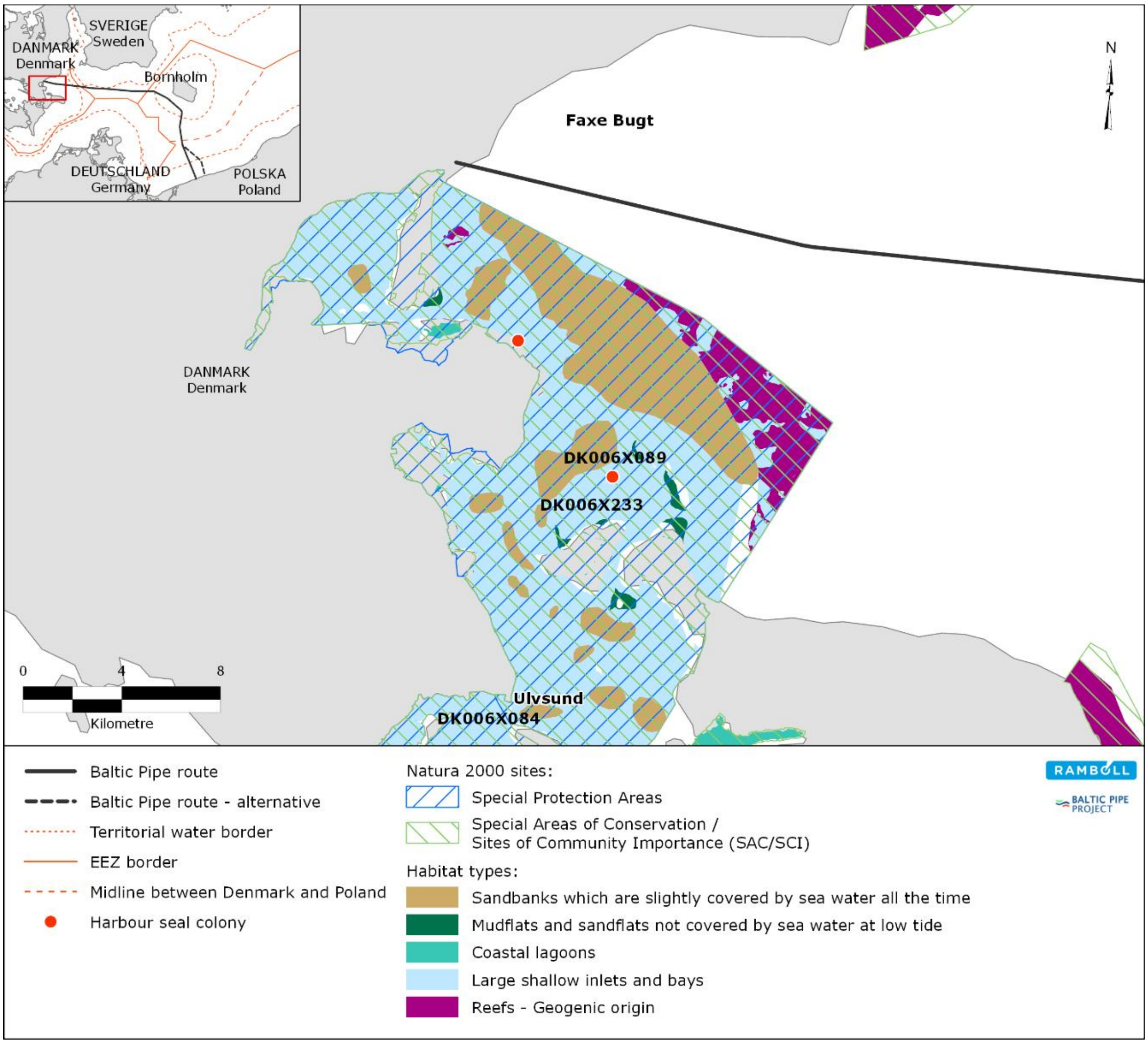

Figure 9-75 Natura 2000 site - Havet og kysten mellem Præstø Fjord og Grønsund with mapped designated habitats and indication of seal colonies in the area.

In the Natura 2000 management plans for 2016-2021, there are no assessment systems for marine habitat types. However, the overall goal is to reach favourable conservation status. The conservation status of harbour seal is assessed as unfavourable (Naturstyrelsen, 2016b).

In the management plans, disturbance from human activities is assessed as a current threat to the harbour seal and the only threat identified for the marine designations.

Natura 2000 site #252 - Adler Grund og Rønne Banke

The Adler Grund og Rønne Banke (Adler Grund and Rønne Bank) habitat site (H261) covers 31,900 ha and is strictly marine. The planned route is situated 3 km from the Natura 2000 site (Table 9-109). The water depth in the area is between 12 m and 35 m. The designation basis is reefs (406 ha) and sandbanks which are slightly covered by seawater at all times (13,787 ha, Table 9-109). Stone reefs cover 40% of the total area (Figure 9-76). The stone reefs decrease with increasing water depth and are covered by marine fauna, mostly blue mussels (*Mytilus* spp.). As the water depth is so great such that light is limited, flora is mostly absent on the reef structures (Naturstyrelsen, 2014d) and absent on the sandbanks.

See a general description of habitats in the paragraph *Relevant habitat types*.

In the Natura 2000 management plans for 2016-2021, there are no assessment systems for marine habitat types. However, the overall goal is to ensure favourable conservation status. There are no current identified threats to the designated habitat types (Naturstyrelsen, 2016d).

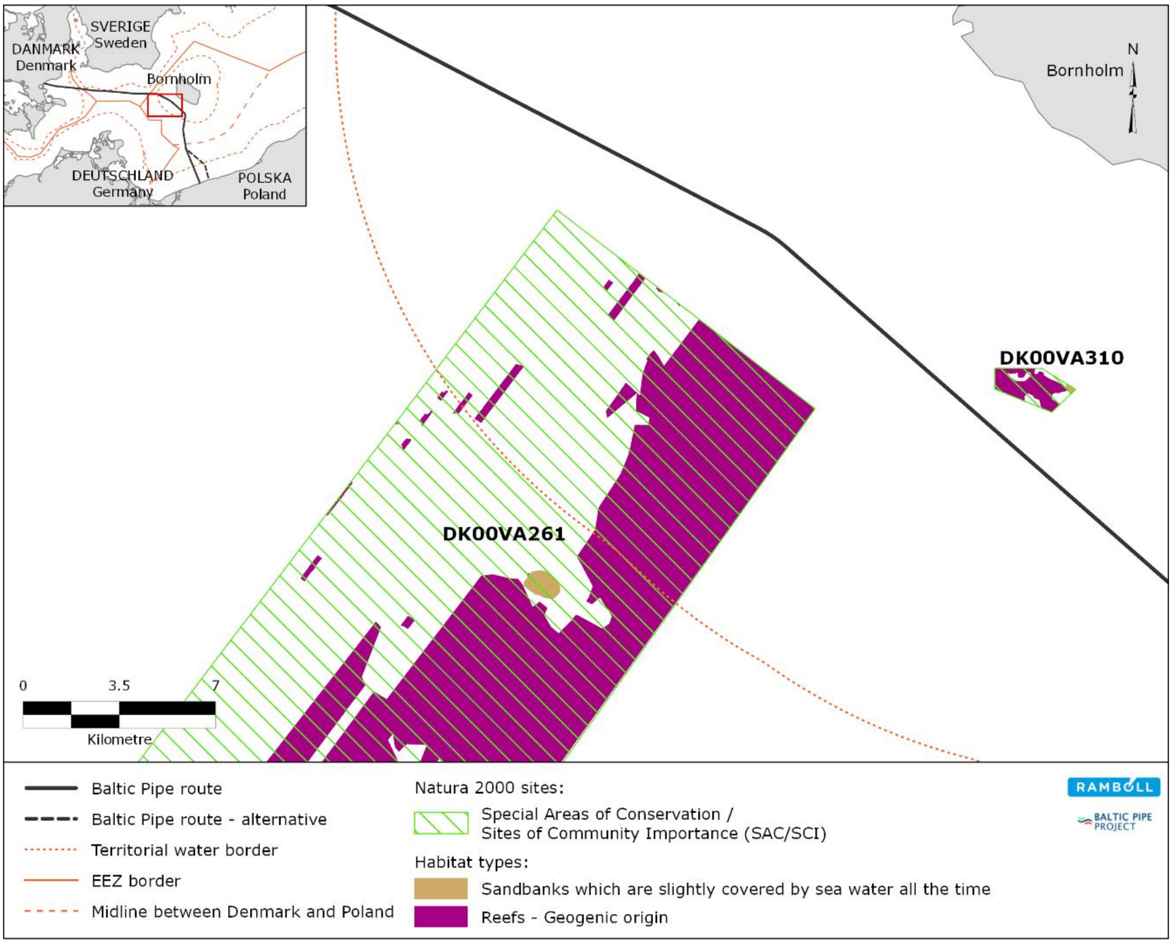

Figure 9-76 Natura 2000 site Adler Grund and Rønne Banke with mapped designated habitats.

Natura 2000 site #212 - Bakkebrædt og Bakkegrund

Bækkebrædt og Bakkegrund (Bakkebrædt and Bakkegrund) is a small habitat site (H212) of 300 ha (3 km^2), designated due to reefs (226 ha) and sandbanks which are slightly covered by seawater at all times (6 ha, Table 9-109). The mapped habitats can be seen in Figure 9-77. The water depth is between 5 and 20 m. The distance to the planned pipeline is approximately 1.1 km from the site (Table 9-109). The reef structures have a 100% coverage of blue mussels (*Mytilus* spp.) together with red algae species. The sandbank can be found at 10 m water depth (Naturstyrelsen, 2014c).

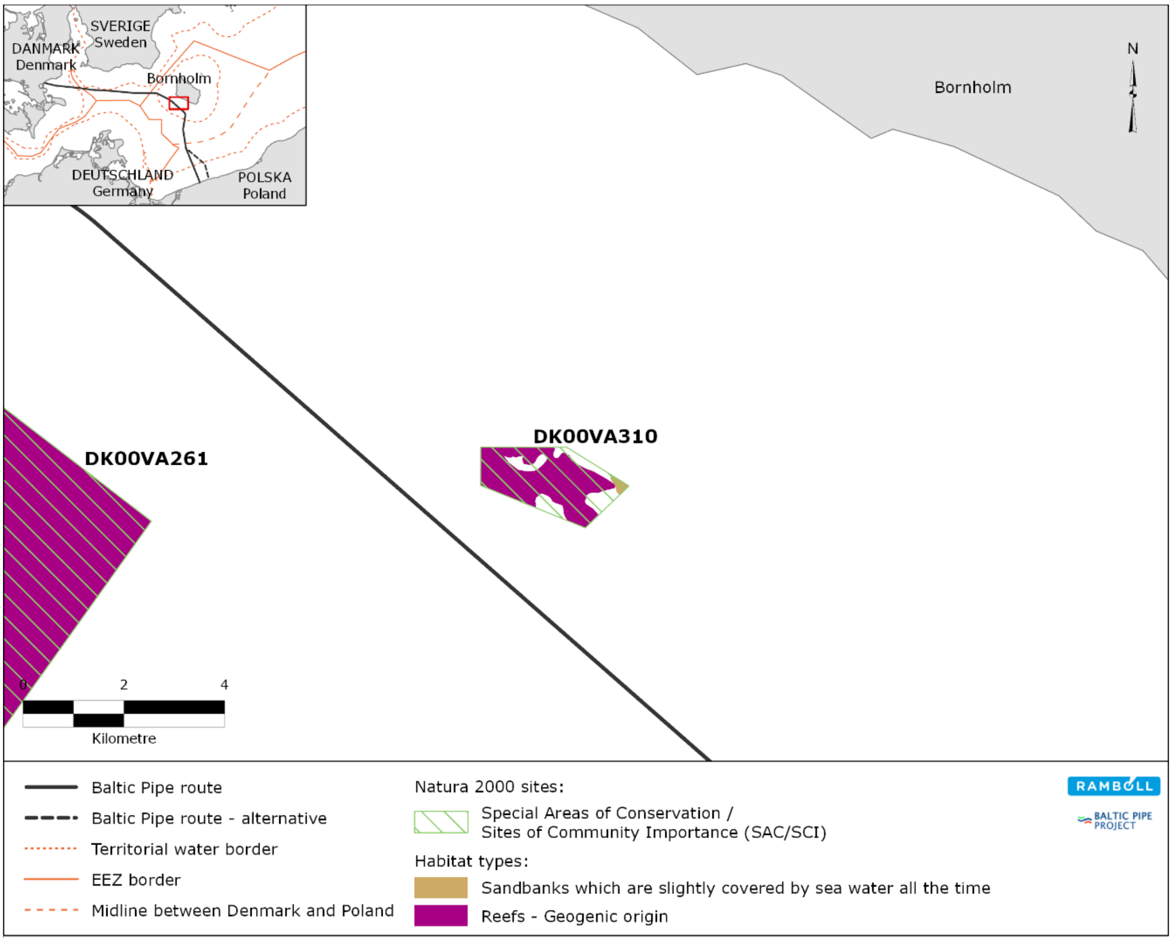

Figure 9-77 Natura 2000 site Bakkebrædt og Bakkegrund with mapped designated habitats.

See a general description of habitats in the paragraph *Relevant habitat types*.

In the Natura 2000 management plans for 2016-2021, there are no assessment systems for marine habitat types. However, the overall goal is to reach favourable conservation status. There are no current identified threats to the designated habitat types (Naturstyrelsen, 2016c).

Natura 2000 site #SE0430187 - Sydvästskånes utsjövatten

Sydvästskånes utsjövatten is a Swedish Natura 2000 site appointed in 2016 and designated for reefs and sandbanks which are slightly covered by seawater at all times habitat types as well as the marine mammals grey seal (1364), harbour seal (1365) and harbour porpoise (1351). The site borders Danish territorial waters and the pipeline crosses the site in Swedish waters. Water depth at the site is between 10 and 44 m.

See a general description of habitats in the paragraph *Relevant habitat types*.

No management plan has been established for the site yet.

Natura 2000 site #DE1652-301 - Pommersche Bucht mit Oderbank

This German Natura 2000 site is situated 9.2 km from the pipeline in Danish waters. The site is designated for the habitat type sandbanks which are slightly covered by seawater at all times (1110) and the species twaite shad (1103) and harbour porpoise (1351).

The harbour porpoise population consists of 600 individuals and is assessed as an endangered population. The general conservation objectives of "Pommersche Bucht mit Oderbank" are:

- Maintenance and restoration of the site's specific ecological functions, biological diversity and natural morphodynamics and hydrodynamics.
- Maintenance and restoration at favourable conservation status of the habitat type "Sandbanks which are slightly covered by seawater at all times (1110) together with its characteristic and endangered ecological species communities, and of the Annex II species harbour porpoise and twaite shad.
- Appropriate habitat management to enable the reintroduction of the Annex II species sturgeon (*Acipenser oxyrinchus,* formerly *A. sturio*).

The current threats within the Natura 2000 site are identified as commercial fishery, recreational fishery, sand and gravel mining, cables, shipping, military exercises, aquatic sports and other pollution or human influences.

Natura 2000 site #PLH990002 - Ostoja na Zatoce Pomorskiej
Ostoja na Zatoce Pomorskiej is a marine habitat site. The bank is one of two key areas in the Polish maritime area for the protection of sandbanks which are slightly covered by seawater at all times habitat. In addition, harbour porpoise (1351) and twaite shad (1103) are registered as present in the area and are part of the designation basis.

There are currently no management plans applicable to the site.

The key threat to the site is various types of pollution.

Relevant habitat types
<u>Sandbanks which are slightly covered by seawater at all times (1110)</u>
Sandbanks that are slightly covered by seawater at all times are often very dynamic in their geophysical features. Sandbanks are mobile, unstable, and easily reorganised by hydrodynamics. If light is available, sandbanks may occur with or without sea grasses. Within the relevant habitat sites, only few sporadic patches of seagrass are expected.

<u>Mudflats and sandflats not covered by seawater at low tide (1140)</u>
Mud- and sandflats not covered by seawater at all times comprise an important habitat type for waterfowl, due to the high diversity and abundance of associated invertebrate species. There are no vascular plants, but the habitat type is often covered by blue algae and diatoms, and eelgrass (*Zostera marina*) communities may occur.

<u>Coastal lagoons (1150)</u>
Coastal lagoons are characterised as areas with brackish water, which are entirely or partly separated from the sea by a sandbank, stones, rocks or similar. The salinity within coastal lagoons hence depend on freshwater runoff (precipitation), evaporation, tide, saltwater inflow etc. The habitat type is not likely to be impacted by the project, see Figure 9-75.

<u>Large shallow inlets and bays (1160)</u>
Large indentations of the coast with a generally low influence of waves result in a great diversity of sediments and substrates and therefore a well-developed zonation of benthic communities. The freshwater influence is limited in large shallow inlets and bays. Eelgrass (*Z. marina*) is often present.

Reefs (1170)
The habitat type reef is characterised by stones or other solid substrates rising from the seabed. Often plant and fauna communities dominate the reef structures, with the density and species community structures characterised by oxygen and light availability (which is in turn influenced by water depth and turbidity). Biogenic reefs, such as mussel beds, are also characterised as reef structures.

9.19.2 Natura 2000 assessment

This Natura 2000 assessment follows the Natura 2000 procedure described in Section 8.3. A summary of the Natura 2000 screenings is presented initially, followed by revised screenings for No. 252 Adler Grund og Rønne Banke and No. 168 Havet og kysten mellem Præstø Fjord og Grønsund as well as a screening for SE0430187 Sydvästskånes utsjövatten.

Summary Natura 2000 screening

Table 9-110 shows a summary of the Natura 2000 screenings performed for sites in Denmark, Sweden, Germany, and Poland, which can potentially be impacted by construction and operation of the Baltic Pipe in Danish waters.

Table 9-110 Summary of Natura 2000 screenings (Rambøll, 2018x; Rambøll, 2018y; SMDI, 2017).

Natura 2000 site (national #)	Site type with EU Natura 2000 code	Potential impact	Conclusion
#206 Stevns Rev	H206 - SAC DK00VA305	Construction: Suspended sediment/ sedimentation Operation: None	Due to the distance of potential sediment dispersion and the distance from construction activities to Stevns Rev, a significant impact on this Natura 2000 site is not likely to occur. It is concluded that potential impacts from the Baltic Pipe project, alone or in combination with other projects and plans, are not likely to have significant effects on the Natura 2000 site.
#168 Havet og kysten mellem Præstø Fjord og Grønsund	H147 - SAC DK006X233 F84 - SPA DK006X089 F89 - SPA DK006X084	Construction: Suspended sediment/ sedimentation Physical disturbance above water Unplanned event – underwater noise (separate section) Operation: None	Significant impact on habitats in H147 (and the SPAs F84 and F89) are not likely to occur. *See revised Natura 2000 screening below.*
#252 Adler Grund og Rønne Banke	H261 - SAC DK00VA261	Construction: Suspended sediment/ sedimentation Physical disturbance above water Operation: Destruction of habitat (footprint)	*See revised Natura 2000 screening below.*

Natura 2000 site (national #)	Site type with EU Natura 2000 code	Potential impact	Conclusion
#212 Bakkebrædt og Bakkegrund	H212 - SAC DK00VA310	Construction: Suspended sediment/ sedimentation Operation: None	Due to the distance of potential sediment dispersion and the distance from construction activities to Bakkebrædt og Bakkegrund, a significant impact on this Natura 2000 site is not likely to occur. It is concluded that potential impacts from the Baltic Pipe project, alone or in combination with other plans and projects, are not likely to have significant effects on the Natura 2000 site.
#SE0430187 Sydväst-skånes utsjövatten	SCI SE0430187	Construction: Suspended sediment/ sedimentation Underwater noise Unplanned event – underwater noise (separate section)	A Swedish Natura 2000 assessment will be prepared for the activities occurring in Swedish waters. *The impact from Denmark to Sweden will be assessed in a Natura 2000 screening below.*
#DE1652-301 Pommersche Bucht mit Oderbank	SCI DE1652301	Construction: Suspended sediment/ sedimentation Underwater noise Operation: None	The distance between this Natura 2000 site and the construction site will be more than 9 km. In combination with the limited duration and range of increased suspended sediment concentration, it is not likely that the sediment spill during construction will have a significant impact on the Natura 2000 site. As the level of noise from construction activities will be within the same level of or less than the background noise level in the Arkona Basin, impacts due to underwater noise from construction activities are not likely to be significant. It is concluded that potential impacts from the Baltic Pipe project, alone or in combination with other projects and plans, are not likely to have significant effects on the Natura 2000 site.
#PLH990002 Ostoja na Zatoce Pomorskiej	SCI PLH990002	Construction: Suspended sediment/ sedimentation Underwater noise Operation: None	The distance between this Natura 2000 site and the construction site will be more than 7 km. In combination with the limited duration and range of increased suspended sediment concentration, it is not likely that the sediment spill during construction will have a significant impact on the Natura 2000 site. As the level of noise from construction activities will be within the same levels of or less than the already existing underwater noise levels in the Arkona Basin, impacts due to underwater noise from construction activities are not likely to be significant. It is concluded that potential impacts from the Baltic Pipe project, alone or in combination with other projects and plans, are not likely to have significant effects on the Natura 2000 site.

Supplementary Natura 2000 screening - Havet og kysten mellem Præstø Fjord og Grønsund

Assessment

Suspended sediment/sedimentation

Due to a changed trenching scenario in Faxe Bugt (see Chapter 5), suspended sediment dispersed into the Natura 2000 site could be a risk to the designated habitats within the Natura 2000 site. The habitats are situated more than 1 km from the construction site. Modelling results have shown that the construction-related sediment spill will be very limited in time, concentration and in potential impacted area at the border of the site (Section 5.1.2), hence a significant impact on the Natura 2000 site is not likely to occur.

Underwater noise

The conclusion of the initial Natura 2000 screening (Rambøll, 2018x) was that significant impact could not be ruled out, due to the risk of hearing damage on harbour seals caused by sheet piling activities, if this was to be the preferred construction method at the landfall offshore. Following project optimisations, sheet piling will no longer be used in construction. It is therefore assessed that significant impact is not likely to occur on designated seals.

Unplanned events

Impacts from underwater noise in the event of munitions clearance (dealt with as an *unplanned event*) have been assessed in Section 9.13 on marine mammals. Modelling of potential munitions clearance in Faxe Bugt, shows that there is a risk of seals experiencing TTS in a small area of the Natura 2000 site (Figure 9-60, marine mammals munitions in Faxe 340 kg TNT). As specified in the assessment, the sensitivity to TTS and avoidance behaviour in general is low for seal, as the impact will cease immediately (minutes to hours) after the blast, although there will be a strong behavioural reaction. Even though the reaction will be strong and there is a risk of TTS, the impact magnitude is assessed low as the hearing ability and the reaction pattern will revert to normal after the impact (minutes to hours) has ceased. The impact is hence assessed as not significant.

Other plans and projects

A small raw material extraction site is situated approximately 500 m from the designated habitat, and other sites are found more than 2 km from the habitat. Modelling results for sediment dispersion obtained in connection with environmental impact assessments for sand extraction in the Arkona Basin (e.g. Rønne Bank and Kriegers Flak[55], FEMA 2013a and 2013b) show that the spill is limited and concentrations above 2 mg/l are mainly found inside the extraction sites. Concentrations of 2 mg/l observed outside the extraction sites are quickly dispersed (i.e., within 2-3 days). The dispersion depends on water currents and the extraction amounts, but the aforementioned examples indicate that significant cumulative impacts on Natura 2000 sites are unlikely.

A current threat to the harbour seal is disturbance from human activities near colonies. Such disturbance could potentially have a cumulative impact with construction activities. As construction works will occur more than 6 km from the nearest seal colony at Jungshoved Nord, cumulative impacts on resting and breeding seals are not likely to occur.

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[55] Rønne Banke: A full model year simulates the dredging of 2.6 mill m^3, i.e. 2.6 times the required quantity (1.0 mill m^3 sand). Krieger's Flak: A full model year simulates the dredging of 4.2 mill m^3 of the total expected extraction of 6.0 mill m^3 sand.

Conclusion

It is concluded that potential impacts from the Baltic Pipe project, alone or in combination with other projects and plans, are *not likely to have significant effects* on the Natura 2000 site.

Supplementary Natura 2000 screening - Adler Grund og Rønne Banke

Assessment

The conclusion of the initial Natura 2000 screening (Rambøll, 2018x) was that significant impact could not be ruled out, due to the risk of impacts on habitats, specifically, a permanent impact on the reef habitat. As the pipeline route no longer crosses this site, significant impact is not likely to occur due to presence of the pipeline or destruction of the habitat.

Impacts on the designated reefs and sandbanks habitats of Adler Grund and Rønne Banke could, on the other hand, potentially occur during the construction phase, where suspended sediment from construction activities, such as trenching and pipelay, could be dispersed into the Natura 2000 site and impact the fauna inhabiting the reefs and sandbanks.

An increase in SSC will be limited to the local area around the construction works, where the increase will be measurable. Modelling results have shown only very limited exceedance in SSC due to trenching activities (Section 5.1.2). Impacts on the designated habitats of Adler Grund and Rønne Banke are therefore not likely to occur.

Other plans and projects

In the area around and within the designated habitat, multiple activities take place. Commercial fisheries within the Natura 2000 site and sediment dispersion from multiple raw material extraction sites are activities (see Chapter 11), which could potentially have a cumulative impact with the Baltic Pipe construction works.

Construction activities and commercial fisheries are not likely to have a cumulative impact on habitats as there will not be a direct physical disturbance on the habitats from construction activities.

Cumulative impacts on habitats from activities at raw material extraction sites in the vicinity of the Natura 2000 site are not likely due to the distance (more than 500 m), as sediment suspended from extraction sites is mainly deposited again within the extraction site (see the above section).

Conclusion

It is concluded that potential impacts from the Baltic Pipe project, alone or in combination with other projects and plans, are *not likely to have significant effects* on the Natura 2000 site.

Natura 2000 screening - Sydvästskånes utsjövatten

Assessment

Impacts on this Swedish Natura 2000 site from construction activities in Danish waters could potentially occur due to:

- Suspended sediment/sedimentation;
- Underwater noise.

Suspended sediment/sedimentation
Modelling of the sediment spill (Section 5.1.2) shows that only very limited (if any) amounts of sediment will be dispersed from construction in Danish waters to Swedish waters (and the Natura 2000 site), both with respect to concentration, duration and scale (dispersion area); hence significant impacts on habitats and species from dispersed suspended sediment are not likely to occur.

Underwater noise
Underwater noise from construction activities can potentially lead to impact on marine mammals. As the level of noise from construction activities will be within the same levels of or less than the already existing underwater noise levels in the Arkona Basin, impacts due to underwater noise from construction activities are not likely to be significant.

<u>Unplanned events</u>
Impacts from underwater noise in the event of munitions clearance (dealt with as an *unplanned event*) have been assessed in Section 9.13 for marine mammals. Modelling of a potential munition clearance in Faxe Bugt has been done, with the results that there will be no transboundary impacts. As the clearance site is not fixed, but merely a fictive spot for clearance within a risk area (Section 5.1.5), blast may occur closer to the Swedish border. Consequently, the underwater noise could propagate into Swedish waters.

The assessment and mitigation measures for marine mammals, Section 9.13 on marine mammals, will be valid for the Natura 2000 site assessment. However, as a potential impact is present, significant impacts cannot be ruled out when doing the initial screening.

Assessments and mitigation measures done in the section for harbour porpoises and seals are valid for the Natura 2000 assessment. The overall conclusions are that if no mitigation measures are applied there is a risk of injury and/or permanent hearing damage (PTS) and hence significant impact on harbour porpoise and seal individuals, and a risk of significant impact on the endangered Baltic Sea harbour porpoise population. When mitigation measures are applied moderate impacts will still be a risk for individuals of both species, due to a risk of minor to moderate severe injuries (survivable), but as the risk of blast injury and severe PTS is lowered significantly, the impact is assessed as not significant both on individual and population scale. Please see Section 9.13.2 for a detailed impact assessment.

<u>Other projects and plans</u>
Krigers Flak offshore wind farm in Danish waters is under construction. Due to the distance (4.5 km), underwater noise is the only potentially cumulative impact. As construction of the Baltic Pipe will not add significantly to increased underwater noise levels, there is no risk of cumulative impacts.

<u>Conclusion</u>
It is concluded that a transboundary potential impact from the Baltic Pipe project in Denmark to the Swedish site, alone or in combination with other projects and plans are not likely to be significant. As the Baltic Pipe project continues into Swedish waters, a Natura 2000 process is in progress with the Swedish authorities.

9.19.3 Conclusion

As there are no significant impacts on any of the Danish Natura 2000 sites or significant transboundary impacts on adjacent Natura 2000 sites, impact on the coherence of the Natura 2000 network is not prejudged.

BIOLOGICAL ENVIRONMENT - ONSHORE

9.20 Protected areas, natural habitats, flora and fauna

The onshore part of the landfall area in Denmark is the area from the coastline to first dry weld, which is about 250 m from the shoreline. In the following the biological conditions on land including protected areas will be presented and assessed.

9.20.1 Baseline

Protected areas

About 1,200 m northwest of the landfall area is a protected area called Gammel Dyrehave, which is part of the larger Strandegård Dyrehave. The area consists of forest and cliffs towards the coast. Due to the distance of approximately 1,200 m between the protected area Strandegård Dyrehave and the work site for construction, no impacts are foreseen, and therefore the subject will not be addressed further.

Natural habitats

Most of the landfall area is agricultural land, as can be seen from Figure 9-78. The area between the coastal line and the agricultural land consists of a narrow strip of beach and cliff that is 15-17 m high. Only few natural habitats are present near the landfall area, consisting primarily of ponds (small lakes), saltmarsh and dry grassland, see Figure 9-78. The nearest pond is situated approx. 100 m northeast of the landfall area, and the nearest saltmarsh and dry grassland are situated about 250 m and 400 m southwest of the landfall area, respectively.

Figure 9-78 Protected habitats according to the Danish Nature Conservation Act in the near vicinity of the landfall.

Other habitats of interest may be stone or earth walls that are overgrown with hedges. The actual stone/earth wall is protected on the basis of archaeological/historical interests, but as the wall is overgrown it may have some biological value as well. The hedges may act as nesting places for birds or as a green corridor for birds and various land mammals migrating between natural habitats.

Some small areas with the character of forest can also be seen in the landfall area and may serve as feeding and breeding areas for birds and mammals.

Natural habitats are designated according to the Danish Nature Conservation Act[56] section 3, and cover a variety of protected habitats (bogs, streams, meadows, saltwater meadows, grasslands, and moors), and are only found on land. The natural habitats are protected against any physical changes according to the Nature Conservation Act, and if the state of a natural habitat is changed, exemption from Faxe Municipality is required. This will generally set terms on compensatory measures for the impacted area, meaning re-establishing an equivalent habitat and, as a minimum, doubling its size, depending on the natural habitat and its quality.

The quality of the natural habitats in Denmark is monitored on an irregular basis by Faxe Municipality or the Danish Nature Agency through registration of the structure of the natural habitat and the plant species growing there. Data from 2013 on the quality of the dry grassland

[56] Consolidated Act on Nature Protection, LBK no. 1122 of 03/09/2018 *(bekendtgørelse af lov om naturbeskyttelse)*.

400 m southwest of the landfall area is available from the Danish environmental database (The Danish Natural Environment Portal, 2018), and shows that the grassland is in poor condition due to drainage and pressure from the agricultural land nearby. No data is available for the nearest pond or saltmarsh.

Flora

The flora associated with the natural habitats from the shoreline to the agricultural land above the cliff are species adapted to an environment affected by saltwater in a decreasing gradient with distance from the sea. At the beach, there are common species with annual growth, such as grass-leaved orache (*Atriplex littoralis*), and at the cliff, various species of herbs and trees with perennial growth can be found (Figure 3-3).

The landfall work site and the access road are situated on agricultural land with no protected species of plants reported as having been observed in the area. The nearest registration of a rare plant species is the wood cow-wheat (*Melampyrum nemorosum*), which was observed south of Strandegård in 2014. The registration is on a public database called www.fugleognatur.dk, where civilians or specialists register findings of plants, animals etc. on a voluntary basis in relation to natural habitats. The location of the observation is approximately 800 m from the working area and access road (Fugle og natur, 2018). Wood cow-wheat is listed on the Danish Red List as vulnerable (VU). The main threat to the species at Strandegård is described as competition with the invasive species known as beach rose (*Rosa rugosa*).

Fauna

The fauna associated with the terrestrial natural habitats near the landfall construction activities will potentially include mammals associated with the open land such as hare (*Lepus europaeus*), fox (*Vulpes vulpes*), badger (*Meles meles*) and roe deer (*Capreolus capreolus*), together with many smaller mammals such as various species of mice, bats, amphibians, insects etc. Strictly protected species, i.e. Annex IV species, are described and assessed in Section 9.22.

A red-listed species of butterfly called pale clouded yellow (*Colias hyale*) was registered at Strandegård in 2016 and Strandegård Dyrehave in 2011, approx. 400 m and 1,300 m from the landfall activities, respectively. Pale clouded yellow is common in Europe and is thus listed as least concern (LC) on the Danish Red List. Pale clouded yellow is a migrating butterfly that lives on lathyrus plants such as lucerne and clover.

In the landfall area, birds comprise a variety of species which can be classified as either breeding birds or birds migrating through or just bypassing the area. Most of the breeding birds observed in the area around the landfall are associated with the nearby forest Strandegård Dyrehave. However, there have been a few observations of birds such as Eurasian skylark (*Alauda arvensis)* in the open fields near Strandegård.

The European sand martin (*Riparia riparia)* has been observed breeding in the cliff in a colony with some 20 nests in 2014. On the coast, common shelduck (*Tadorna tadorna)* and Eurasian oystercatcher (*Haematopus ostralegus)* were observed breeding (one pair each) on the coast in 2014 (Dofbasen.dk, 2018).

<u>Surveys</u>

Field surveys have been performed during April-May 2018 with observations for breeding birds near the landfall and have revealed around 60 breeding bird pairs (Rambøll, 2018x). Most of the observed bird species are associated with forest habitats (Strandegård Dyrehave (north of the landfall)) as well as bushes and shrubs along the coast/cliff. All the species are commonly occurring species. In the open fields near Strandegård, the survey confirmed that Eurasian skylark is breeding with up to five pairs, and furthermore, one pair of grey partridge (*Perdix perdix)* was observed. Although the populations of both Eurasian skylark and grey partridge are declining, the species are listed as of LC in Europe (BirdLife International, 2015); the species are not found on the HELCOM Red List, as it only deals with marine species.

Two breeding pairs of common merganser/goosander (*Mergus merganser)* was observed, north of the landfall in Strandegård Dyrehave. This species is a rare breeding bird in Denmark, with the main breeding population found in southeastern Sjælland, Lolland-Falster and Møn, the southern part of Jylland and Bornholm. Typical nesting boxes are used to support breeding, having resulted in increased breeding success in Denmark. Common merganser /goosander is listed as LC on the HELCOM Red List (HELCOM Red List Assesment/Breeding birds). As the breeding sites are more than 1 km north of the construction site where tunneling is planned, these will not be impacted from construction, and common merganser/goosander will not be addressed further.

9.20.2 Impact assessment

The potential impacts from landfall activities on terrestrial natural habitats (including stone and earth walls, areas with the character of forest), flora and fauna will be related to physical disturbance during the construction phase (Table 9-111); no impacts during operation of the pipeline are expected.

Table 9-111 Potential impacts on natural habitats, flora and fauna.

Potential impact	Construction	Operation
Physical disturbance	X	

Physical disturbance

The planned method for landfall construction will be tunnelling. The work site onshore will have an area of 9,000 m^2 and will be situated in agricultural land (see Figure 9-78) as will an access road, which is not further detailed; vegetation will be cleared to allow access and for the positioning of necessary equipment as well as a temporary deposit for reclaimed soil. The work site will be re-instated after finalization of construction of pipeline and pre-commissioning.

Natural habitats

Due to the use of tunnelling and as this method will only impact agricultural land during construction, there will be no physical disturbance during the construction phase on the nearby natural habitats. Therefore, impacts on natural habitats have been screened out and will not be further assessed.

Flora

Due to the distance from the working area to this observation, no impacts on this red-listed species from the project activities are foreseen, and therefore this will not be further assessed.

Fauna

As there are no impacts on natural habitats, no impacts on the fauna associated with these habitats are foreseen.

Impacts on amphibians during landfall construction activities are screened out since impacts on natural habitats such as ponds and saltwater meadows have been screened out.

Most of the mammals potentially living and searching for food in the area or in the surroundings are active in the twilight hours or during night time and are not assessed to be impacted from the construction activities, which mainly are planned to take place during the daytime hours.

No significant impacts on the Red Listed butterfly are expected during the construction phase due to the distance of more than 400 m between the work site and the its registered location.

Concerning birds, the construction site for tunneling and the access road may impact birds breeding in the fields, such as the Eurasian skylark and the grey partridge, as these species have been confirmed as breeding in the area in 2018 (Rambøll, 2018x). The construction activities will take place in agricultural land with associated activities during the year that also result in general unstable breeding conditions for birds in the fields. The planned construction work will not change this. As the construction activities will be ongoing for 11 months and the occupation of work site will last 1½-2 years, up to two breeding seasons for birds such as skylark within this limited area is expected to be impacted. The construction site will be restored after termination of works, and breeding conditions for birds in open land such as the Eurasian skylark and the grey partridge will be identical to the baseline conditions. Hence, the construction activities are not believed to cause an impact at the population level for the involved species.

The sensitivity of onshore fauna, i.e. breeding birds, is rated as high; the impact magnitude caused by physical disturbance from construction activities is assessed to be of medium intensity, but of a local scale. As the construction activities will last less than one year, the duration is short-term. Therefore, the severity of the impact is assessed to be minor and thus not significant (Table 9-112).

Table 9-112 Impact significance on onshore fauna (breeding birds) from physical disturbance.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance	High	Minor	Local	Short-term	Minor	Not significant

9.20.3 Conclusion

The overall impact significance of the landfall construction activities on fauna are summarized in Table 9-113.

Table 9-113 Overall impact significance on fauna (breeding birds).

	Severity of impact	Significance	Transboundary
Physical disturbance	Minor	Not significant	No

9.21 Biodiversity

Biodiversity generally refers to the variety and variability of life in an area. According to the United Nations Environment Programme (UNEP), biodiversity typically measures variation at the genetic, species, and ecosystem levels. Together with 189 other countries and the EU (October 2008), Denmark has signed the UN Biodiversity Convention (Order of Convention no. 142 of 21th of November 1996), adopted at the Rio World Summit in 1992. The purpose of this Convention is to preserve biodiversity, promote the sustainable exploitation of natural resources and ensure a fair distribution of the yield by exploiting genetic resources.

9.21.1 Baseline

The 2013 municipal plan for Faxe Municipality, describes nature interests and biodiversity within the municipality (Faxe Municipality, 2013b). On the digital map of Faxe Municipality[57], nature interest areas in the landfall areas can be seen according to the district plan. The landfall area is categorized as an area of high agricultural value and thus not as an area of high biodiversity. The

[57] http://faxekom.maps.arcgis.com/apps/webappviewer/index.html?id=7809304d419a41779eacab3d9249fa49.

landfall area is not included in areas designated for wetland constructions, new nature, or ecological connections according to the district plan.

The onshore biodiversity of the landfall area is the sum of Section 9.20 on natural habitats, flora, and fauna. Very few natural habitats such as small lakes, saltmarsh and dry grassland are registered, all more than 100 m away from the landfall area. The landfall area is situated in agricultural field with the nearest observation of a protected plant species, wood cow-wheat, approximately 800 m from the construction site. The fauna, which potentially can be observed in the area, are species associated with open land such as hare, fox, badger and roe deer etc. One red-listed species of butterfly, pale clouded yellow, has been registred in the area approx. 400 m from the landfall activities. Pale clouded yellow is common in Europe and is thus listed as least concern (LC) on the Danish Red List. Few breeding birds have been observed such as Eurasian skylark and grey partridge, both being related to open land.

In general, the landfall area is agricultural land, and according to the biodiversity map of Denmark[58], the biodiversity of the landfall area is low.

9.21.2 Impact assessment

Potential impacts from landfall activities on biodiversity will be related to physical disturbance during the construction phase (Table 9-114), and no impacts are expected during operation.

Table 9-114 Potential impacts on biodiversity.

Potential impact	Construction	Operation
Physical disturbance	X	

The sensitivity of biodiversity is high, and the intensity of the impact is medium. As the scale of construction activities are local and short-term, and the severity of the impact is minor, this leads to assessing the impact as not significant. This is also in line with the assessment of natural habitats, flora, and fauna, where impacts have been categorized as not significant, Table 9-115.

Table 9-115 Impact significance on onshore biodiversity from physical disturbance.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance	High	Medium	Local	Short-term	Minor	Not significant

9.21.3 Conclusion

The overall impact significance of the landfall construction activities on biodiversity is summarized in Table 9-116.

Table 9-116 Overall impact significance on biodiversity.

	Severity of impact	Impact significance	Transboundary
Physical disturbance	Minor	Not significant	No

9.22 Annex IV species

The EU Habitats Directive contains a list of selected animal and plant species, Annex IV, that Member States are required to generally protect, both inside and outside the Natura 2000 sites.

[58] http://miljoegis.mim.dk/cbkort?profile=miljoegis-plangroendk.

The protection of Annex IV species is implemented in Danish legislation through the Habitats Order[59].

9.22.1 Baseline

According to the handbook on fauna on the Habitat Directive Annex IV list (Søgaard and Asferg, 2007) the following Annex IV species can potentially be found near the landfall area:

- Northern crested newt (*Triturus cristatus*);
- Agile frog (*Rana dalmatina*);
- Moor frog (*Rana arvalis*);
- European tree frog (*Hyla arborea*);
- Soprano pipistrelle (*Pipistrellus pygmaeus*);
- Daubenton's bat (*Myotis daubentonii*); and
- Serotine bat (*Eptesicus serotinus*).

The northern crested newt was registered in Strandegård Dyrehave in 2010[60] approx. 1,300 m northeast of the landfall area, and at Store Elmue in 2016 about 1,500 m north of the landfall area[61]. In 2018, the agile frog was also registered at Store Elmue. The European tree frog and moor frog have not been registered near the landfall area.

None of the potentially three species of bats have been recorded near the landfall area.

There are no Annex IV plant species in the area.

9.22.2 Impact assessment

Potential impacts from landfall activities on Annex IV species will be related to physical disturbance and only during the construction phase. The methodology for impact assessment for Annex IV species is described in Section 8.4.

Impacts on the amphibian species northern crested newt and agile frog during landfall construction activities are screened out since there will be no impacts on natural habitats such as ponds and saltwater meadows.

Deliberate killing

Since no registrations of bats have been made near the landfall area and no removal of trees that could potentially be relevant as breeding, roosting, or resting areas for bats is planned, no potential impacts on bats are expected during construction and the planned project activities will not cause intentional or deliberate capture or killing.

Deliberate disturbance and impact on ecological functionality

As there will be no physical disturbance of potential breeding sites for Annex IV species, no risk of deliberate disturbance and impact on populations is expected. Hence the impacts from the landfall construction activities will not affect the *ecological functionality* of potential Annex IV species in the landfall area.

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[59] Administrative Order no. 926 of 27/06/2016 on appointment and administration of international nature protection sites and protection of certain species *(bekendtgørelse om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter)*.

[60] https://www.fugleognatur.dk/lokalitet.aspx?ID=27511.

[61] https://www.fugleognatur.dk/lokalitet.aspx?ID=18831.

9.23 Natura 2000

A separate Natura 2000 screening document has been prepared and submitted to the Danish authorities (Rambøll, 2018x) regarding the Danish Natura 2000 sites, which potentially can be impacted by construction and operation of the Baltic Pipe. The Natura 2000 screening for the Baltic Pipe project has ruled out significant impacts on the terrestrial parts of the Natura 2000 site No. 168 Havet og kysten mellem Præstø Fjord og Grønsund.

In an official statement regarding the Natura 2000 screening, the Danish Energy Agency has agreed to the screening conclusion, namely that no Appropriate Assessment will be obligatory for the terrestrial habitats in Natura 2000 site No. 168 Havet og kysten mellem Præstø Fjord og Grønsund. The terrestrial habitats included in this Natura 2000 site will accordingly not be described or assessed further.

SOCIO-ECONOMIC ENVIRONMENT - OFFSHORE

9.24 Shipping and shipping lanes

The Baltic Sea constitutes one of the most intensely trafficked seas in the world and accounts for approximately 15% of the world's cargo transportation. Ship traffic from the North Sea enters the Baltic Sea either via the Kadet Channel, located between Denmark and Germany, or through the Sound between Denmark and Sweden. The marine ship traffic industry is considered to be of high importance given that it has a high economic value and is a key contributor to the economy at the national and international levels.

9.24.1 Baseline

It is not possible to design a pipeline route from Denmark to Poland that avoids all shipping lanes. However, the planned route has been designed to minimise the route length over which there are a high number of ship passages. The traffic intensity in the southwestern Baltic Sea, based on Automated Identification System (AIS) data from 2016, is shown in Figure 9-79.

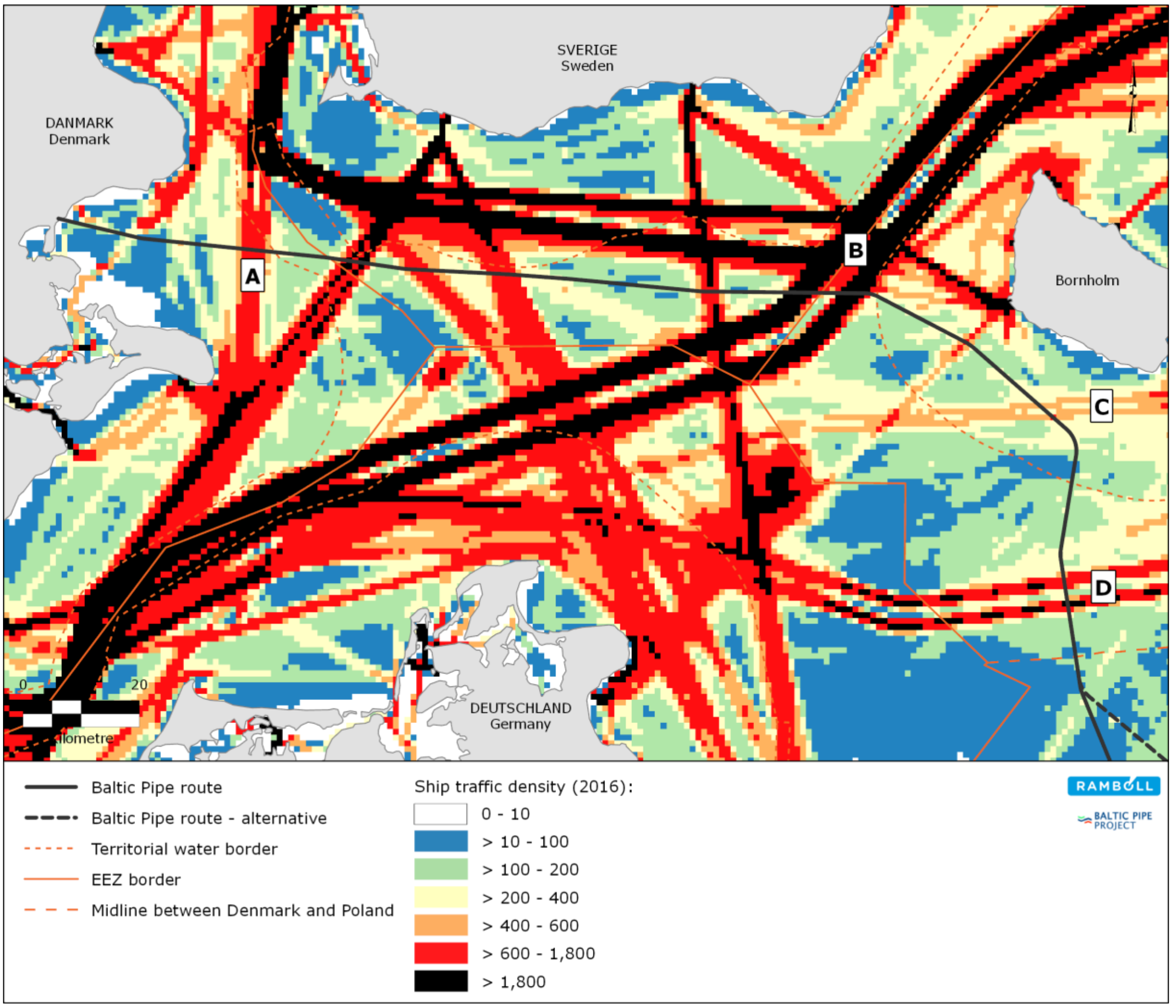

Figure 9-79 Ship traffic intensity in the southwestern Baltic Sea, based on AIS data from 2016 (Danish Maritime Authority, 2016), and the four identified shipping lanes A, B, C and D.

As can be seen from Figure 9-79, most ship traffic in the southwestern part of the Baltic Sea follows pre-designated routes that are in accordance with traffic separation schemes (TSSs). In Danish waters, the planned route crosses four shipping lanes, as described in Table 9-117[62].

Table 9-117 Shipping lanes crossed by the planned pipeline in Danish waters (Danish Maritime Authority, 2016; Rambøll, 2018h).

Shipping lane	Route description	Ship traffic intensity in 2016[63]	Forecasted ship traffic in 2032
Lane A	This shipping lane is the primary route through the Sound passing through the TSS Falsterborev, located off the coast of Stevns within the Swedish and Danish EEZs. Lane A is primarily used for cargo (33%) and passenger transport (25%) (see Figure 9-80). The Malmö-Lübeck ferry service operates in the area and crosses the planned pipeline route.	5,143 passages	6,344 passages
Lane B	This shipping lane is the main entrance to/exits from the Baltic Sea through the Femern Belt. It is used by all ships travelling along the main routes in the Baltic Sea and is, therefore, the most intensively trafficked shipping lane in the Baltic Sea. The shipping lane passes through the TSS Bornholmsgat, west of Bornholm within the Swedish and Danish EEZs. The planned pipeline crosses this shipping lane south of the TSS Bornholmsgat, where ships travelling through the Sound via the southern coast of Sweden separate from this shipping lane. Cargo vessels (53%) and tankers (23%) represent more than two thirds of the ship traffic currently using Lane B (see Figure 9-80).	27,587 passages	34,029 passages
Lane C	This shipping lane passes south of Bornholm and merges with shipping lane D west of Bornholm within German waters. When travelling eastward, the main destination on this route is Klaipeda Port in Lithuania. Lane C is primarily used by passenger ships (20%) and smaller cargo vessels (51%) that are able to cross the shallow Rønne Banke (see Figure 9-80).	1,902 passages	2,346 passages
Lane D	This shipping lane is used by ships passing to/from Gdynia and Gdansk in Poland, Kaliningrad in Russia and Klaipeda in Lithuania, and passes through TSS Adlergrund. The route merges with shipping lane B	6,342 passages	7,824 passages

[62] These shipping lanes have been identified as part of the risk assessment (Rambøll, 2018h).
[63] Number of ships sailing in the shipping lane in 2016 at the point where the pipeline crosses the shipping lane.

Shipping lane	Route description	Ship traffic intensity in 2016[63]	Forecasted ship traffic in 2032
	within the German EEZ, southwest of the TSS and north of Rügen. Lane D is primarily used by cargo vessels (62%). Out of the four shipping lanes crossed by the planned pipeline, this is the shipping lane used by most fishing vessels (14% of the ship movements are fishing vessels) (see Figure 9-80).		

Figure 9-79 shows the number of ships crossing the planned pipeline route in 2016 in the four shipping lanes described in Table 9-117. As can be seen from the figure, shipping lane B passing north of Bornholm through the TSS Bornholmsgat is, with an annual movement of 27,587 passages in 2016, the largest shipping lane crossed by the planned pipeline. The other three shipping lanes crossed in Danish waters are significantly smaller, ranging from approximately 2,000 to 6,500 ship movements per year. The planned pipeline will cross all shipping lanes at a minimum water depth of 20 m to reduce the risk of ships grounding on the pipeline system.

Table 9-117 also shows the forecasted ship traffic in 2032, calculated in connctions woth the Baltic Pipe project, where the total future maritime freight transport is expected to grow by 30% from 2010 to 2030 (Rambøll, 2018h).

A shipping forecast prepared for the Nord Stream 2 project, based on AIS data from the period 2007-2014, shows that the length of ships is anticipated to increase in the future (Rambøll / Nord Stream 2 AG, 2017a). Increase in length is expected to be related to the economic advantage of using larger vessels. Figure 9-81 shows the ship length distribution for the four shipping lanes crossed by the planned pipeline in Danish waters.

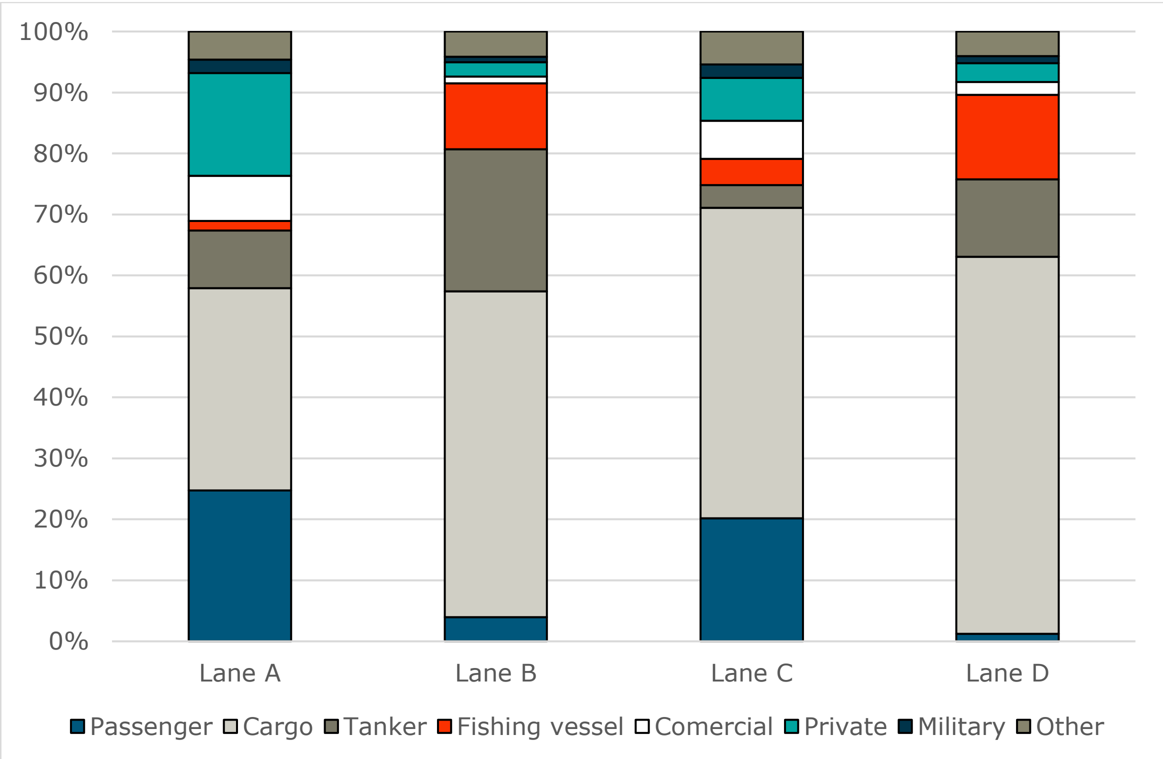

Figure 9-80 Ship type distribution in the four identified major shipping lanes in Danish waters in the southwestern Baltic Sea.

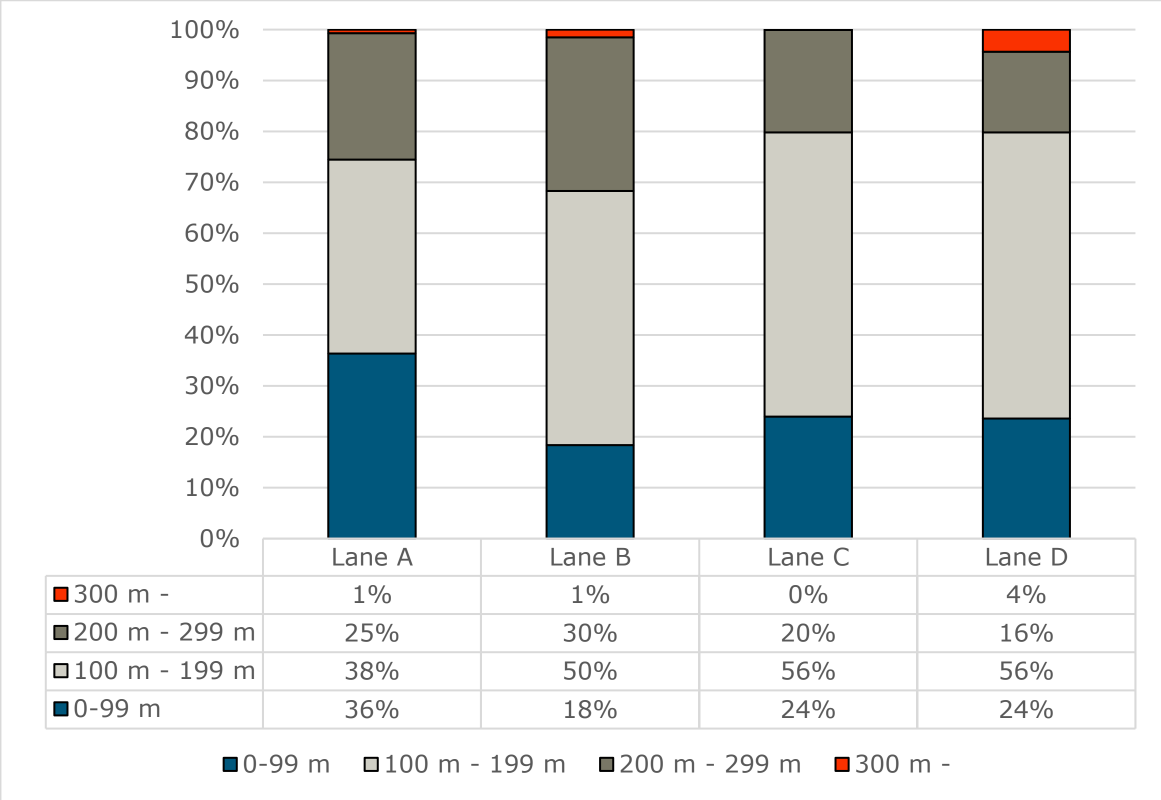

Figure 9-81 Ship length distribution in the four identified major shipping lanes in Danish waters in the southwestern Baltic Sea.

9.24.2 Impact assessment

The construction of the Baltic Pipe project may interfere with ship traffic within Danish waters both during construction and operation. See Table 9-118 for an overview of the potential impacts.

Table 9-118 Potential impacts on shipping and shipping lanes.

Potential impact	Construction	Operation
Safety zones	X	X

The following sources of impacts have been screened out:

- **Physical disturbance above water (construction and operation):** Increased ship traffic caused by project-related vessels not requiring safety zones can be screened out, as these ships will sail at normal speed and obey the same navigation regulations as commercial ships and will, therefore, be of negligible impact.
- **Presence of pipeline (operation):** No shipping lanes will be crossed within Danish waters shallower than 20 m, and to protect the pipeline from anchor drop and drag, the pipeline will be trenched and backfilled within all shipping lanes. Potential impacts from the presence of the pipeline can therefore be screened out, as no restrictions to ship movements are expected.
- **Restriction zone (operation):** The impact from a permanent restriction zone of 200 m on either side of the pipeline can be screened out, as anchoring is already prohibited within shipping lanes.

Safety zones

Construction

The establishment of temporary safety zones around the pipe-lay vessels, and safety zones of other vessels of limited manoeuvrability (e.g. ploughing vessel and rock installation vessel), is a source of potential impact during construction of the planned pipeline. It is expected that the safety zone around the anchor lay barge will have a radius of 1,000 – 1,500 m, while the safety zone around the DP pipe-lay vessel will have a radius of approximately 1,000 m. For all other vessels with restricted manoeuvrability, a safety zone of 500 m will be implemented. No non-project related vessels will be permitted to enter the vessel safety zones, and vessels will therefore need to plan their route around the safety zones during construction activities. The waters around the shipping lanes crossed by the planned route are sufficiently deep, which is needed for many of the ships using the shipping lanes in order to not become grounded, and it is expected that ships can navigate around the construction vessels. Therefore, the sensitivity is assessed to be low.

In cooperation with the contractor and the Danish Maritime Authority, the developer will announce the planned periods of construction activities.

The impact from the establishment of the safety zones will be local, immediate and with low intensity, as no permanent changes occur. Combined with a low sensitivity, this impact is assessed to be of minor severity and not significant overall.

Operation

During the operational phase, planned inspections and maintenance activities will be carried out along the pipeline with a low frequency (e.g. 1-2 times a year during the first years and once every 5 years thereafter). The vessels carrying out the inspections will also have a safety zone imposed in which all other ships will be prohibited from entering. The inspection/maintenance vessels are smaller and move faster than pipe-lay vessels and will, therefore, only require a safety zone with a radius of 500 m. The impact from the establishment of this safety zone will be local, immediate and with low intensity. Combined with the low sensitivity, this impact is assessed to be of negligible severity and therefore not significant overall, Table 9-119.

Table 9-119 Impact significance on shipping and shipping lanes from safety zones during construction and operation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Safety zones (construction)	Low	Low	Local	Immediate	Minor	Not significant
Safety zones (operation)	Low	Low	Local	Immediate	Negligible	Not significant

9.24.3 Conclusion

The potential impacts on shipping and shipping lanes resulting from the construction and operation of the planned pipeline within Danish waters are summarized in Table 9-120.

Table 9-120 Overall impact significance for shipping and shipping lanes.

Potential impact	Severity of impact	Significance	Transboundary
Safety zones (construction)	Minor	Not significant	No
Safety zones (operation)	Negligible	Not significant	No

9.25 Commercial fisheries

In this section, the baseline for the commercial fishery in the Arkona and Bornholm Basin is described and the impacts from the project are assessed.

9.25.1 Baseline

Commercial fishing is carried out in large parts of the Baltic Sea by all countries in the region. The fisheries target both marine and freshwater species, but approximately 95% of the total fish catch in terms of biomass consists of cod, sprat and herring (ICES, 2017). For a detailed biological description of the important commercial fish species, please consult Section 9.12. The composition of the catch is to some extent determined by the salinity, as there is a change in the distribution from marine species to freshwater species from south to north in the Baltic Sea (Leppäranta & Myrberg, 2009). The catches are used for both human consumption and industrial use. The Baltic fisheries also target demersal species such as plaice and flounder along with migratory species such as trout and salmon. Species of freshwater origin that are commercially exploited in the Baltic Sea include pike, pikeperch, perch, and whitefish. Lastly, the Baltic fisheries also catch eel, but it is prohibited to fish for eel of an overall length of 12 cm or more in union waters, including the Baltic Sea, for a consecutive three-month period to be determined by each member state during atumn and winter. This is the time at which eels are migrating and, therefore, are most vulnerable. Denmark has determined the period to be 1. November 2018 - 31. January 2019[64]. The period will be updated on a yearly basis.

The greatest spatial resolution of available fishery data for the Baltic Sea is provided in ICES rectangles (~ 30 x 30 nautical miles (nm)). The rectangles are used for the gridding of data to make simplified analysis and visualization. In the Baltic Sea region, fishing vessels longer than 8 m are obliged to complete a logbook. The logbook contains fishing information on quoted fish species (date, gear used, ICES rectangle, and landings in kg). These data are used to provide an overview of the spatial distribution of the catches on a species level and the amount that is landed. The fisheries that are distributed along the Baltic Pipe are found within the ICES subdivisions (SD) 24 and 25. The SDs contain 13 and 17 ICES rectangles, respectively. It is relevant to analyse landings data for ICES rectangles that are located along the Baltic Pipe route and adjacent to those, i.e. 36G4, 37G2, 37G3, 37G4, 37G5, 38G2, 38G3, 38G4, 38G5, 39G2, 39G3, 39G4 and 39G5, see Figure 9-82.

[64] Danish Fisheries Agency at https://fiskeristyrelsen.dk/erhvervsfiskeri/aal/

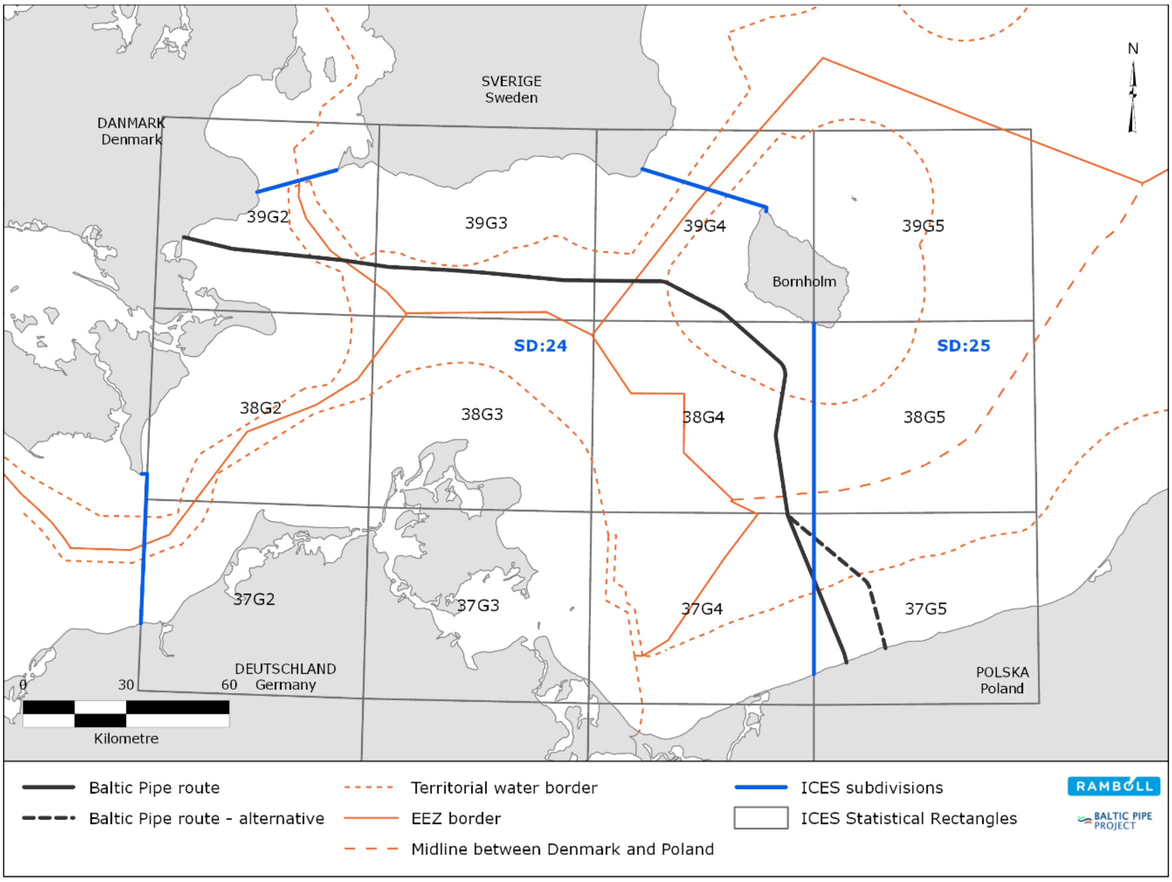

Figure 9-82 ICES rectangles in subdivision (SD) 24 and 25, which encompass the Arkona and Bornholm Basins, respectively.

Vessel monitoring system (VMS) data are collected from HELCOM for bottom-contacting gear and midwater trawl fisheries. The VMS data have greater spatial resolution than the ICES rectangles and describe the fishing effort, i.e. hours per c-square (grid 0.05 x 0.05 degrees).

Fishing techniques

Commercial fishers use a variety of fishing techniques, which are adapted to the characteristics of the species they target. The characteristics of the target species determine to a large extent the technological characteristics affecting catchability, e.g. for fisheries that target a pelagic schooling fish, the detection of the fish schools with fish finders is more critical than the actual catching process. For demersal species that have a less heterogeneous distribution, detection is less important, as catchability is mainly driven by the area swept (Eigaard *et al.*, 2014).

<u>Pelagic trawl and seine</u>

Pelagic trawl and seine fisheries target a mixture of herring and sprat. The catches vary with season and area, and are used for consumption, fishmeal, and oil production. Trawlers using mesh sizes smaller than 32 mm fish for industrial purposes, whereas meshes above 32 mm are mostly used to fish for human consumption. The main proportion of sprat catches is taken by pelagic single and pair trawling. Fishing for sprat is carried out year-round, with the main fishing season in the first half of the year. There are currently three types of fleets: small cutters (17-24 m length) with an engine power of up to 300 h.p., medium-size cutters (25-27 m length) with an engine power of up to 570 h.p., and large vessels (>40 m length) with an engine power of 1050 h.p (ICES, 2013).

<u>Demersal trawl and seine</u>

Demersal trawls and, to a lesser degree, seines, are the most common gear types in the southwestern part of the Baltic Sea. These mobile contacting gear types primarily target cod, as indicated in Table 9-121. Flatfish is often caught as bycatch when fishing for cod, but in certain periods and areas, demersal trawlers may target flatfish. Occasionally, small-meshed demersal trawls are used to catch herring and sprat.

<u>Gillnet</u>

Gillnets are used to catch fish in a wide range of habitats. They are generally considered a shallow-water gear. However, bottom sets can be used at depths exceeding 50 m (Hubert *et al.*, 2012). They are widely used in offshore fisheries targeting cod, flatfish, and herring. In coastal fisheries, gillnets are set to catch a mix of marine and freshwater species, i.e. cod, flatfish, herring, whitefish, pikeperch, perch, and pike. Drift nets have been prohibited since 2008, and the European Union has limited the length of gear depending on the vessel size and the immersion time.

<u>Other gear types</u>

For commercial fisheries, the following types of gear contribute with relatively small catches by weight to the Danish fisheries:

- Longlines are used to target cod, salmon and sea trout. After the prohibition of drift nets in 2008, longlines have become an important gear type in the offshore salmon fishery.
- There is a wide range of traps used for trap net fisheries, where the type of trap net used depends on the targeted species, e.g. herring, salmon, whitefish, and eel.
- Generally, fyke nets and trap nets are set in shallow water not much deeper than the height of the first frame or hoop. However, they can be set in water greater than 10 m deep (Hubert *et al.*, 2012).

An overview of the number of Danish commercial fishing vessels (≥ 8 m) over time can be seen in Figure 9-83.

ICES rectangles	Bottom trawl						Gill nets						Other gear						Pelagic trawl						Seine nets					
	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015
36G4			1	1																										
37G2	3	2	3		1	1		1		1	1					1		1	3			2	2	6	6	3	8	5	5	8
37G3																			1											
37G4		1	1		1															3	1									
37G5				2	1	3								1	1			1	1	2	4	2		1						
38G2	32	39	35	15	22	21	27	27	29	18	17	16	17	15	13	9	11	13	5	4	9	13	14	5	12	12	11	10	10	9
38G3	37	42	55	27	20	16	2					1	1	2				2	2	2	12	15	10	7	8	4	5	4	3	4
38G4	77	48	62	47	40	27	8	6	5	8	6	2	11	13	10	8	9	6	2	7	9	8	9	6	3	1	3	1		
38G5	92	75	74	65	49	48	11	8	6	6	7	3	20	15	9	9	8	7	36	41	36	22	15	7	1	1				
39G2	25	34	19	11	13	13	19	20	24	23	14	16	18	14	12	12	13	10	6	7	11	14	11	13						
39G3	33	36	45	22	22	20	4	1					2		1	1	1	2	3	6	7	13	6	7						
39G4	78	59	76	60	49	34	27	16	20	20	17	13	15	17	16	18	16	14	6	14	7	11	9	3						
39G5	108	69	80	64	52	45	25	14	15	8	7	7	27	22	20	12	12	6	57	47	50	35	31	17	1	2	1			

Figure 9-83 Number of commercial fishing vessels ≥ 8 m according to fishing gear and year in ICES areas 36G3, 36G4, 37G2, 37G3, 37G4, 37G5, 38G2, 38G3, 38G4, 38G5, 39G2, 39G3, 39G4 and 39G5.

The Danish fishing fleet

The Danish fishing fleet in the Baltic Sea includes fisheries in the Arkona Basin and the area around Bornholm, see Figure 9-82. The fisheries are carried out with trawls (bottom and pelagic), seine-haul fishing, gillnets and other gear types (including passive gear, i.e. hooks and lines, fish traps, pound nets and fyke nets), as described above (ICES, 2017).

Danish logbook data and statistics
From 2010 to 2015, 45 different species were caught and registered in the ICES rectangles 36G4, 37G2, 37G3, 37G4, 37G5, 38G2, 38G3, 38G4, 38G5, 39G2, 39G3, 39G4, and 39G5. The summed catch for the period was 193,223 tonnes with a mean annual catch of 32,203.79 tonnes. Denmark was responsible for 26% of the total catch by weight in the area. The commercially important species, i.e. cod, herring, flounder, plaice, and sprat amounted to 177,520.3 tonnes in the period, which is equivalent to approximately 92% of the total catch by weight and a sales value of 167.3 million euro (€).

Fishing importance and ratio for countries with fisheries activity within the ICES rectangles adjacent to the Baltic Pipe based on the mean value of catches (€) from 2010 to 2015 for cod, flounder, herring, plaice, and sprat, are shown in Figure 9-84. Sandeels were also highly important to the Danish fleet in the region, as they comprised 6.5% of the total catch by weight in the period.

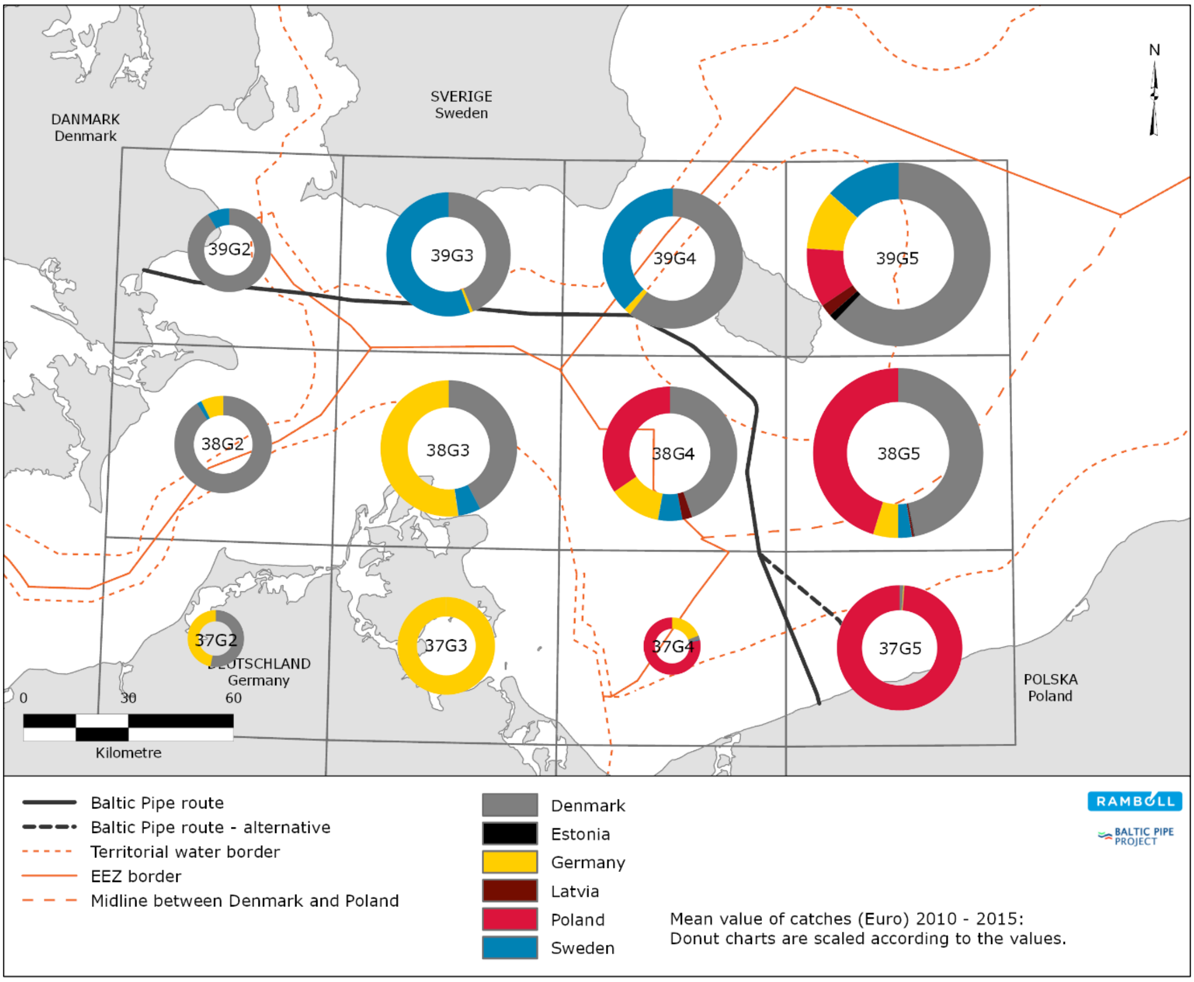

Figure 9-84 Fishing importance and ratio for countries with fisheries activity within the ICES rectangles adjacent to the Baltic Pipe, based on the mean value of catches (€) from 2010 to 2015 for cod, flounder, herring, plaice, and sprat. Data were collected from national fishery authorities for fisheries that operate in subdivision 24 and 25. Finnish data are not included due to data protection, but the summed catch for the period comprises less than <1% when compared to Danish landings.

The logbook data provided to the Ministry of Foreign Affairs of Denmark contained relatively few registrations of crustaceans, cephalopods, cartilaginous and freshwater species compared to the primary catch, which is a composition of marine fish species. In terms of catch by weight, the 10 most important species are marine species, i.e. cod, sprat, herring, sandeels sp., flounder, plaice, whiting, and garfish, except for the anadromous salmon.

Table 9-121 The total quantity (tonnes) of the main species caught by the Danish fishing fleet in the ICES rectangles 36G4, 37G2, 37G3, 37G4, 37G5, 38G2, 38G3, 38G4, 38G5, 39G2, 39G3, 39G4, and 39G5 from 2010 to 2015. Data collected from the Ministry of Foreign Affairs of Denmark.

Species	Scientific name	Quantity (tonnes)
Cod	*Gadus morhua*	68,125.4
Sprat	*Sprattus sprattus*	67,499.1
Herring	*Clupea harengus*	32,372.2
Sandeels sp.	*Ammodytes* sp.	12,552.7
Flounder	*Platichthys flesus*	6,931.3
Plaice	*Pleuronectes platessa*	2,592.1
Whiting	*Merlangius merlangus*	873.5
Salmon	*Salmo salar*	661.9
Garfish	*Belone belone*	538.8

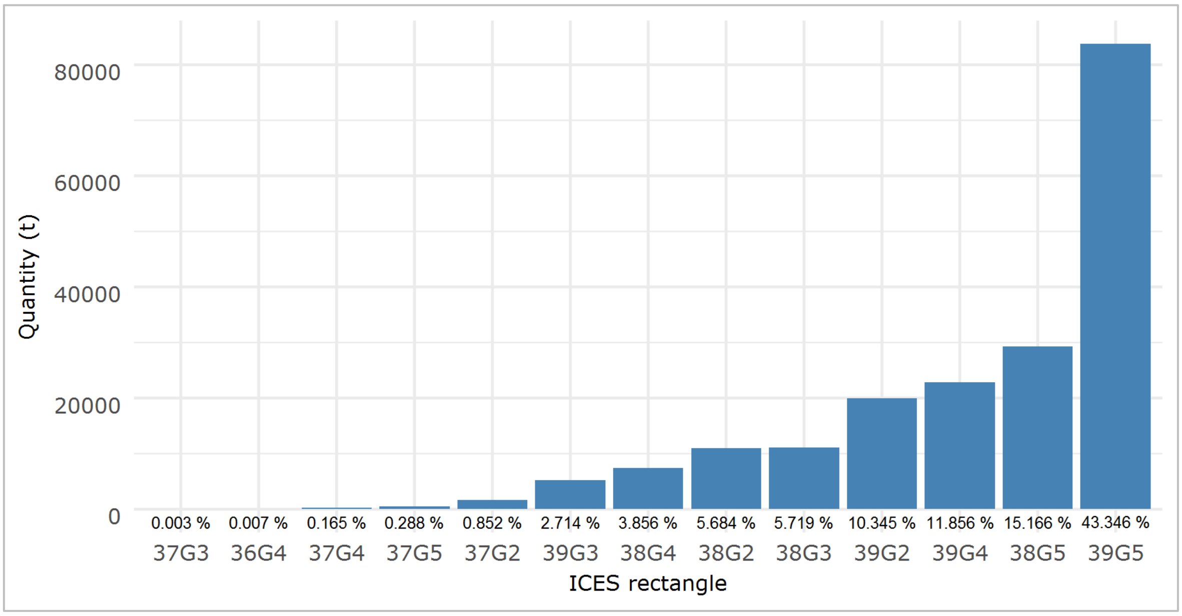

Figure 9-85 Summed quantity (tonnes) of Danish catches in the ICES rectangles 36G4, 37G2, 37G3, 37G4, 37G5, 38G2, 38G3, 38G4, 38G5, 39G2, 39G3, 39G4, and 39G5 from 2010 to 2015. Data collected from the Ministry of Foreign Affairs of Denmark.

As the plotted data from the Danish Ministry of Foreign Affairs suggests (see Figure 9-84, Figure 9-85 and Table 9-122), certain areas are of higher economic interest than others. Three of the four ICES rectangles surrounding Bornholm, i.e. 39G5, 38G5, and 39G4 are, in terms of catch by weight, the most important areas. 39G2, which includes Faxe Bugt, is also an important area for the Danish fishing fleet when looking at quantity (tonnes) as it contributed with 10.3% of the total catch by weight in the period 2010 to 2015.

Table 9-122 Mean annual catch (tonnes) and value (1,000 €) of catch by Denmark during 2010 – 2015 from ICES rectangles that are adjacent to the Baltic Pipe in subdivisions 24 and 25. Data collected from the Ministry of Foreign Affairs of Denmark. Numbers are valid for commercial species (sprat, herring, plaice, cod and flounder).

ICES rectangle	Catch in tonnes	Value in 1,000 €
36G4	2.1	3.7
37G2	262.4	339.7
37G3	0.9	0.4
37G4	48.6	15.7
37G5	80.9	26.4
38G2	1,459.6	1,739.5
38G3	1,779.0	2,231.7
38G4	940.6	1,482.0
38G5	4,803.6	5,114.5
39G2	1,718.3	1,130.9
39G3	823.7	1,066.1
39G4	3,734.1	4,466.3
39G5	13,932.7	10,275.2

There is a strong correlation between the mean annual catch (tonnes) and the value (€), as 39G5, 38G5, and 39G4 are of the highest importance for both parameters. A combination of central and shore-close ICES rectangles to Denmark i.e. 39G2, 38G2, 39G3, 38G3 and 38G4 are relatively similar in both mean annual catch and value (see Table 9-122).

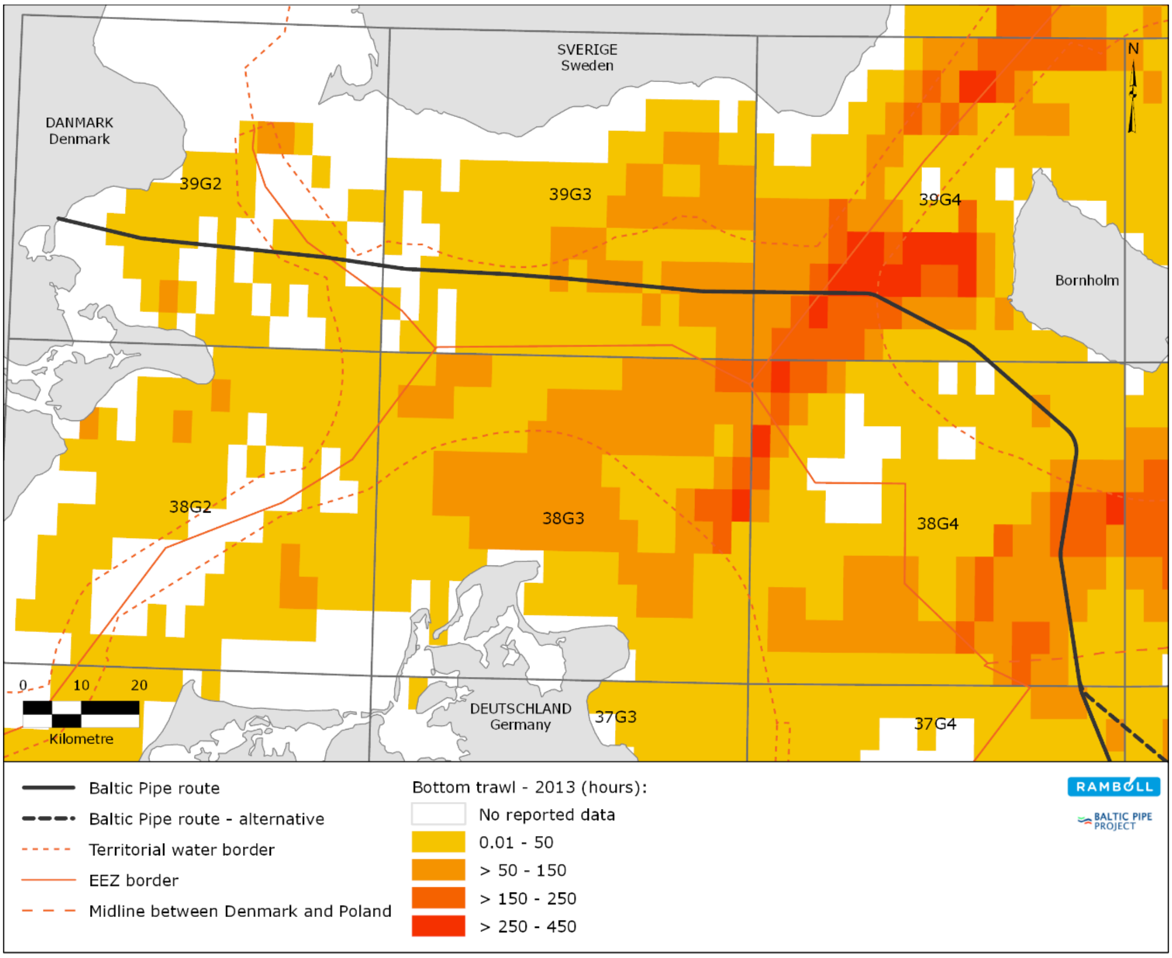

Figure 9-86 Fishing effort in terms of estimated hours per c-square for mobile contacting gear in 2013 based on VMS/logbook data processed by the ICES Working Group on Spatial Fisheries Data (WGSFD) (HELCOM, 2015b). The rectangles and codes (ICES rectangles) are used for the gridding of data to make for simplified analysis and visualization.

Figure 9-86 shows the fishing effort for mobile contacting gears in 2013 for HELCOM members, excluding Russia, in the Arkona and Bornholm Basins. Even with the scarcity of data for 38G2, 39G2, 38G4, and 37G4, a pattern emerges, which correlates well with Figure 9-84. As the pipeline will be located on the seabed, it is important to assess the fishing effort for mobile contacting gears such as demersal trawls. As Figure 9-86 includes the fishing effort of other nations than Denmark, it is beneficial to evaluate based on intensity by comparing to Table 9-122, in order to get the full overview of the fisheries in the area.

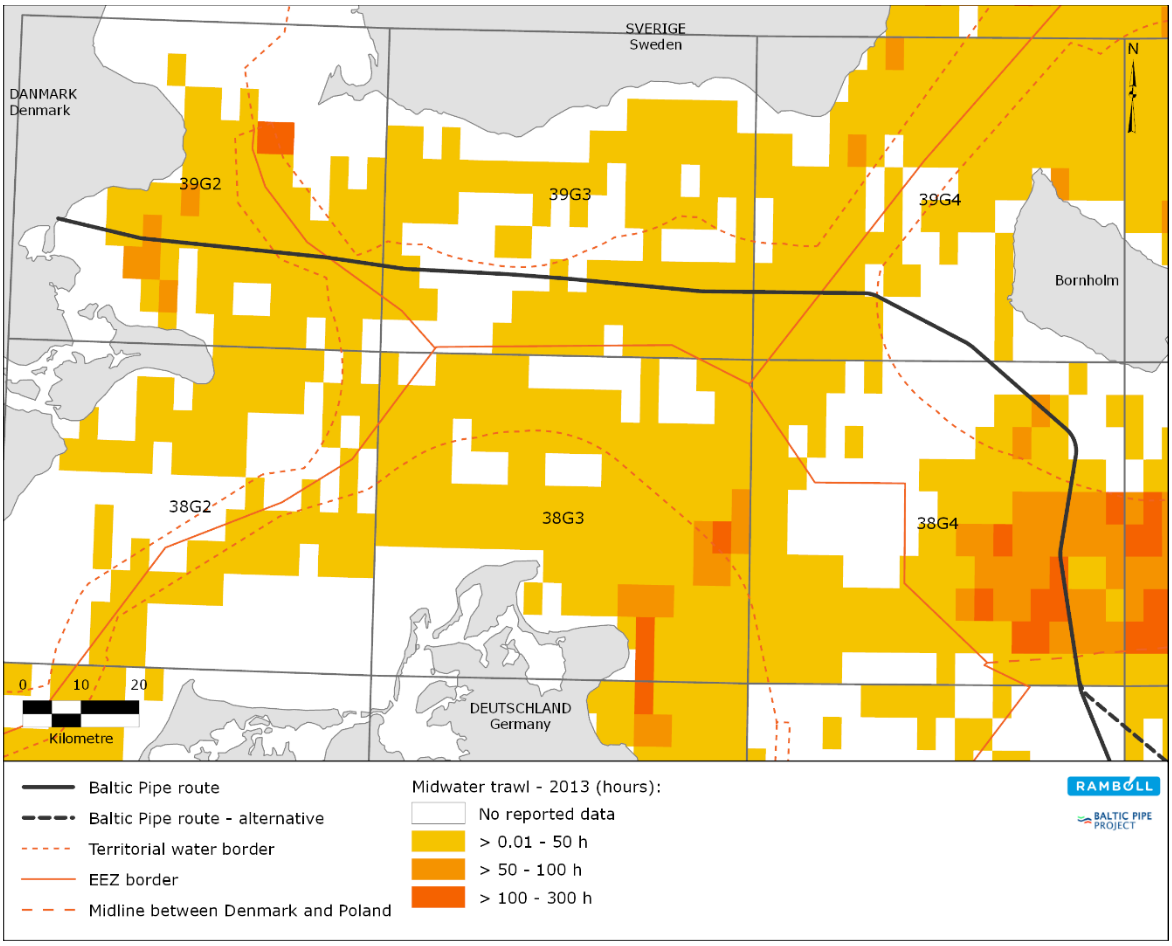

Figure 9-87 Fishing effort in terms of estimated hours per c-square for midwater trawl gear in 2013 based on VMS/logbook data processed by the ICES Working Group on Spatial Fisheries Data (WGSFD) (HELCOM, 2015b). The rectangles and codes (ICES rectangles) are used for the gridding of data to make for simplified analysis and visualization.

Figure 9-87 shows the fishing effort for midwater trawl gears in 2013 for HELCOM members, excluding Russia, in the Arkona and Bornholm Basins. Many of the c-squares in Figure 9-87 are reported with no available data. The lack of data is most likely connected with the overall low biomass of sprat and herring in the area that are normally caught by midwater trawling vessels, see Figures 9-50 and 9-51 (Section 9.12). Midwater trawl effort was less intense than bottom-contacting gears. The year 2013 is assessed to be a representative year for both fishing techniques in the period, as there are little to no changes in the fishing effort pattern in the period 2010 to 2013 where data are available from HELCOM.

9.25.2 Impact assessment

The Baltic Pipe pipeline can potentially interfere with Danish commercial fisheries both during the construction and operational phases. See Table 9-123 for the potential impacts on commercial fisheries.

Table 9-123 Potential impacts on commercial fisheries.

Potential impact	Construction	Operation
Safety zones	X	X
Restriction zone		X
Presence of pipeline		X
Physical disturbance above water	X	X

The following sources of impact have been screened out:

- **Physical disturbance of seabed (construction)**: An indirect impact on the fishing resource (fish). Fish will be susceptible to showing avoidance behaviour because of physical disturbance of the seabed. Despite the disturbance of the seabed, the period will be temporary, and fish will return shortly afterwards (See Section 9.12).
- **Underwater noise (construction):** An indirect impact on the fishing resource (fish), (See Section 9.12). In a worst-case scenario, where munitions clearance is unavoidable, mortality can occur within a maximum distance of 0.7 km for Faxe Bugt and 1.3 km for Bornholm (Section 9.12, Table 9-83). The same worst-case scenario applies for injuries to fish at Bornholm, but the maximum distance for Faxe Bugt is 0.8 km. It is likely that it will be lethal for shoals or schools of fish that are present within these mentioned distances when munitions clearance occurs. On a population level, the severity of the impact is minor. Munitions clearance will only present a lethal or injury risk for few individuals in larger populations. This means that the structure and function of the populations will remain unaffected. Mitigation measures will reduce the severity of the impact. Still, the impact severity is assessed as minor because it is possible that there will be some short-term variability within the respective fish populations, but it will be closer to negligible than if no mitigation measures were used.

Safety zones

Safety zones will be established around the construction vessels. The safety zone will have a radius of 1,000 - 1,500 m around the pipe-lay vessel and accompanying vessels, depending on the use of DPS (Dynamic Positioning System) or anchors and anchor chains. Safety zones will follow the vessels as they move continuously with a speed of 3-4 km per day at water depths of over 20 m, which is where the most high-intensity fishing is carried out. Therefore, impact on commercial fisheries from safety zones will be regional/transboundary and temporary, Table 9-124.

As Table 9-122 shows, some of the ICES rectangles are of higher economic mean annual value. The socioeconomic impact that can occur from physical disturbance above water can vary greatly for the individual fisher, as there are differences in the métiers e.g. gear types, target assemblage, mesh sizes, etc. In general, fishermen tend to fish in more than a single ICES rectangle, so it is unlikely that the temporary safety zone will restrict fisheries activity. However, it can alter the catch per unit effort (CPUE) for a short period of time.

In cooperation with the contractor and the Danish Maritime Authority, the developer will announce the planned periods of construction activities. Also, compensation will be a mitigation measure to reduce the economic impact on fishermen fishing in areas that will temporarily be closed due to the imposition of safety zones.

Table 9-124 Impact significance of safety zones on commercial fisheries.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Safety zones	Low	Minor	Regional/ transboundary	Immediate	Negligible	Not significant

Restriction zone

A restriction zone with a radius of 200 m will be set around the pipeline once it is fully operational. This can have a potential impact on the total fishable area for commercial fisheries and alter the fisheries pattern in the area. There are no nearshore fisheries in spatial conflict with the restriction zone, as the last known fishermen in the area decided to stop fishing activities in 2018. As for demersal trawlers, it is very unlikely that the restriction zone will have any effect, as it will occupy less than 1% of the total fishable area in the Arkona and Bornholm Basins, see Table 9-125.

Table 9-125 Uptake (%) of fishable area by the restriction zones in un-trenched areas for each ICES rectangle.

ICES rectangle	Restriction zone km²	ICES area [km²]	Uptake of fishable area in %
39G2	6.11	3539.98	0.24
39G3	19.08	3539.98	0.69
39G4	9.35	3539.98	0.32
38G4	18.36	3539.98	0.52
37G4	4.80	3539.98	0.14

Therefore, the effect on CPUE and availability of fishable area is assessed as minor. The intensity of the impact is minor. The restriction zone will be of a local and transboundary scale, because it influences both national and foreign fisheries within a 200 m radius of the pipeline. The duration of the restriction zone is assessed to be long-term. Lastly, the severity of the impact is assessed to be minor and not significant, Table 9-126.

Table 9-126 Impact significance of safety zones on commercial fisheries.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Restriction zone	Low	Minor	Local/ transboundary	Long-term	Minor	Not significant

Presence of pipeline

Where the pipeline is placed directly on the seabed and where rock installations are present, there may be an impact on commercial fisheries, see Section 3.5.3 Figure 3-22. Demersal trawls can be affected by the presence of the pipeline, as their gear can get hooked upon contact with the pipeline. However, hooking is a seldom occurring accidental situation where the trawl equipment becomes stuck under the pipeline created by a span. The seabed is relatively flat where the pipeline will be laid, but in areas where free spans are present and high trawl intensity exists, trawl infill, i.e. rocks will be used to fill potential spans. Demersal trawlers are advised to avoid fishing across the pipeline. It is very unlikely that the presence of the pipeline will restrict fisheries activity, as the fishermen tend to fish in more than a single ICES rectangle, but there will be a need for adaptation in regard to trawl patterns for demersal trawlers. Pelagic trawlers will not be affected by the presence of the pipeline, as the towed net maintains a natural distance to the seabed. Furthermore, the presence of the pipeline will occupy less than 1% of the total fishable area in the Arkona and Bornholm Basins, which will constitute a minor effect on the CPUE and the availability of fishable area, see Table 9-125.

The impact intensity will, therefore, be minor and local/transboundary, because it affects national and foreign fisheries. However, the impact will be long-term. Nevertheless, the severity of the impact is assessed to be minor and therefore not significant, Table 9-127.

Table 9-127 Impact significance on commercial fisheries from the presence of the pipeline.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Presence of pipeline	Low	Minor	Local / transboundary	Long-term	Minor	Not significant

Physical disturbance above water

The presence of vessels during the construction and operational phases will be conditions that the national and foreign fisheries fleet are already adjusted to, as they are accustomed to the heavy ship traffic that exists in the Baltic Sea under normal circumstances. Therefore, the sensitivity of commercial fisheries is assessed to be low.

Vessels used during both the construction and operational phases may accidentally cut a line of fishing gear, such as longlines and gillnets, which are both considered shallow-water gear. Abandoned, lost, or otherwise discarded fishing gear is a problem of increasing concern, as it may cause environmental impacts and economic loss for the fishermen. Despite this potential impact, there are relatively few fishermen who use these gear types, as shown in Figure 9-83, and the process of pipe-lay in shallow water will be short. The impact is therefore assessed to be of minor intensity. As the vessels will move continuously, the scale is local, and the duration is immediate. Combined with a low sensitivity, the severity of impact is assessed to be negligible and not significant.

Table 9-128 Impact significance on commercial fisheries from the presence of vessels during construction and operation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance above water	Low	Minor	Local/ transboundary	Immediate	Negligible	Not significant

Transboundary

All Baltic coastal states except Russia are members of the European Union, with their fisheries activities being regulated by the EU Common Fisheries Policy. In 2006, the EU and Russia agreed to a bilateral framework fisheries agreement. The Baltic Pipe project will, with its safety zones, restriction zones and presence on the seabed affect the fishable area available to the Baltic coastal states. However, once the pipeline is constructed, it will occupy less than 1% of the total fishable area in the Arkona and Bornholm Basins, see Table 9-125, so even though there will be a transboundary (socio-economic) impact, the impact will not be significant.

9.25.3 Conclusion

In general, the sensitivity of the potential impacts on fisheries is evaluated as low, the intensity minor and scale local/regional. In terms of duration, the imposition of safety zones and the presence of vessels (i.e. physical disturbance above water) have an immediate duration, whereas the presence of the pipeline and the restriction zone around the pipeline are long-term. The severity of each impact is either negligible or minor, and no impacts are evaluated as significant, see Table 9-129.

Table 9-129 Overall impact significance on commercial fisheries.

	Severity of impact	Significance	Transboundary
Safety zones	Negligible	Not significant	Yes
Restriction zone	Minor	Not significant	Yes
Presence of pipeline	Minor	Not significant	Yes
Physical disturbance above water	Negligible	Not significant	Yes

9.26 Archaeology and cultural heritage

Submerged Stone Age landscapes, shipwrecks that bear proof of intensive navigation for thousands of years, and structures from old ports or sea fortifications may be found in the seabed of the Baltic Sea. In this section, the baseline for offshore archaeology and cultural heritage is described and the impacts from the project are assessed.

9.26.1 Baseline

The Danish Agency for Culture and Palaces (SLKS - Slots og Kulturstyrelsen) is the national authority for cultural heritage, including submarine heritage. The Danish pre-investigation area for the Baltic Pipe located within the responsibility of the Viking Ship Museum in Roskilde (VIR (Vikingeskibsmuseet in Roskilde)).

The Danish Museum Act[65] protects known and unknown submarine heritage up to 24 nm from land, whereas archaeological findings from 24 nm to the border of the EEZ are not covered by the Danish Museums Act. Outside the 24 nm radius, the Danish Agency for Culture and Palaces can only recommend to the developer what considerations should be taken in regard to potential cultural heritage objects or sites. However, 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.

Disturbance to or alteration of protected submarine heritage is prohibited.

Submarine cultural heritage includes, according to section 29(g) of the Danish Museum Act[65], objects older than 100 years. Such objects or sites are divided into two main categories; wrecks and submerged Stone Age sites. In special cases, the Danish Agency for Culture and Palaces may decide that wrecks of aeroplanes, boats, and ships from e.g. the First or Second World Wars are also to be protected, even though they are not yet 100 years old.

According to the Danish Museum Act[65], any activities, such as diving, fishing, submarine investigation and construction works, must be stopped if potential archaeological objects or sites are found, and any such finds must be reported to the Danish Agency for Culture and Palaces.

If the Danish Agency for Culture and Palaces (2018) suspects that the work associated with the Baltic Pipe will disturb protected submarine heritage or shipwrecks, the developer may be ordered to pay for a marine archaeological investigation. This also applies if traces of submarine heritage are found during the construction work.

[65] Consolidated Act on Museums, LBK nr 358 af 08/04/2014; https://www.retsinformation.dk/forms/R0710.aspx?id=162504.

Based on the above obligations to protect cultural heritage, it is considered an important socio-economic receptor. For this reason, it is important to obtain knowledge of recognized archaeological objects or buried sites prior to construction and as well as to investigate, through desktop studies and surveys, whether any other objects of potential cultural heritage value exist along the pipeline route and within the installation and impact depth. The mapping of these potential objects and relevant Stone Age landscapes will contribute to the final detailed routing of the planned pipeline.

Accordingly, detailed geophysical and geological surveys and investigations along the preferred Baltic Pipe route corridor are currently underway, and the preliminary geophysical results and data have been sent to VIR for supplemental assessments of potential archaeological finds along the route. However, at this early stage, no conclusions can be made regarding potential submarine heritage. Hence, the following baseline is based on existing archival data and information.

The primary input for the baseline is the national database of sites and monuments (*Fund og Fortidsminder*[66]). The register is maintained by the Danish Agency for Culture and Palaces. The database comprises more than 170,000 finds, including approx. 17,000 shipwrecks and submarine Stone Age settlements.

These reports of observations at sea originate from various stakeholders, such as reported observations from fishermen, maritime traffic, amateur divers, amateur archaeologists, archives, various authorities, survey companies and professional archaeologists over different periods of time. However, it is far from a complete register of wrecks and debris thereof that indeed have cultural heritage value, as only a small percentage of the registered wrecks have been subject to an archaeological study.

Wrecks

Many of the registered wrecks, or other man-made objects, in the national database of sites and monuments (*Fund og Fortidsminder*) have been observed and reported more than once during historical and more recent times. Thus, each registered submarine find in the database may contain information from many different observations. Even though each registered object has a unique registration number and positional coordinates, the positional accuracy of each registered find may be associated with some uncertainty, both due to the different nature of how the objects were observed and due to difficulties in accurate positioning at sea, especially during historical times. Therefore, some identical shipwrecks may have more than one registration number in the database and two or more different shipwrecks lying very close to each other may be registered as only one shipwreck.

Even though some predictability can in theory be applied when assessing the likelihood of finding wrecks on the seabed (e.g. higher occurrences may be expected within historical naval battle zones, along preferred sailing / merchant routes, along fierce and wind-prone shallow coasts, and above bathymetrical shoaling areas), there is still a high degree of randomness attached to the existence and locations of wrecks.

The following registered shipwrecks have their registered positional coordinates within the Baltic Pipe survey route corridor (*Fund og Fortidsminder*), Figure 9-88:

- Seven wrecks are registered as existing within a buffer of 250 m on each side of the planned pipeline centre along the route from the landfall Faxe S to the Swedish EEZ;

[66] http://www.kulturarv.dk/fundogfortidsminder/Kort/

- No wrecks are registered as existing within buffers of either 250 m or 500 m on each side of the planned pipeline centre along the route west of Bornholm.

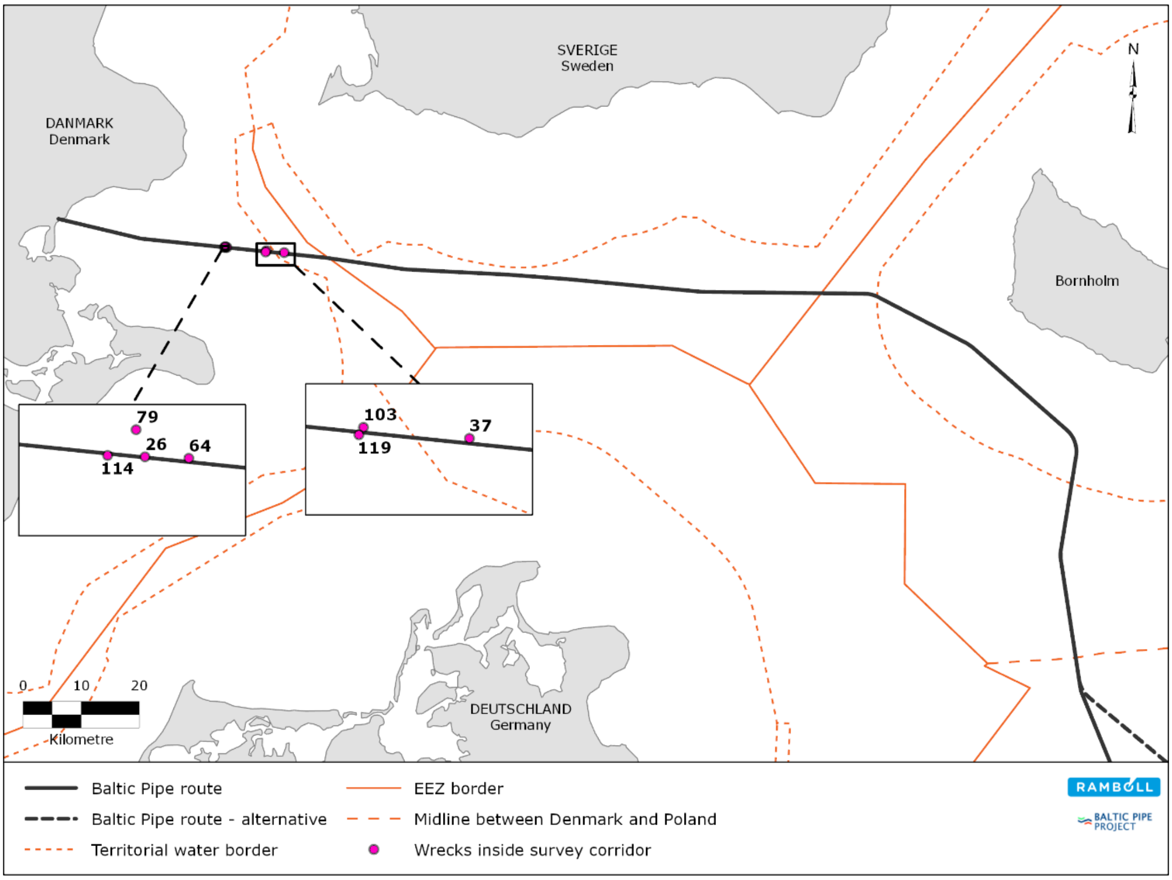

Figure 9-88 Overview of registered wrecks in the *Fund og Fortidsminder* database[66] within the preferred route corridor.

The seven registered wrecks, of which six are registered within 24 nm of shore, and one (system no. 177992) is registered in the Danish EEZ, are also listed in Table 9-130, which includes their approximate age as listed in the *Fund og Fortidsminder* database.

Table 9-130 Overview of registered wrecks in the *Fund og Fortidsminder* database within the preferred route corridor.

ID no	System no.	Location no.	Year from	Year to	Weblink
231394	177931	26	1970	1979	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/177931/
231455	177992	37	1940	1945	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/177992/
234938	182809	64	1970	1979	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/182809/
236019	183956	79	1900	1999	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/183956/
236071	184008	103	1850	1899	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/184008/
236297	184337	114	1970	1979	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/184337/

ID no	System no.	Location no.	Year from	Year to	Weblink
236674	184984	119	1920	1929	http://www.kulturarv.dk/fundogfortidsminder/Lokalitet/184984/

Submerged Stone Age landscapes and potential settlements
According to the national register of sites and monuments (*Fund og Fortidsminder*), no submerged Stone Age settlement sites are registered along the planned Baltic Pipe route.

Due to changing sea levels since the last glaciation, some former land and coastal areas are presently submerged. These former land and coastal areas may potentially have hosted human Stone Age settlements and associated activities, and if so, and if the former landscapes have not undergone severe erosion, such objects are also protected as cultural heritage.

As is the case with submerged wrecks, the exact location of submerged Stone Age sites cannot be predicted, as there is also a high degree of randomness associated with this type of submarine cultural heritage. However, given certain conditions, it is possible to exclude seabed areas that could not historically have been dry land, and thus could not have hosted pre-historic settlers during the Stone Age.

When assessing submerged Stone Age landscapes based on existing knowledge and detailed seabed survey data, the focus for marine geo-archaeologists will most likely be on the following parameters:

- The likelihood of whether the seabed impact zone was inhabitable or not during the archaeological period of interest;
- The likelihood of whether the former now submerged dry land surfaces are still relatively intact, and potentially buried by marine sediments;
- Subsistence economy – were the conditions favourable for settlement in the area of investigation as a whole; and
- Habitat / settlement model – do well-known settlement patterns exist that make it possible to track potential sites through (paleo-) topographic models for the period and area of interest.

As part of the so-called geo-archaeological desktop study for the Baltic Pipe pre-investigation area (Rambøll, 2018z), theoretical paleo-geographic maps have been prepared for selected time-slices, thus exhibiting different bathymetry conditions, during the recommended applicable period of the Mesolithic in the southwestern part of the Baltic area, c. 9,500 – 5,900 years before present. The paleogeographic maps assume that the current seabed corresponds to a potential former dry land surface before the Holocene marine transgressions and does not consider later potential erosion or sedimentation.

Also, as part of the geo-archaeological desktop study for the Baltic Pipe, a pre-investigation area (Rambøll, 2018z), approximating the lowest levels for potential coastal/land areas, was determined. Seabed areas lying significantly deeper than these lowest levels for submerged potential coastal settlements should in theory be ignored in regard to potential submerged Stone Age relicts.

Due to differences particularly in crustal uplift in the Baltic Pipe pre-investigation area, where the northern part has experienced larger uplift since the last glaciation than the southern part, the approximate lowest levels for potential coastal/land areas varies along the preferred Baltic Pipe route. However, some selected levels for the Danish areas along the preferred route include the following:

- The centre of Faxe Bugt: Seabed areas at depths greater than approximately 15 m water depth were not dry land during the relevant period of the Mesolithic, and thus could not have hosted coastal Stone Age settlers;
- Eastern part west of Bornholm (Rønne Banke): Seabed areas at depths greater than approximately 17 m water depth were not dry land during the relevant period of the Mesolithic, and thus could not have hosted coastal Stone Age settlers.

Since the selected areas east of the landfall at Faxe and west of Bornholm are at the approximate same latitude, the lowest levels for potential coastal/land areas do not differ much.

Evaluation of potential cultural heritage
Several surveys, including a geophysical survey and a geotechnical-geological survey, are being conducted for the preferred BP route corridor. These surveys include investigations of the seabed and sub-seabed with multibeam echo-sounder (MBES), side-scan sonar (SSS), sub-bottom profilers (SBP) and magnetometer (MAG), as well as geotechnical grab sampling and ground truthing (vibrocores and associated geological descriptions and geotechnical laboratory analyses).

As recommended by the Danish Agency for Culture and Palaces, the preliminary geophysical data associated with the seabed (i.e. SSS, MAG and MBES data) and associated video footage of selected sonar and magnetic targets are currently being screened by VIR with the aim of identifying potential cultural heritage objects (CHOs). The integrated results from the geophysical and geotechnical surveys, as well as the geoarchaeological desktop study, has been delivered to VIR for assessments of potential pre-historic sites along the route.

Based on the above, VIR has identifyed a need for further inspection of a number of remaining potential CHOs with exclusion zones that are lying within or very close to the planned pipeline route have been selected (archaeological Target list). Therefore, ROV video inspections January-February 2019 will be carried out according to instructions by VIR. VIR will examine the videos for a visual assessment of the inspected objects. Objects that are assessed to be non-CHO will be removed from the Target list.

Objects that are assessed to still be potential CHOs (Inconclusive or Probably/Likely) will be maintained in the target list. Baltic Pipe project will then, if possible, re-route around the potential CHOs and their associated exclusion zones. For specific areas, where re-routing is not fully, but almost possible, a dialogue with VIR/SLKS will be initiated to potentially determine customized in general smaller exclusion zones based on geology and survey data, installation procedures, and the videos. For specific areas, where re-routing is not possible, VIR will in the late winter/early spring 2019 carry out supplementary archaeological diving and ROV investigations to finalize the assessment of the objects being CHO or not. Based on the results from the planned archaeological diving and ROV investigations final re-routing will be carried out.

9.26.2 Impact assessment
The construction and installation of a submarine pipeline and activities related to maintenance and decommissioning may potentially affect probable submarine heritage lying at or buried immediately below the seabed within the depths and widths of potential impact (see Chapter 5). The potential impact on such objects could potentially be a result of direct impact into the seabed; e.g. trenching and/or anchoring during installation.

The handling of marine archaeology will be based upon the final evaluation of potential cultural heritage objects along the preferred route for the offshore pipeline, which is in process, as described above. The Viking Ship Museum (VIR) is responsible for this evaluation.

Furthermore, the Museum Act[67] section 29(h) always applies within 24 nm from land, which means that construction activities should be stopped if archaeological objects appear during construction offshore.

Assuming the applicable regulations regarding the handling of objects of submarine archaeological interest and cultural heritage are followed, it is unlikely that there will be significant impacts on archaeology and cultural heritage, and this topic will not be dealt with further.

9.27 Cables, pipelines, and wind farms

Existing cables, pipelines, and wind farms are the main types of installations that are encountered along the planned pipeline route in the Baltic Sea within the Danish territorial waters and EEZ. These installations are an important receptor due to their economic importance.

9.27.1 Baseline

The planned route of the pipeline has been designed to avoid all planned and existing wind farms. Figure 9-89 shows the cables, pipelines and wind farms currently located or under construction in the project area.

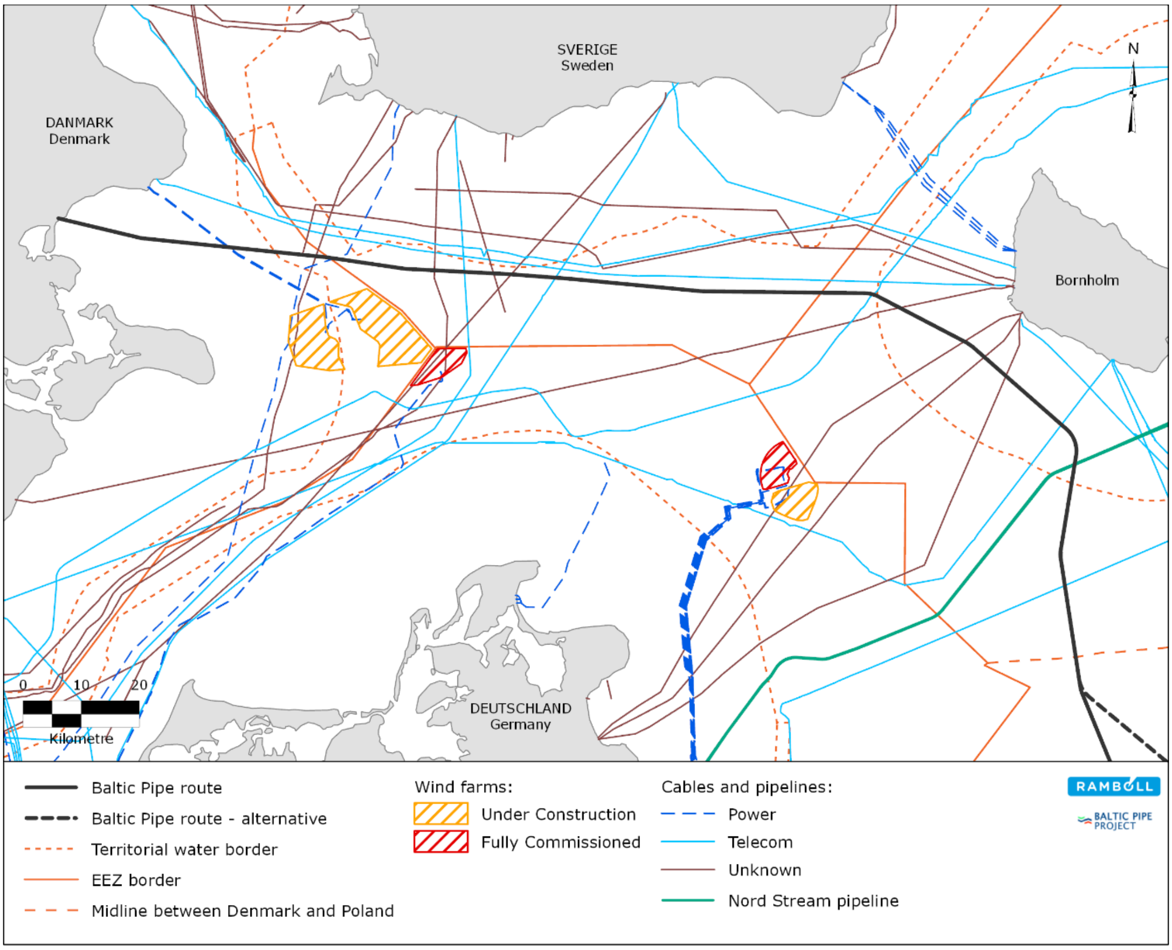

Figure 9-89 Existing installations within the southern Baltic Sea.

Within Danish territorial waters, the planned route crosses the grid connection to the planned offshore wind farm Krieger's Flak and passes northwest of the wind farm itself (Figure 9-89). The

[67] Consolidated Act on Museums, LBK nr 358 af 08/04/2014.

construction of the grid connection is scheduled to be completed by December 2018, while the construction of the wind farm is planned to be concluded in 2021.

In addition to crossing the grid connection to Krieger's Flak, the planned pipeline crosses the three telecommunication cables Falster-Rønne, C-Lion, and Baltica Segment 3, another three telecommunication cables that are located between Bornholm and Rügen and the GK-22 telecommunication cable from Pionersky, Russia to Usedom, Germany (Table 9-131).

The route crosses the Nord Stream pipelines in the Danish territorial waters southwest of Bornholm. Nord Stream consists of twin gas pipelines established in 2010-2012 and which run through the Baltic Sea from Russia to Germany. Furthermore, Nord Stream 2, also consisting of two twin gas pipelines, are under planning but has not been approved at the moment of this EIA report.

Finally, there are two unknown cables from Sweden crossing the Baltic Pipe. The type and owner of the cables will be identified as part of the detailed design of the project.

Table 9-131 Installations crossed by the planned route in Danish waters. The table is based on information from the Danish Coastal Authority, the Danish Maritime Authority and the Danish Geodata Agency.

Name	Type	Owner	Status
Krieger's Flak Grid Connection	Power (two cables)	Vattenfall	Planned
Falster-Rønne	Telecom	Unknown*	Inactive from 1997
C-lion	Telecom	Cinia Group OY	Active
Baltica Segment 3	Telecom	TDC	Active
Bornholm – Rügen I	Telecom	Unknown*	Inactive from 1968
Bornholm – Rügen II	Telecom	Unknown*	Inactive from 1968
Bornholm – Rügen III	Telecom	Unknown*	Inactive from 1968
Nord Stream	Gas pipeline (two pipes)	Nord Stream AG	Active
GK-22	Telecom	Deutsche Telecom	Inactive
Unknown*	Unknown*	Unknown*	Unknown*
Unknown*	Unknown*	Unknown*	Unknown*
*Determination of type and ownership of the unknown cables will be handled as part of the detailed design of the project.			

9.27.2 Impact assessment

The construction of the Baltic Pipe pipeline may affect existing and planned installations within Danish waters during construction and operation. See Table 9-132 for an overview of the potential impacts.

Table 9-132 Potential impacts on existing and planned installations.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Presence of pipeline		X

Physical disturbance of seabed

Construction activities causing physical disturbance of the seabed, such as pipe-lay, trenching, and rock placement, may result in damage to existing installations. The sensitivity to this type of impact is high since the installations are of high economic importance to the owners who themselves are unable to influence or mitigate the continuity of supplies to customers in the case of damage. The installations are also of high importance to the customers, who will be affected during outages caused by damage to the installations.

To avoid damage to existing cables and pipelines, all crossings will be protected by rock installations or concrete mattresses and a detailed crossing design for each crossing will be prepared. The crossing design will be based on survey results and provide input to the rock/mattrass installation design. After installation, the Baltic Pipe will be covered to the top of the pipe at crossings to provide protection. Impacts are not likely to occur; thus, the impact is not assessed further.

Prior to construction of the offshore part of the Baltic Pipe, agreements will be reached with all involved owners of the crossed infrastructure.

Presence of pipeline

During the operational phase, the presence of the planned pipeline may hinder the ability to repair the existing cables and pipelines at crossings, which may have financial implications for th owners of these installations. However, the sensitivity of existing installations to the presence of the pipeline will be low, as the owners of the installations will be involved in the crossing design to minimise the risk of damage.

The impact intensity is assessed to be minor, with a local scale but long-term duration. Combined with the low sensitivity, the severity is assessed to be minor and overall not significant, Table 9-133.

Table 9-133 Impact significance on existing and planned installations from the presence of pipeline.

Potential impact	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Presence of pipeline	Low	Minor	Local	Long-term	Minor	Not significant

Furthermore, the presence of the pipeline on the seabed will also affect the availability of the seabed for future installations. However, it will be possible to place some types of future installations on top of the pipeline, such as cables and pipelines.

9.27.3 Conclusion

The potential impacts on existing and planned installations resulting from construction and operational activities of the planned pipeline within Danish waters are summarized in Table 9-134.

Table 9-134 Overall impact significance for existing and planned installations.

Potential impact	Severity of impact	Significance	Transboundary
Presence of pipeline	Minor	Not significant	No

9.28 Raw material extraction sites and dumping sites

Marine sediments may comprise valuable raw material resources, especially for construction purposes, and extraction of marine sediments is therefore an important receptor due to the economic interest of several countries around the Baltic Sea.
Dumping sites are established marine sites where excess material (sediments) from e.g. maintenance of water depth in harbours or ship channels, can be dumped.

9.28.1 Baseline

The extraction of marine sediments is limited by the fact that the variety of suitable dredging equipment decreases with increasing water depth. Furthermore, the costs of extraction and transportation increase with distance from the coast. Therefore, most exploitation of sediments occurs at water depths of less than 20 m.

The planned route has been optimised so the pipeline does not cross any active areas for raw material extraction within Danish waters and crossing of potential areas has been minimised to the extent possible, see Figure 9-90 and Table 9-136.

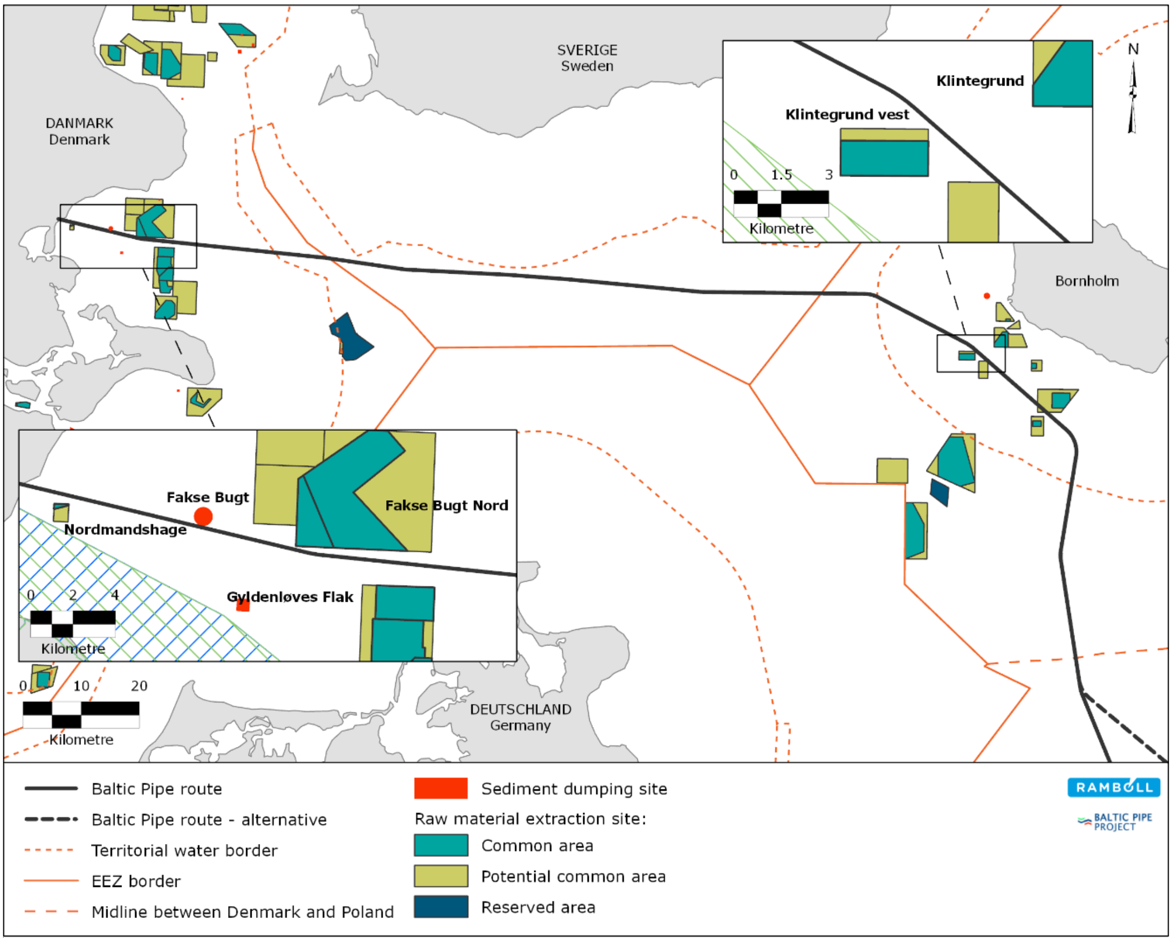

Figure 9-90 Sites designated for raw material extraction and sites reserved for potential future extraction of raw materials in the southwestern Baltic Sea.

There are four types of extraction areas in the Danish waters in the Baltic Sea:

- Common areas (sites for raw material extraction where multiple permit holders may extract the amount of raw material defined in their permit);
- Potential common areas (previous extraction sites that may be used again in the future);
- Reserved areas (areas reserved for specific large development projects or coastal protection projects that require significant amounts of extraction of raw materials);
- Auction areas (areas where exclusive rights to extraction are allocated based on an auction).

There are seven common areas currently used for sand extraction in Faxe Bugt (see Figure 9-90). Within Danish territorial waters southwest of Bornholm, there are an additional six common areas (see Figure 9-90). Further south, within the Danish EEZ, one site is reserved for future raw material extraction by a developer and an additional two common areas are currently operational. In addition to this, there are a number of potential common areas in the southwestern part of the Baltic Sea (see Figure 9-90 and Table 9-136).

Table 9-135 shows the distance between the planned pipeline and these raw material extraction sites.

Table 9-135 Distance from planned pipeline to existing raw material extraction sites. Potential common areas within 1 km is presented in the table.

Area name	Area ID	Type of area	Distance from pipeline [km]
Fakse Bugt Nord	520-AA	Common area	0.2
Nordmandshage	520-DA	Common area	0.4
Gyldenløves Flak	520-EA	Common area	1.0
Gyldenløves Flak Vest	520-EF	Common area	2.6
Gyldenløves Flak	520-EB	Common area	4.3
Gyldenløves Flak Vest	520-EG	Common area	6.7
Rønne	526-CA	Common area	7.1
Klintegrund	526-DA	Common area	2.5
Klintegrund Vest	526-HA	Common area	0.4
Bakkegrund Nord	526-EA	Common area	3.9
Bakkegrund Syd	526-IA	Common area	1.1
Rønne Banke Øst	526-JA	Common area	1.6
Rønne Banke Syd	564-BA	Common area	12.6
Adler Grund Øst	264-AA	Common area	23.5
Rønne Banke	-	Reserved	20.5
Krieger's Flak	-	Reserved	8.7
Nordmandshage	520-D	Potential common area	0.5
Fakse Bugt Nord	A3-16A	Potential common area	0.7
Fakse Bugt Nord	520-A	Potential common area	0.6
Klintegrund Vest	526-H	Potential common area	0.2
Klintegrund Syd	526-G	Potential common area	0.01
Bakkegrund Syd	526-I	Potential common area	0
Rønne Banke Øst	526-J	Potential common area	0.9

Within the project area there are three dumping sites (Figure 9-90):

- K_046_03 - 8.2 Faxeladeplads (0.12 km from pipeline);
- K_046_01- Sandhage Rende (2.8 km from pipeline); and
- K_058_01 - Rønne (8.2 km from pipeline).

Only K_046_03 - 8.2 Faxeladeplads can potentially be impacted by the project, due to the distance to the construction and pipeline. According to the Danish Environmental Protection Agency webpage, one permit for dumping material has been given. The permit runs from December 2017 to December 2022 with a license to dump 100,000 m^3 material (20,000 m^3 per year).

The cumulative impacts from the project activities and dumping activites are assessed in Chapter 11.1.

9.28.2 Impact assessment

The Baltic Pipe pipeline may interfere with the daily activities within raw material extraction sites and one dumping site in Danish waters during both construction and operation. See Table 9-136 for an overview of the potential impacts.

Table 9-136 Potential impacts on raw material extraction sites.

Potential impact	Construction	Operation
Safety zones	X	
Presence of pipeline		X
Restriction zone (around the pipeline)		X

The following sources of impacts have been screened out:

- **Safety zones (operation):** The safety zones around vessels carrying out planned inspections and maintenance activities during the operational phase will have a radius of 500 m. The safety zones will only cross the boundary of the extraction site Faxe Bugt Nord for 1-2 days per year and the impact will therefore be negligible.
- **Physical disturbance above water (construction):** The only potential impact from physical disturbance above water is increased ship traffic. However, no significant increase in ship traffic near the extraction sites is expected during construction, and as a result, the impact can be screened out.
- **Physical disturbance of seabed (construction):** The impact from physical disturbance of the seabed on raw material extraction sites are assessed as negligible as the seabed used for extraction are already highly influenced by the extraction activities and the temporary and very local disturbance will not change the value of the resource.

Safety zones

The establishment of temporary safety zones around the pipe-lay vessels, and safety zones of other vessels of limited manoeuvrability (e.g. ploughing vessel and rock installation vessel), is a source of potential impact during construction of the planned pipeline. It is expected that the safety zone around the anchor lay barge will extend 1,000 - 1,500 m in radius around the vessel, while the safety zone around the DP pipe-lay vessel will be approximately 1,000 m in radius. For all other vessels with restricted manoeuvrability, a safety zone with a radius of 500 m will be implemented. No non-project related vessels will be permitted to enter the safety zones. The presence of vessels with safety zones will interfere temporarily with the extraction activities in their vicinity. However, as the construction activities can be coordinated with the extraction permit holders to avoid overlapping activity periods, the sensitivity of raw material extraction sites to this type of impact is assessed to be low.

Due to the extent of the safety zone of the pipe-lay vessels, the extraction areas Faxe Bugt Nord, Nordmandshage and Gyldenløves Flak will be affected during the construction of the pipeline. Faxe Bugt Nord, Normandshage and Gyldenløves Flak will be affected during the construction of 9 km, 3.5 km and 6 km stretches of the pipeline, respectively. Due to shallow water conditions, a smaller pipe-lay vessel, which is expected to move at a rate of approximately 0.5 km per day, will be used during the construction. Faxe Bugt Nord, Nordmandshage and Gyldenløves Flak will, therefore, be affected for approximately 18 days, 7 days and 12 days, respectively, depending on weather conditions. Approximately 29% of the area of Faxe Bugt Nord and Gyldenløves Flak will be affected during the construction phase, whereas 100% of Nordmandshage will be impacted.

Similarly, parts of the extraction sites Klintegrund Vest and Bakkegrund Syd off the coast of Bornholm are located within 1,500 m of the planned route. During construction, 34% of Klintegrund Vest and 2% of Bakkegrund Syd will be affected for approximately 4 days each, as also here the smaller and slower pipe-lay vessel will be used. Three potential common areas will also be impacted, but as these areas are not in use to date, there will not be a conflict during the construction period, hence there will be no impact.

The impact is assessed to be of medium intensity, but local and immediate. Combined with the low sensitivity, the overall impact is assessed to be of minor severity and not significant, Table 9-137.

Table 9-137 Impact significance on raw material extraction sites from the imposition of safety zones during construction.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Safety zone	Low	Medium	Local	Immediate	Minor	Not significant

Presence of pipeline
Presence of the pipeline itself (without restriction zone) will impact a *potential common area*, Bakkegrund Syd (526-I) as a 2 km stretch of the pipeline crosses the area in the southwestern corner of the area. As the presence of the pipeline will hinder future extraction in this area, the impact will be long-term. The lost area will include the restriction zone around the pipeline and the total impact of the presence of the pipeline and the restriction zone in Bakkegrund Syd is assessed below.

Restriction zone
A permanent 200-metre wide restriction zone is expected to be established around the pipeline to safeguard it against physical damage during the operational phase.

Approximately 2,600 m^2 of the raw material extraction site Fakse Bugt Nord overlaps with this restriction zone. Within this site, extraction of raw materials will be required to cease. However, this area only accounts for 0.01% of the entire extraction site. No other existing raw material extraction sites are located within the permanent restriction zone and, therefore, the intensity is assessed to be minor. Although the impact of Fakse Bugt Nord will be long-term, it will also be local, and the severity of the impact is therefore minor and not significant, Table 9-138.

In addition, two potential common areas will be impacted by the restriction zone: Klintegrund Syd (526-G) and Bakkegrund Syd (526-I), which will be crossed by the restriction zone. Bakkegrund Syd will, as mentioned previously, be crossed by the pipeline, which is not the case for Klintegrund Syd.

An area of approximately 37,000 m^2 at Klintegrund Syd northeastern corner overlaps with the restriction zone and within this area, the sand and gravel will no longer be available as a potential resource for future extractions. The impacted area corresponds to approximately 0.8% of the total area.

The impact on the potential common area Bakkegrund will be larger, as the pipeline crosses the site. The direct impact from the pipeline and the restriction zone on this site will be approximately 820,000 m^2, which corresponds to 3.8% of the total area. As the pipeline divides the area in two (Figure 9-90), the most southwestern corner might be lost as an extraction site for future extractions in the lifetime of the pipeline. The total area of the direct impact and the corner of the site which most likely also will be lost, adds up to 1,460,000 m^2 (1.46 km^2) and corresponds to 6.7% of the site.

The intensity on these sites are medium, as the resource will not be destroyed and can be used again after removal of the pipeline. Impact is long-term and local. Overall, as the main impacts will be on sites which are potential sites for furture extractions and not exsisting sites; the severity of impact on raw material extraction sites is assessed as minor and not significant for the raw material resources in Denmark.

The restriction zone around the pipeline will have impact on the dumping site in Faxe Bugt. Approximately 32,000 m^2 (6.5%) will be impacted. Within this area, dumping can be restricted. However, late route adjustments in Faxe Bugt due to seabed conditions have shown that the route will be adjusted to a more southern position (within the survey corridor), hence leading to placing the pipeline more than 300 m from the dumping site. Impacts due to the restriction zone is hence no longer present.

Table 9-138 Impact significance on raw material extraction sites from the imposition of a restriction zone during operation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Restriction zone	Medium	Minor-medium	Local	Long-term	Minor	Not significant

9.28.3 Conclusion

The potential impacts on raw material extraction sites resulting from construction and operational activities in relation to the planned pipeline within Danish waters are summarized in Table 9-139.

Table 9-139 Overall impact significance for raw material extraction.

Potential impact	Severity of impact	Significance	Transboundary
Safety zone	Minor	Not significant	No
Restriction zone	Minor	Not significant	No

9.29 Military practice areas

Military practice areas are an important receptor to assess due to their role in national security and international training, as the Baltic Sea is a strategic area where various types of military practice areas are maintained.

9.29.1 Baseline

There are a number of military practice areas within the Danish territorial waters and EEZ along and in the vicinity of the planned routes (see Figure 9-91). Temporary practice areas are not included on the map.

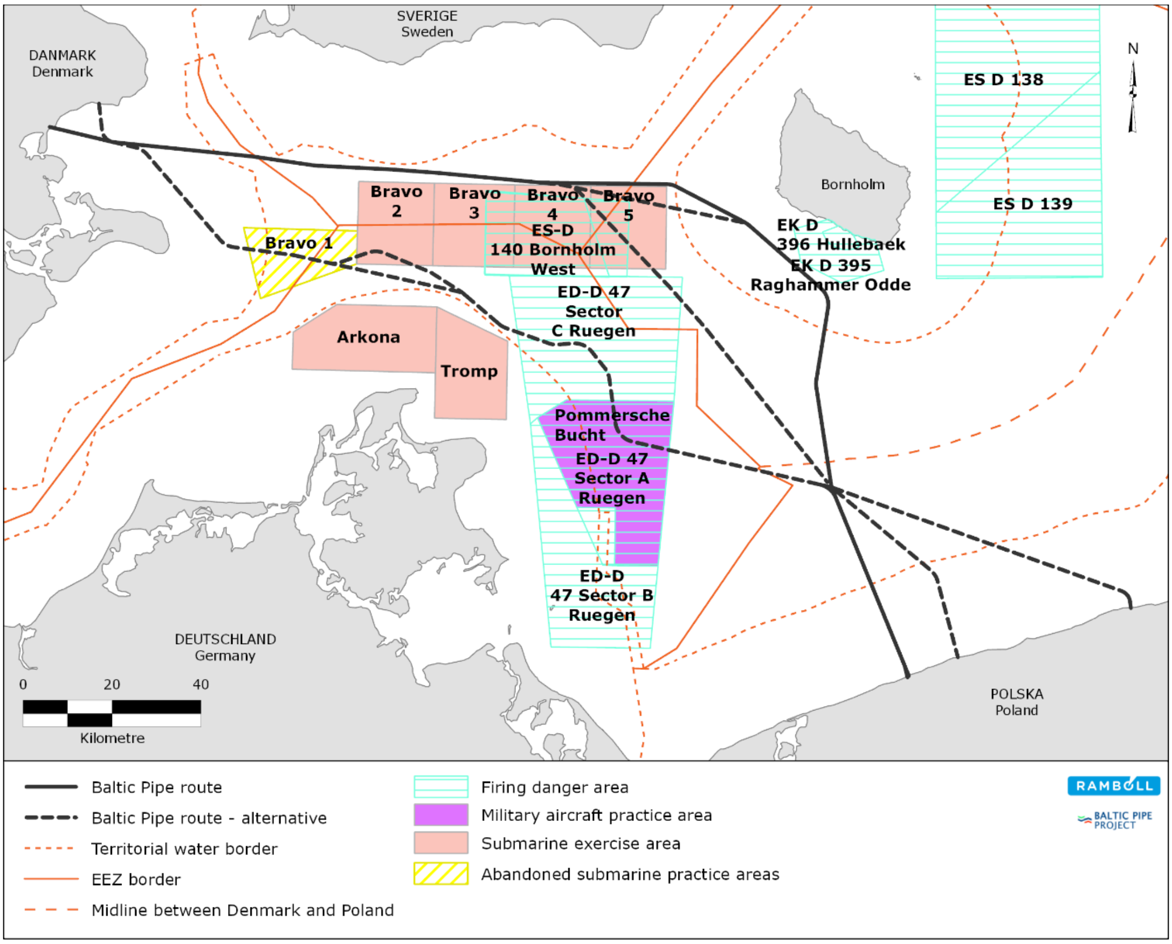

Figure 9-91 Military practice areas in the southern Baltic Sea.

The submarine exercise areas Bravo 2 through Bravo 5 are located along the EEZ borders shared by Germany, Sweden and Denmark (see Figure 9-91). The planned route passes north and east of Bravo 5 within the Danish EEZ west of Bornholm. This submarine exercise area is under the coordination of the German Navy (Submarine Exercise Area Coordinator) and is used for NATO training and exercise patrols. Bravo 1 is no longer in use as military training area.

Furthermore, within Danish territorial waters, the firing danger area "EK D 395 Raghammer Odde" is located directly to the southwest of Bornholm, and inside this is located the military area "EK D 396 Hullebaek". These firing areas are actively used by the Danish Armed Forces and the Danish Home Guard for live fire practice from Bornholm. These activities are highly active and can be in use 24 hours a day.

9.29.2 Impact assessment

The construction of the Baltic Pipe pipeline may interfere with the daily activities in military practice areas within Danish waters. No impacts are anticipated during the operational phase. See Table 9-140 for an overview of the potential impacts.

Table 9-140 Potential impacts on military practice areas.

Potential impact	Construction	Operation
Safety zones	X	

The following sources of impacts have been screened out:

- **Physical disturbance above water (construction):** Increased ship traffic caused by project-related vessels not requiring safety zones can be screened out, as the military practice areas are located within and along high-intensity shipping lanes. Therefore, an increase in traffic of ships sailing at normal speed and obeying same navigation regulations as commercial ships will be negligible.
- **Restriction zone (operation):** A permanent restriction zone of 200 m on either side of the pipeline will be established in the operational phase. Since the pipeline is located 550 m from the nearest military practice area, no impact is expected.
- **Safety zones (operation):** The safety zone around vessels carrying out planned inspections and maintenance activities during the operational phase have a radius of only 500 m. This safety zone will therefore not overlap with any military practice areas and no impact will occur.
- **Presence of pipeline (operation):** Since the pipeline does not pass within any military practice areas, no impact is expected.

Safety zones
The establishment of temporary safety zones around the pipe-lay vessels, and safety zones of other vessels of limited manoeuvrability (e.g. ploughing vessel and rock installation vessel), is a source of potential impact for the military practice area Bravo 5 during construction of the planned pipeline. It is expected that the safety zone around the anchor lay barge will extend 1,000 - 1,500 m in radius around the vessel, while the safety zone around the DP pipe-lay vessel will be approximately 1,000 m in radius. For all other vessels with restricted manoeuvrability, a safety with a radius of 500 m will be implemented. No non-project related vessels will be permitted to enter the safety zones. Since the pipeline will run only 550 m from the northern border of Bravo 5 for a distance of 8 km, some temporary impact from the safety zones can be expected. The pipeline route runs approximately 1.4 km away from one of the corners of the firing danger area “EK D 395 Raghammer Odde”, and a 1,500 m safety zone would therefore overlap with this corner of the military area, potentially causing an impact.

The sensitivity of military practice areas to this type of impact is judged to be medium, as the presence of vessels will suspend all military activities in their vicinity and these areas are of high importance to the military as international training areas. However, the pipe-lay vessels are expected to move at a rate of approximately 3 km a day for the 8 km stretch where the route is located adjacent to the northern border of Bravo 5, and the pipe-lay activities will therefore be completed within 3-4 days, depending on weather conditions. Restrictions in the use of the submarine exercise areas will therefore be limited to these 3-4 days. If a safety zone of 1,500 m is required for the construction vessel, then the firing danger area “EK D 395 Raghammer Odde” will be affected for a distance of 300 m along the pipeline route, and the impact will be restricted to a few hours. The planned activities will be coordinated and communicated with the relevant authorities to ensure minimum disruption of military practice activities.

As a result, the impact is assessed to be of medium intensity but local and immediate. Combined with the medium sensitivity, the overall impact is assessed to be of minor severity and not significant (Table 9-141).

Table 9-141 Impact significance on military practice areas from safety zones during construction.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Safety zones	Medium	Medium	Local	Immediate	Minor	Not significant

9.29.3 Conclusion

The potential impacts on military practice areas resulting from construction of the planned pipeline within Danish waters are summarized in Table 9-142.

Table 9-142 Overall impact significance for military practice areas.

Potential impact	Severity of impact	Significance	Transboundary
Safety zones	Minor	Not significant	No

9.30 Environmental monitoring stations

9.30.1 Baseline

Long-term national and international environmental monitoring stations within the Baltic Sea are managed by several countries as well as under the Baltic Marine Environment Protection Commission (also known as the Helsinki Commission or HELCOM). Various parameters are measured at different stations, including physical and chemical properties, phytoplankton and primary production, zooplankton, benthic fauna, and microbiology. Each station records a sequence of data from a fixed position, which can provide valuable information on trends over time. The Danish national monitoring programme is managed under the NOVANA programme (Miljøstyrelsen, 2019).

There are seven monitoring stations within Faxe Bugt, three stations out from the coast near Rødvig and six stations within Danish waters off the coast of Bornholm (see Figure 9-92). In addition, a number of near-coastal NOVANA stations at Bornholm are present, but impacts on these stations are not likely to occur, hence not presented further. Likewise Præstø Fjord is located outside of the potential areal extent of sediment dispersion (Section 5.1.2) and hence outside the zone of potential impact, Præstø Fjord is not included in this review. Table 9-143 provides an overview of the characteristics of each environmental monitoring station in the project area.

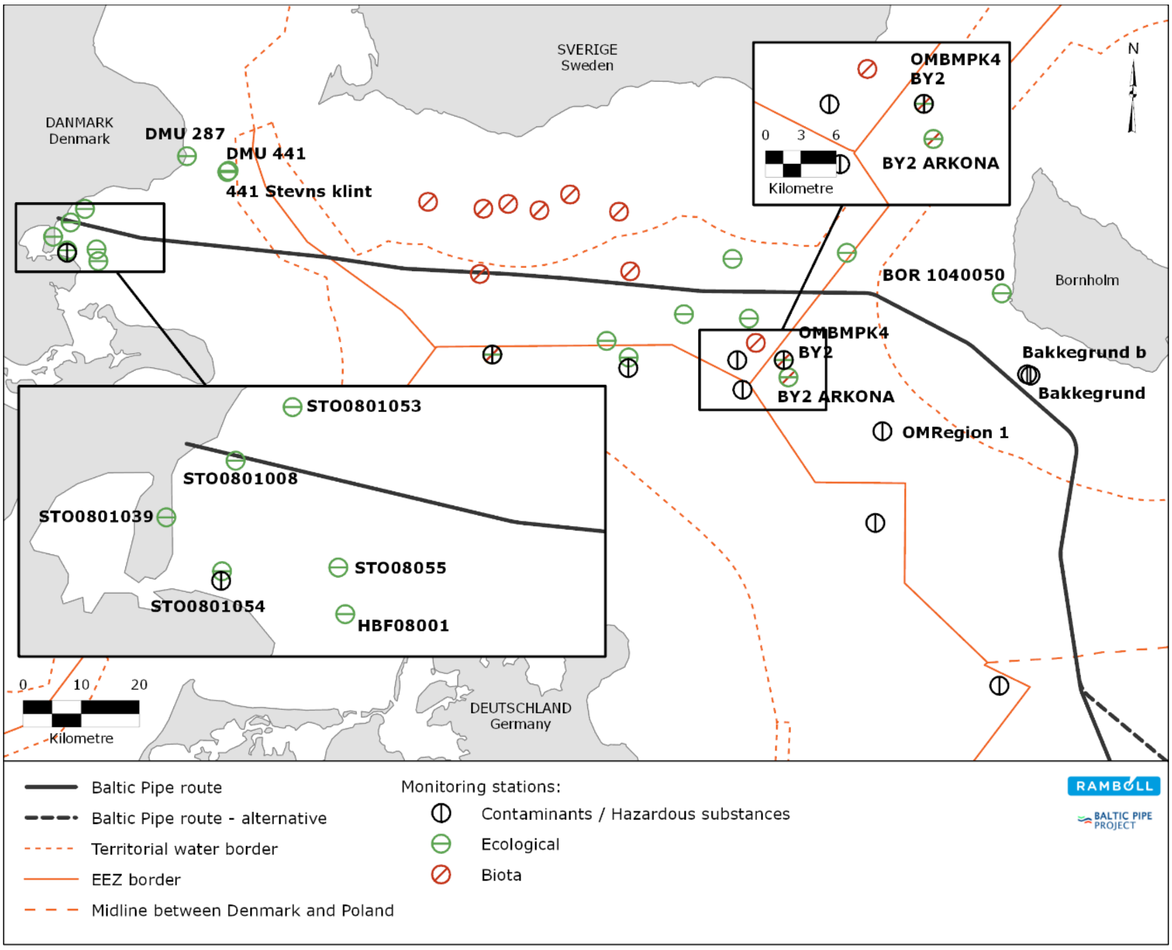

Figure 9-92 Environmental monitoring stations within the Arkona Basin (ICES, 2018b; Miljøstyrelsen, 2019).

Table 9-143 Environmental monitoring stations within Danish waters (ICES, 2018b; Miljøstyrelsen, 2019).

Name of environmental monitoring station	Type of station	Distance from proposed route [km]	Sampling water depth [m]	Administrator
Faxe Bugt				
STO0801008	NOVANA station Ecological (water chemistry, profile measurements)			Danish Environmental Agency
STO0801039	NOVANA station Ecological (macrophytes)			Danish Environmental Agency
STO0801053	NOVANA station Ecological (macrophytes)			Danish Environmental Agency
STO0801054	Contaminants / hazardous substances	5	0	Aarhus University, Department of Bioscience, Marine Ecology Roskilde

Name of environmental monitoring station	Type of station	Distance from proposed route [km]	Sampling water depth [m]	Administrator
STO0801054	Ecological (macrophytes)			Danish Environmental Agency
STO0801055	NOVANA station Ecological (macrophytes)			Danish Environmental Agency
HBF0801001	NOVANA station Ecological (habitat nature)			Danish Environmental Agency
Off the coast of Rødvig				
441 Stevns Klint	Ecological	13	26	Swedish Meteorological and Hydrological Institute (SMHI)
DMU 441	Ecological (water chemistry, profile measurements)	12	26	Aarhus University, Department of Bioscience, Marine Ecology Roskilde
DMU 287	Ecological (habitat nature)			Danish Environmental Agency
Off the coast of Bornholm				
BY2 / OMBMPK4	Ecological, biota	10	48/ 0	Finnish Environment Institute (SYKE) / Leibniz Institute for Baltic Sea Research Warnemünde
BY2 Arkona	Ecological, biota	12	Entire water column	Swedish Meteorological and Hydrological Institute (SMHI)
BOR1040050	Ecological	10.5	20	Aarhus University, Department of Bioscience, Marine Ecology Roskilde
OMRegion1	Contaminants / hazardous substances	18	Entire water column	Thünen-institute of Fisheries
Bakkegrund B	Contaminants / hazardous substances	2.6	8	Aarhus University, Department of Bioscience, Marine Ecology Roskilde
Bakkegrund	Contaminants / hazardous substances	2.8	6	Aarhus University, Department of Bioscience, Marine Ecology Roskilde

9.30.2 Impact assessment

The construction of the Baltic Pipe pipeline may interfere with the data collection from environmental monitoring stations within Danish waters. See Table 9-144 for an overview of the potential impacts.

Table 9-144 Potential impacts on environmental monitoring stations.

Potential impact	Construction	Operation
Suspended sediments	X	

The following sources of impact have been screened out:

- **Safety zones (construction, operation)**. The impact from safety zones around project-related vessels during construction and operation can be screened out as these safety zones are smaller than the shortest distance to a monitoring station. These will therefore not impose temporary restrictions on planned measurement/sampling programme activities at monitoring stations in Danish waters.

Suspended sediments

Environmental monitoring stations are of high importance, as they provide an important service at the national and international levels. The sensitivity of environmental monitoring stations to the release of sediments to the water column is high because an increase in SSC has the potential to affect the data collected at the stations.

The proposed construction activities (including pipe-lay, anchor-handling, post-lay trenching, and rock installation) may result in increased suspension and spreading of sediment and the release of contaminants and/or nutrients to the water column. This may affect the data collection from environmental monitoring stations located close to the proposed activities. As previously described (see Section 5.1.2) modelling results show that offshore there will be no risk of increased SSC close to the monitoring stations, hence there will be no impact on monitoring stations offshore in Danish waters, Table 9-145. Nearshore in Faxe Bugt, SSC can impact monitoringstations, located stations within the bay (macrophytes, profile measurements and water chemistry). The impact will be short-term, with high intensity for profile and water chemistry measurements and low for macrophytes. Scale will be local. Planning is crucial to prevent significant impact on monitoring. Therefore, the project will inform the Danish Environmental Protection Agency when project acitivites will take place in Faxe Bugt, to prevent that monitoring occurs simultaneously with construction works (dredging/trenching). When simultaneous monitoring and construction works are prevented, impacts will not be signficiant.

Table 9-145 Impact significance on environmental monitoring stations from suspended sediments.

Suspended sediments	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Nearshore	High	Low-high	Local	Short-term	Minor	Not significant
Offshore	High	None	None	None	None	Not significant

9.30.3 Conclusion

The potential impacts on environmental monitoring stations resulting from construction of the proposed pipeline within Danish waters are summarized in Table 9-146.

Table 9-146 Overall impact significance for environmental monitoring stations.

Potential impact	Severity of impact	Significance	Transboundary
Suspended sediments	None	Not significant	No

SOCIO-ECONOMIC ENVIRONMENT - ONSHORE

9.31 Archaeology and cultural heritage

Cultural heritage in Denmark is protected by the Museum Act[68] and the Nature Protection Act[69]. In the following, cultural heritage at the landfall area is mapped and it is subsequently assessed how onshore cultural heritage will be affected by the planned pipeline.

9.31.1 Baseline

Cultural heritage located close to the landfall area at Faxe Ladeplads is shown in Figure 9-93.

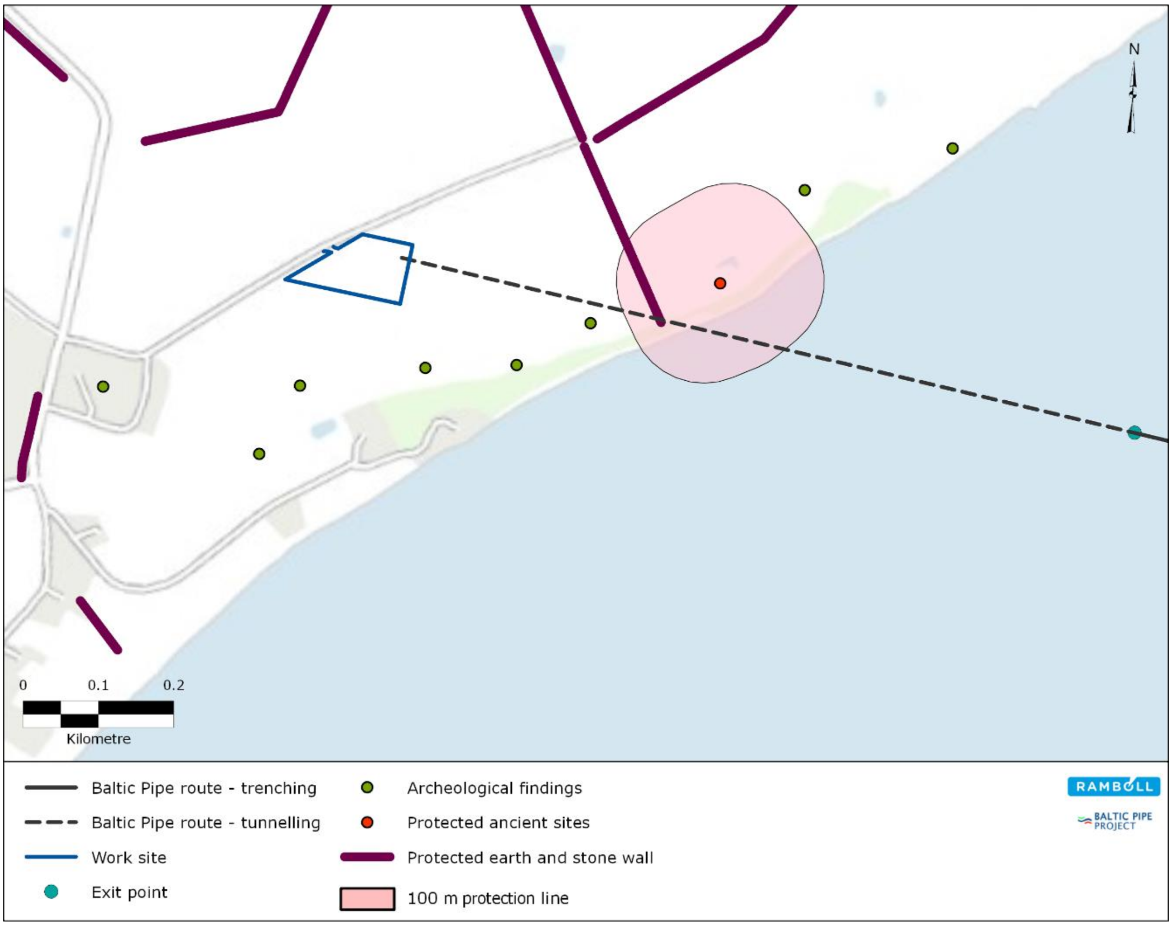

Figure 9-93 Cultural heritage at landfall, Faxe Bugt.

A cultural heritage site (conservation no. 392725) is located near the coastline/cliff (The Danish Natural Environment Portal, 2018). According to the Museum Act section 29(e), the state of cultural heritage sites cannot be changed. A protection line of 100 m is established around each site, according to the Nature Protection Act section 18.

The cultural heritage site at the landfall area is called "Skansen" and is a historical redoubt. Skansen dates from 1067 AD (Danish Agency for Culture and Palaces, 2018) and was expanded in 1808 (Danish Society for Nature Conservation, 2018). Skansen was newly renovated.

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[68] Consolidated Act on Museums, LBK no. 358 of 08/04/2014 *(bekendtgørelse af museumsloven)*.

[69] Consolidated Act on Nature Protection, LBK no. 1122 of 03/09/2018 *(bekendtgørelse af lov om naturbeskyttelse)*.

Furthermore, a stone/earth wall protected according to Museum Act section 29(a) is located close to the landfall area. More protected stone/earth walls are present in the area, but not near the landfall area.

Additionally, several non-protected archaeological sites are registered close to the landfall area (Danish Agency for Culture and Palaces, 2018). Although the sites are not themselves protected, all in all, they give an indication of the probability of finding other possible archaeological objects in the area.

According to the Faxe Municipal Plan, there are no designated cultural heritage environments at the landfall area (Faxe Municipality, 2013b).

9.31.2 Impact assessment

The work site for the onshore construction activities is located approximately 400 m from the cultural heritage site, Skansen, and approximately 300 m from the protection line. The nearest stone/earth wall is approximately 250 m away.

As such, there will not be any construction activities at Skansen, within the 100 m protection line of the cultural heritage site or close to the protected stone/soil walls. As the construction activities will however take place close to the non-protected archaeological sites, archaeological objects in the nearby area may be found.

The responsible museum (Museum of Southern Denmark) has been contacted according to the Museum Act § 25, for the museum to give a statement about the risk of finding archaeological objects during construction of the project. The museum states that there is a risk of finding archaeological objects at the landfall and recommends a preliminary study to be executed by the museum before the construction works begin (Museum of Southern Denmark, 2018).

The preliminary study will be performed by the museum, as recommended, before the construction activities begin, and potential archaeological objects will be identified. Furthermore, the Museum Act § 27 applies at all times, which means that construction activities should be stopped if archaeological objects appear during construction.

Due to the aforementioned regulation regarding the handling of objects of archaeological interest and cultural heritage, it is unlikely that there will be significant impacts on archaeology and cultural heritage, and this will not be dealt with further.

9.32 Population and human health

Population and human health is considered as an important receptor and will only be described onshore, as most human receptors stay on land. Human receptors offshore include fishermen and recreational users of the sea, which are assessed in Sections 9.25 (commercial fisheries) and 9.33 (tourism and recreational areas), respectively. The potential impact on population and human health, however, can arise from both onshore and offshore activities of the project.

9.32.1 Baseline

The closest human receptors to the project are a few summerhouses/dwellings approximately 200 m south of the work site. Strandegård, a country estate owning most of the land in the area, is located west of the work site. Other houses (a mix of summerhouses and dwellings) are located southwest of the landfall area, and approximately 700 m south of the landfall area is a big camping site at “Feddet” (see Section 9.33 for further description). The town Faxe Ladeplads is located 3-4 km north of the landfall area. The existing land use of the landfall area is agricultural.

Faxe Municipality has a population of approximately 35,000 (Faxe Municipality, 2015) and Faxe Ladeplads has a population of approximately 3,000.

The health statistics of people in Faxe Municipality is based on the Health Profile 2017 of Region Sjælland (Blaakilde *et al.*, 2018) and on information from Statistics Denmark (Statistics Denmark, 2017). Statistics are only available for Faxe Municipality as a whole and are not available for Faxe Ladeplads separately.

The average life expectancy of people in Faxe Municipality is 79.8 years, which is slightly lower compared to the average in Denmark (80.6 years) (Statistics Denmark, 2017).

On average, the citizens in Faxe Municipality assess their health as good (82%), while 13.5% assess themselves as having bad physical and mental health, which is in line with the averages in Region Sjælland. For most parameters assessed in the 2017 health profile, citizens in Faxe Municipality do not significantly deviate from the average citizens in Region Sjælland. The share of citizens who are extremely overweight is 24%, which is 3 percentage points higher than the rest of the Region. Daily smokers comprise 19% of the citizens (Blaakilde *et al.*, 2018).

9.32.2 Impact assessment

The potential impacts on population and human health onshore are shown in Table 9-147.

Table 9-147 Potential impacts on population and human health.

Potential impact	Construction	Operation
Physical disturbance	X	
Airborne noise	X	
Emissions to air	X	

The following sources of impact have been screened out:

- **Land use (construction):** The construction works will require clearing of a work site of approximately 9,000 m^2 and a temporary access road (apart from crossing the fields, the location is not yet decided) from which the onshore construction activities will take place, resulting in a temporary land use change from agricultural land. The work site will be used for the project both during construction and pre-commissioning and the site will be occupied by the project for about 1½-2 years. The affected land owner will be compensated according to general regulations. After construction is finalized, the land will be restored and can return to agricultural use.
- **Employment generation (onshore, construction):** The onshore part of the construction activities mainly relates to tunnelling and pre-commissioning and will generate work for a limited number of personnel during approximately 13 months in total. As the tunnelling work is very specialised, it is expected that a contractor from outside the local area will be engaged. A local contractor might be engaged to prepare the temporary access road, the work site and launch shaft and to restore these areas after construction. This minor increased employment and turnover in the local area related to accommodation, food, etc. is foreseen to be marginal. It is expected that approximately 12 people will be working with the tunnelling activities.
- **Employment generation (offshore, construction):** It is expected that approximately 2,000 man-years will be needed as part of the offshore construction activities for the total project in Denmark, Sweden and Poland. The personnel working on the construction-related vessels are expected to be engaged by a contractor, and the personnel will mainly stay on the vessels and are therefore not expected to contribute economically to any noticeable

higher sales in the form of accommodation or food in the local area. Thus, no impact from employment generation in relation to the offshore construction activities on population and human health is foreseen.

- **Emissions to air (offshore, construction and operation):** The emissions to air described in Section 9.4 from constructing the offshore part of the project and from survey and maintenance during operation will mainly occur far from the coast and under great dispersion conditions. No impact on population and human health is expected during either construction or operation.

Physical disturbance

During construction of the Baltic Pipe project, tunnelling and pre-commissioning will take place at the landfall area, causing physical disturbance for the neighbouring surroundings. The physical disturbance includes visual disturbance and disturbance from traffic to/from the work site. The onshore part of the construction activities related to tunnelling will take approximately 11 months and pre-commissioning will take approximately two months. However, the work site will be occupied for 1½-2 years. The nearshore activities related to tunnelling and nearshore pipe-lay (up to 2 km off the coast) will take up to 16 weeks in total, divided into four phases. There will, however, be breaks between the different phases of the construction works.

<u>Visual disturbance</u>

The neighbours of the landfall area, mainly the residents of Strandegård but also other neighbours living south of the area, will be able to see the work site, construction machines, trucks and other equipment, as the landfall area is an open field with no barriers. Lights at the work site will be arranged to minimise the impact on the surroundings and the work site will be fenced. The visual presence of the vessels undertaking nearshore and offshore activities will be noticeable for people living close to the shore.

The sensitivity of the receptor to this type of impact is assessed as medium. The impact magnitude caused by the visual disturbance is assessed to be of medium intensity with a local scale and short-term duration. All combined, the severity of the impact is assessed to be minor and thus not significant.

<u>Traffic to/from the work site</u>

There will be traffic to/from the work site with equipment, materials, soil and personnel. Most of the traffic will enter and exit the work site from the motorway exit at Rønnede (motorway exit no. 37). Approximately 1,180 trucks will be needed for transport of materials and soil to and from the work site as a part of the tunnelling activities. On average, the daily number of trucks to the work site are expected to be approximately 6 (resulting in 12 transports in total). Most of the trucks will be needed for transport of excavated soil from the tunnel away from the site. During the most intensive period, where both soil from tunnelling will be transported away from the work site and pre-fabricated tunnel elements will be transported to the site, approximately 18 trucks will be needed per day for three weeks and 15 trucks will be needed per day for another six weeks, resulting in a total of approximately 36 and 30 transports each day, respectively. Additionally, personnel travelling to and from the work site will also generate traffic throughout the construction period.

All users and neighbours of the route to be used by construction-related traffic will be affected by the extra amount of traffic, which includes heavy traffic from trucks. The work site is located in a partly secluded area with only minor roads and the existing amount of traffic is considered low. Thus, especially residents at Strandegård, Feddet and neighbours of these minor roads will be affected by the trucks driving to and from the work site. It is recommended that the construction-related traffic be assigned routes to use, appointed by the local authorities and police to minimise the impact for neighbours and users of the roads.

It is assessed that the sensitivity of population and human health to this impact is high, especially due to the low existing amount of traffic and the minor size of the roads, Table 9-148. The intensity of the impact is medium on average, but large in the most intensive periods, with a local scale and short-term duration. Combined, the severity of impact is assessed to be moderate but not significant during the most intensive periods, and minor on average.

Table 9-148 Impact significance on population and human health from physical disturbance.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance (visual disturbance)	Medium	Medium	Local	Short-term	Minor	Not significant
Physical disturbance (traffic to/from site)	High	Medium to large	Local	Short-term	Minor to moderate	Not significant

Airborne noise

Noise from the onshore activities at the landfall relates to the construction activities from the work site and the extra amount of traffic.

<u>Noise from the work site</u>

Noise calculations have been made for the noisiest activities within the five construction phases (see further description in Sections 5.3.3 and 9.9).

As there are no official limit values for noise from construction work in Denmark, it is customary practice to assess noise from construction work in relation to the following two noise levels:

- 70 dB(A): The guiding limit value used for construction works within regular working hours; and
- 40 dB(A): The guiding limit value used for construction works outside regular working hours.

See Section 9.9.1 for a specification of regular working hours. These guiding limit values have been applied for assessing the impact on population and human health from noise arising from the project.

There are documented correlations between noise and several health conditions, including cardiovascular disease, cognitive impairment in children, sleep disturbance and general annoyance. However, these conditions mainly relate to continuous noise, such as traffic noise (WHO, 2011). Based in this, the sensitivity of population and human health to construction noise is high for activities outside regular working hours and medium for activities during regular working hours.

The intensity of the impact varies for the five phases; it is considered large during sheet piling (phase 2), medium during tunnelling (phase 3) and pre-commissioning (phase 4) and minor during clearing and subsequently restoring the work site (phases 1 and 5). The scale is local for most activities during the different phases of construction, except phase 2 (sheet piling), which is regional.

The duration is immediate for phases 1, 2 and 5 and short-term for phases 3 and 4.

All combined, the severity of the impact is assessed as negligible to moderate, with a moderate and significant impact when the guiding limit value is exceeded outside regular working hours during phases 3 and 4. However, the number of dwellings or summer houses affected above 40 dB(A) is very limited and the duration of the impact is short-term. The severity of the impact for phases 1 and 5 are considered negligible, and the impact for phase 2, sheet piling, is considered minor, as the duration is immediate and the applied guiding limit values are complied with.

The assessments for airborne noise from construction are summarised in Table 9-149.

Table 9-149 Impact significance on population and human health from airborne noise – before mitigation.

	Sensi-tivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise (construction phases 1 and 5)	Medium	Minor	Local	Immediate	Negligible	Not significant
Airborne noise (construction phase 2)	Medium	Large	Regional	Immediate	Minor	Not significant
Airborne noise (construction phase 3)	High	Medium	Local	Short-term	Moderate	Significant
Airborne noise (construction phase 4)	High	Medium	Local	Short-term	Moderate	Significant

Mitigation measures

The impact is considered significant for phases 3 and 4 as the applied guiding limit values are exceeded outside regular working hours. It is possible to reduce the noise impacts from construction activities through simple means, e.g. by stacking containers or straw bales around the work site, the use of sound insulation on the stationary machinery i.e. generators and pumps and/or the use of less noisy machinery, or a combination (for further description, see Section 9.9.3).

If mitigation measures are applied, reduction of the construction noise at the nearby dwellings is assessed to comply with the stricter guiding limit value of 40 dB(A) outside regular working hours for phases 3 and 4. This will result in a medium intensity of the impact for phases 3 and 4, and the severity of the impact is assessed to be minor, see Table 9-150.

Table 9-150 Impact significance on population and human health from airborne noise (only the phases 3 and 4) - after mitigation.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise (construction phase 3)	High	Medium	Local	Short-term	Minor	Not significant
Airborne noise (construction phase 4)	High	Medium	Local	Short-term	Minor	Not significant

Noise from traffic

Traffic to/from the work site (see the above impact assessment for physical disturbance (traffic to/from work site)) will also generate noise. When traveling on public roads, noise from trucks is considered as road traffic noise, which is governed according to other guidelines without requirements for limiting nuisance for the adjacent dwellings. The work site is located in a partly secluded area with only minor roads, and the average noise level from road traffic is considered to be relatively low. It can be expected that the residents along the local roads leading to the work site will experience an increase in the road traffic noise due to the increased number of trucks, also during periods of night-time work. However, most of the heavy traffic is expected to occur within regular working hours.

As a result, the sensitivity of population and human health to traffic noise is high for neighbours of the local roads being affected, while the intensity is considered medium over the whole construction period and large for the most intensive period, Table 9-151. Combined with the local to regional scale and short-term duration, the severity of the impact is assessed as moderate for the most intensive period but not significant, and minor on average.

Table 9-151 Impact significance on population and human health from airborne noise (traffic).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise (traffic)	High	Medium to large	Local to regional	Short-term	Minor to moderate	Not significant

Emissions to air

Emissions to air from the construction activities can have an impact on population and human health, as the air quality near dwellings can be affected. Sections 9.4 and 9.8 provide an overview and description of the assessed polluting components, where especially NO_X and PM can have negative impacts on human health by causing, *inter alia*, respiratory diseases, but high concentrations of SO_X can also have negative impacts on human health.

The impact on air quality during tunnelling, which is the most energy-consuming phase of the onshore construction activities, has been modelled. As described in Section 9.8, the air quality during tunnelling, including background levels, is under the limit values of the Air Quality Directive measured at the nearest dwelling (approximately 175 m from the work site). According to the modelling results, the amounts of polluting components in the air decrease with increasing distance from the work site.

As the dominating wind direction at Faxe Bugt is generally from the west /southwest (see Figure 9-32 in Section 9.8), the emissions from the construction activities are mainly dispersed away from dwellings and to the sea. Furthermore, the dispersion conditions at the landfall area, which is an open field, are good.

It is assessed that the sensitivity of population and human health to this impact is high. However, the intensity of the impact is low, as limit values are complied with at nearby dwellings. The impact has a local scale and is of a short-term duration. Combined, the overall impact is assessed to be minor and not significant, Table 9-152.

Table 9-152 Impact significance on population and human health from air emissions during construction.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Emissions to air	High	Low	Local	Short-term	Minor	Not significant

9.32.3 Conclusion

The potential impacts on population and human health from the onshore activities at the landfall are summarized in Table 9-153.

Table 9-153 Overall impact significance for population and human health after implemented mitigation measures (only for the airborne noise from construction phases 3 and 4).

	Severity of impact	Significance	Transboundary
Physical disturbance (visual disturbance)	Minor	Not significant	No
Physical disturbance (traffic to/from site)	Moderate	Not significant	No
Airborne noise (construction phases 1 and 5)	Negligible	Not significant	No
Airborne noise (construction phase 2)	Minor	Not significant	No
Airborne noise (construction phase 3)	Minor	Not significant	No
Airborne noise (construction phase 4)	Minor	Not significant	No
Airborne noise (traffic)	Minor to moderate	Not significant	No
Emissions to air	Minor	Not significant	No

9.33 Tourism and recreational areas

In the following, recreational interests and areas of interest in relation to tourism close to the landfall area at Faxe S and water-related recreational activities in the project area are described and the potential impacts from the project are assessed.

9.33.1 Baseline

Tourism accounts for 4.4% of the total employment in Region Sjælland, including derived effects (VisitDenmark, 2017), and together with recreational areas, is an important socio-economic receptor. In Faxe Municipality, the share of tourism compared to the total supply of products and services in the municipality accounts for 1.4%, which is a bit below the share of tourism in Region Sjælland (2%) (VisitDenmark, 2017).

Figure 9-94 gives an overview of the recreational interests and areas of interest in relation to tourism close to the landfall area. The following description is based on information from the tourism website of Faxe Municipality (Faxe Municipality, 2018) and the website of the local tourism organisation, VisitSydsjælland-Møn (VisitSydsjælland-Møn, 2018).

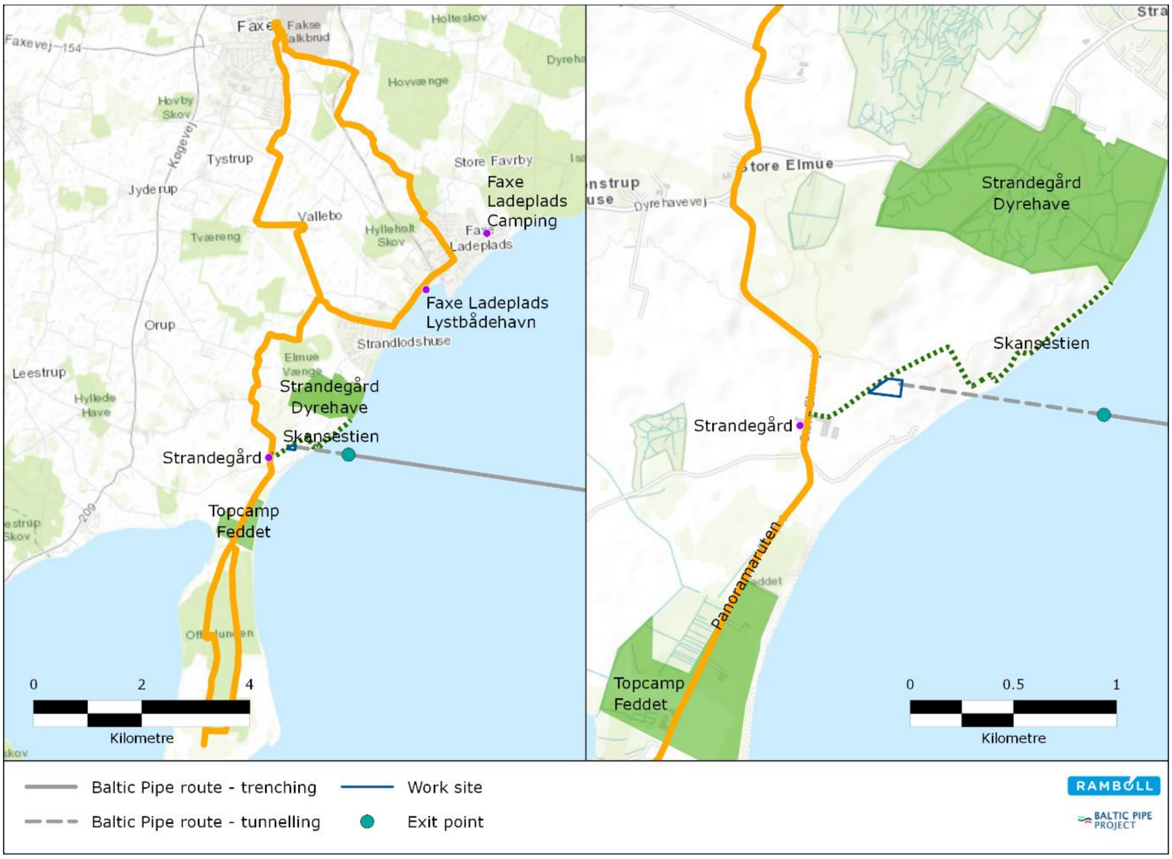

Figure 9-94 Overview of recreational interests and areas of interest in relation to tourism close to the landfall area at Faxe.

The landfall area is located between Præstø Fed (also called Feddet) and Strandegård Dyrehave. Feddet is a small peninsula with unique nature and several recreational activities. A large camping site is located at Feddet, and at the small harbour "Fed Havn" it is also possible to overnight in three shelters. The beach at Feddet is used for bathing and is especially popular among families with young children due to the shallow water. The area is furthermore used for water-based activities such as kitesurfing, kayaking and recreational fishing. Feddet is also popular to visit for birdwatchers because of its rich and variated bird life, especially in Præstø Bugt. A few summerhouses are located close to the cliff south of the landfall.

Strandegård Dyrehave north of the landfall is an old, preserved forest with old oaks and mounds located at the top of a cliff. The beach is rocky and used for recreational fishing.

From Strandegård Dyrehave, the footpath Skansestien follows along the cliff to Skansen, the cultural heritage site (see Section 9.31), which is located close to the landfall area. Furthermore, the landfall area is located close to the cliff with a rocky beach below from where recreational fishing is done; the beach is not suitable for bathing.

The small-town Faxe Ladeplads, located 3-4 km north of the landfall area, has a camping site and a marina. Faxe Ladeplads has a miniature town, which is a copy of Faxe Ladeplads as it was in the 1920s, in the proportion 1:10. Southwest of Faxe Ladeplads is "Strandlodderne", a part of the town with mixed residential houses and summerhouses (Faxe Municipality, 2013b).

The 36 km bicycle route "Fed, fjord og fossiler" (Spit, fjord, and fossils) is one of 26 Panorama routes in Denmark. The route covers Feddet and Faxe Ladeplads and is a loop off of the cycling route between Copenhagen and Berlin (the national cycling route no. 9 is also a part of this route).

An area between Faxe Ladeplads and the beginning of Feddet, which also includes the landfall area, is designated as a recreational area in the Faxe Municipal Plan (Faxe Municipality, 2013b). Furthermore, the landfall area is included in the plans for a new nature park (Naturpark Præstø Fjord).

As regards tourism offshore, the number of leisure boats in the Baltic Sea, especially in the Scandinavian region, has been increasing, a trend which is expected to continue in the coming the years (Baltic LINes, 2016). The leisure boats are mainly active in coastal areas, where recreational fishing from boats and recreational sailing takes place (Baltic LINes, 2016). In the Danish part of the project area, the recreational activities offshore mainly relate to Faxe Bugt and Faxe Ladeplads (north of the landfall), where a marina and a rowing club are located. Furthermore, there is a kitesurfing spot with shallow water about 5 km north of the landfall.

9.33.2 Impact assessment

The potential impacts from the planned project on tourism and recreational areas onshore are listed in Table 9-154.

Table 9-154 Potential impacts on tourism and recreational areas, onshore and offshore.

Potential impact	Construction	Operation
Physical disturbance	X	
Safety zones	X	X
Restriction zone		X
Airborne noise	X	

The following sources of impact have been screened out:

- **Suspended sediment (construction):** The construction activities offshore will generate suspended sediment in the surroundings, potentially having an impact on the water quality and recreational use of the sea, including bathing. Modelling results of suspended sediment during construction show that the amounts of suspended sediment nearshore close to the landfall are expected to be minimal and hardly noticeable (see Section 5.1.2 and 9.2). Thus, it is expected that suspended sediment from the project will have no impact on bathing, kitesurfing or other recreational activities offshore.
- **Physical disturbance above water (offshore, operation):** The potential impact from physical disturbance above water on those using the nearshore waters will take place both during construction and operation. However, the disturbance during operation, which will result from inspections and maintenance activities, will be of a lower magnitude than during construction, as these activities will be carried out along the pipeline with a very low frequency (i.e. 1-2 times per year in the first years, and once every 5 years thereafter). Thus, these minor operational activities are not expected to impact recreational interests offshore.

Physical disturbance

During construction of the Baltic Pipe project, tunnelling and pre-commissioning will take place at the landfall area, causing physical disturbance of the closest surroundings. The physical disturbance includes visual disturbance, both from the onshore and offshore activities as well as disturbance from traffic to/from site. The onshore work site is expected to be occupied by the project for about 1½-2 years.

The offshore construction activities related to tunnelling and nearshore pipe-lay (i.e. between 0.4 and 2 km off the coast) will take up to 16 weeks in total, divided in four phases. There will, however, be breaks between the different phases of the construction works.

Visual disturbance

The users of the summerhouses and the recreational areas Skansen and Skansestien will be directly affected by the visual disturbance from the fenced work site and by the construction and pre-commissioning activities as they take place, both onshore and offshore. However, it will still be possible to use these recreational areas during construction.

Furthermore, the users of the beaches and the nearshore waters of the Baltic Sea (including recreational fishing, kite surfing and bathing) as well as recreational boaters along the route in Danish waters will be able to see the offshore activities as they take place. However, these recreational activities can be sustained regardless of the visual disturbance from the project (keeping in mind the potential impact of the safety zones, see next paragraph).

It is possible to use the construction activities of the pipeline as a 'local event' and inform of the Baltic Pipe project by setting up an information stand at e.g. Feddet Camp Site and in Faxe Ladeplads. This will give the opportunity to inform the local population and visitors to Feddet of the different activities of the project.

It is assessed that the project does not conflict with the municipally designated recreational area nor the plans for a new nature park, as the construction period will be temporary and after construction, the landfall area can be used as before.

The sensitivity of the receptor to this impact is assessed as medium. The impact magnitude caused by visual disturbance during construction is assessed to be of medium intensity for the onshore recreational interests and minor for the offshore recreational interests, with a local scale and short-term duration. All combined, the severity of the impact is assessed to be moderate but not significant for onshore recreational interests and minor and not significant for offshore recreational interests.

Traffic to/from the site

There will be traffic to/from the work site containing equipment, materials and personnel. An access road from the work site to St. Elmuevej north of the site will be established, but its precise location is not yet clarified. Most of the traffic will enter or exit the work site from the motorway exit at Rønnede (motorway exit no. 37). As described in Chapter 5, approximately 1,180 trucks will be needed for the transport of materials and soil to and from the work site, which averages about 6 trucks (12 transports) per day. During the most intensive periods, however, where soil from the excavated tunnel will be transported from the work site and pre-fabricated tunnel elements will be delivered to the work site, there approximately 18 trucks will be needed per day for about three weeks, and 15 trucks will be needed per day for about six weeks, resulting in approximately 36 and 30 total transports each day, respectively. Additionally, personnel will be transported to/from the landfall.

A minor part of the cycling route "Fed, fjord og fossiler" (less than 1 km) overlaps with the route the construction traffic will be using. Many of the visitors to Feddet and the camping site will also use the same route as the trucks, as there are only two roads to Feddet. Along the route, signs warning about the construction activities will be posted. Furthermore, the access road is expected to cross Skansestien at some point. Access to Skansestien during construction should be maintained.

It is assessed that the sensitivity of the recreational activities and areas to this impact, especially for cyclists and users of Skansestien, is high, because of the small roads and existing low amount of traffic. The intensity of the impact is medium with a local scale and short-term duration. Thus, the overall impact is assessed to be moderate but not significant (Table 9-155).

Table 9-155 Impact significance on tourism and recreational areas from physical disturbance.

	Sensitivity	Magnitude of impact			Severity of impact	Signifi-cance
		Intensity	Scale	Duration		
Physical disturbance (visual disturbance), onshore	Medium	Medium	Local	Short-term	Moderate	Not significant
Physical disturbance (visual disturbance), offshore	Medium	Minor	Local	Short-term	Minor	Not significant
Physical disturbance (traffic to/from site)	High	Medium	Local	Short-term	Moderate	Not significant

Airborne noise

As described above, there are several recreational activities close to the landfall area, which is designated as a recreational area in the municipal plan. Airborne noise from the construction activities can influence how a recreational area is perceived, and a total sound level exceeding 50 dB is no longer perceived as pleasant by most individuals (Gidlöf-Gunnarsson *et al.*, 2008). There are no limit values for construction activities in recreational areas, and the following assessment is made based on the applied guiding limit values for construction activities, i.e. 70 dB(A) for activities taking place within regular working hours and 40 dB(A) for activities taking place outside regular working hours (see Section 9.9). Noise maps for the construction phases which are the noisiest or have the longest duration are also presented in Section 9.9.

Sheet piling is the most intense and noisiest activity, but the work is expected to take 1-2 weeks within regular working hours. The applied guiding value on 70 dB(A) is complied with for most recreational areas, with only users of Skansestien close to the work site being affected above 70 dB(A).

Tunnelling and pre-commissioning are expected to take place both within and outside regular working hours, and the applied guiding limit value of 40 dB(A) may be exceeded for the closest summerhouses. However, it is expected that the noise level can be mitigated to comply with the applied guiding limit value. It is assessed that a minor part of Skansestien and a minor part of the designated recreational area will be affected, with raised noise levels during these construction phases.

The sensitivity of this receptor to noise is assessed as high, as the existing noise level in the area is relatively low, mainly originating from agricultural machinery and minor traffic. The intensity is large during sheet piling but minor during the construction period on average. Combined with a local scale and short-term duration, the severity of the impact is minor and thus not significant, Table 9-156.

Table 9-156 Impact significance on tourism and recreational areas from airborne noise, based on implemented mitigation measures (see Section 9.9 and 9.35).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Airborne noise	High	Minor and large	Local	Short-term	Minor	Not significant

Safety zones

Construction

Safety zones will be established around the vessels used for construction and operation of the pipeline. The safety zones will be established with a radius of 1,000 – 1,500 m around the pipe-lay vessel and 500 m around other vessels. No non-project related vessels or other activities (such as kitesurfing and kayaking) may take place in the safety zones. As a result, the recreational use of the Baltic Sea in Danish waters near the landfall at Faxe S will temporarily be subject to limitations.

During construction, there will be activities nearshore for up to 16 weeks in total, with breaks between the different phases of the construction works as part of the tunnelling activities and nearshore pipe-lay. It is assessed that the kitesurfing spot will not be affected by these zones, as it is located 5 km from where construction activities take place. Recreational boating, rowing and kayaking, however, may be affected during some periods if it is not possible to navigate around these zones.

Operation

During operation there will also be safety zones around survey and maintenance vessels (a radius of 500 m). The frequency of the survey and maintenance activities is, however, low.

The sensitivity of the recreational use of the Baltic Sea near Faxe is assessed as high near the coast and close to landfall area. The intensity of the impact is medium during construction and minor during operation. Combined with a local scale and short-term duration, the impact is assessed as minor during construction and negligible during operation, resulting in a not significant impact, Table 9-157.

Table 9-157 Impact significance on tourism and recreational areas from safety zones.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Safety zones (construction)	High	Medium	Local	Short-term	Minor	Not significant
Safety zones (operation)	High	Minor	Local	Short-term	Negligible	Not significant

Restriction zone

A permanent 200 m wide restriction zone will be established around the pipeline to safeguard it against physical damage during operation. This restriction zone extends from the tunnelling exit point approximately 500 m from the shoreline and outwards along the offshore pipeline. Within this restriction zone, no activities may occur on the seabed. Anchoring is therefore prohibited within this zone.

The sensitivity to this impact is assessed as medium, mainly due to recreational boaters not being permitted to anchor within the restriction zone. However, the restriction zone constitutes a limited part of Faxe Bugt, where most recreational boating in the project area is expected to take place, and the intensity is thus low. Combined with a local scale and long-term duration, the overall impact is assessed to be of minor severity and not significant, Table 9-158.

Table 9-158 Impact significance on tourism and recreational areas from restriction zone.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Restriction zone	Medium	Low	Local	Long-term	Minor	Not significant

9.33.3 Conclusion

The assessed impacts on tourism and recreational areas resulting from the construction and operational activities are summarized in Table 9-159.

Table 9-159 Overall impact significance for tourism and recreational areas.

Potential impact	Severity of impact	Significance	Transboundary
Physical disturbance (visual disturbance), onshore	Moderate	Not significant	No
Physical disturbance (visual disturbance), offshore	Minor	Not significant	No
Physical disturbance (traffic to/from site)	Moderate	Not significant	No
Airborne noise	Minor	Not significant	No
Safety zones (construction)	Minor	Not significant	No
Safety zones (operation)	Negligible	Not significant	No
Restriction zone	Minor	Not significant	No

10. MARINE STRATEGY FRAMEWORK DIRECTIVE, WATER FRAMEWORK DIRECTIVE AND BALTIC SEA ACTION PLAN

In the process of analysing potential impacts on specific receptors in accordance with the EU EIA Directive, it is also necessary to analyse potential impacts of the Baltic Pipe project in relation to other relevant EU legislation and recommendations designed to protect the marine environment in the Baltic Sea.

In Chapter 7, an overview of the legal framework which applies to the Baltic Pipe project has been given. However, in this section a more detailed description of the Marine Strategy Framework Directive (MSFD, Section 7.4.2) and Water Framework Directive (WFD, Section 7.4.3) as well as the Baltic Sea Action Plan (BSAP, Section 7.4.4) is given. These legislative tools have been transposed into national legislation and management plans and the degree of compliance of the Baltic Pipe project with the objectives will be assessed in this section based on the potential impacts of the Baltic Pipe project during construction and operation.

The MSFD and WFD have similar criteria for reaching Good Environmental Status (GES) of marine waters and Good Ecological and Good Chemical Status of surface waters, respectively, and these criteria originate from the BSAP (Section 7.4.4). The directives include both criteria for chemical quality and eutrophication together with criteria for the hydro-morphological quality of marine waters.

The MSFD applies to the marine area from the tidal limit until the 200 nm limit, and thus covers all Danish waters (territorial waters and within the EEZ). The WFD (the part related to marine waters) covers the area between the Danish coastline to the 1 nm limit in regard to the ecological status of marine waters and to the 12 nm limit in regard to the chemical status of marine waters. There is a geographical overlap between the directives in the 12 nm zone, and in this area, the MSFD applies to subjects not covered by the WFD.

The MSFD and the WFD are both linked to the Habitats and Birds Directives, which aim to protect selected habitats and species within appointed Natura 2000 sites. The MSFD deals with the whole marine ecosystem, including species, water quality and habitats, rather than in just selected areas, as do the Habitats and Birds Directives, or individual ecosystem components, as does the WFD.

The BSAP has the goal of reaching GES for the Baltic Sea, and thus covers the whole of the Baltic Sea area, including inland waters as well as the water of the sea itself and the seabed. Measures are also taken in the whole catchment area of the Baltic Sea to reduce land-based pollution.

10.1 Marine Strategy Framework Directive

10.1.1 Baseline of descriptors

The aim of the Marine Strategy Framework Directive[70] (MSFD) is to protect the marine environment and the natural resources within marine waters and to support and strive towards their sustainable use. The Member States of the MSFD are responsible for taking measures to achieve or maintain GES of the marine environment by the year 2020 at the latest (Article 1).

[70] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

The MSFD outlines 11 descriptors used to assess GES of the marine environment (Annex I). The descriptors encompass both receptors and sources of impacts for identifying human impact on marine ecosystems. This combination of causes and effects are described in rather general terms and the MSFD does not include clear criteria that define “good” environmental status. The EU Commission has thus identified a list of detailed criteria and methodological standards to help Member States measure their progress toward the status for reaching GES (Commission Decision (EU), 2017).

The MSFD is implemented in Danish legislation through the Consolidated Act on Marine Strategy[71] (Section 7.4.2). The Danish Ministry of Environment and Food has in accordance with this legislation prepared a basis analysis for the MSFD. The basis analysis describes the current environmental status for each descriptor and gives a definition of GES for the descriptor (Naturstyrelsen, 2012a). An update of the MSFD strategies, including the baseline, the description of GES, the monitoring programme, and the programme of measures, is to be conducted every 6th year according to Article 17. A new marine strategy for Denmark is in consultation, why new environmental targets are on their way. The marine strategy will not be finalized before the release of this EIA, but partial analyses have been made. The draft marine strategy is dealt with in Section 10.1.3. The final footprint on the habitat types on the seabed will be provided to the authorities when 'as built' materials are available.

The 11 descriptors of the MSFD are shown in Table 10-1. Under each descriptor, the definition of GES is given along with the current environmental status within the Danish sector of the Baltic Sea (Faxe Bugt, Bornholm Basin and Arkona Basin) where data have been available. Table 10-1 also outlines the relevance for each of descriptor in regard to the Baltic Pipe project activities and the potential effects. Sections containing further baseline descriptions and impact assessments are also referred to in the table.

The 11 descriptors of the MSFD are divided into either state descriptors or pressure descriptors (or both - for D3 only). State descriptors characterise the marine biodiversity (D1, D4 and D6), while pressure descriptors relate to human-induced pressures (D2, D5, D7, D8, D9, D10 and D11).

The definition of the classification scheme for current ecological and chemical status includes five categories: high, good, moderate, poor and bad. 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 ‘not good’ status.

The Danish Marine Strategy defines the overall environmental status of the Danish waters around Bornholm as poor and bad for Faxe Bugt, with the most significant anthropogenic pressures related to eutrophication, fishery and pollutants (e.g. metals) (Naturstyrelsen, 2012a).

[71] Consolidated Act no. 117 of 26/01/2017 on Marine Strategy *(bekendtgørelse af lov om havstrategi)*.

Table 10-1 Description of Good Environmental Status (GES) with relevant criteria and statuses.

Descriptors based on the MSFD	Current environmental status	Relevance for the Baltic Pipe project	Potential impact	Sections in EIA with baseline and impact assessment
Descriptor 1 Biodiversity: The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic, and climatic conditions.	'Not good'[1]	To ensure the protection of biodiversity in the project area, the associated habitats must be kept in line with their natural preconditions. Safeguarding the living conditions for sensitive species living in the area (such as the harbour porpoise) will be in focus.	• Physical disturbance of seabed • Suspended sediment • Sedimentation • Contaminants and nutrients • Underwater noise • Physical disturbance above water • Presence of the pipeline • Non-indigenous species	Sections 9.10-9.14
Descriptor 2 Non-indigenous species: Introduced by human activities are at levels that do not adversely alter the ecosystems.	"Not good"[3]	Risk of introducing new species during the construction and operational phases.	• Non-indigenous species	Chapter 5
Descriptor 3 Commercial fish and shellfish: Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	'Not good'[2 and 3]	Important areas for fishing occur nearby and along the Baltic Pipe route.	• Physical disturbance of seabed • Suspended sediment • Sedimentation • Contaminants and nutrients • Underwater noise • Presence of the pipeline	Sections 9.11 and 9.12
Descriptor 4 Food webs: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	'Not good'[2]	Top predators such as marine mammals can be found in the project area. Their presence is indicative for the good functioning of the local food web.	• Physical disturbance of seabed • Suspended sediment • Sedimentation • Contaminants and nutrients • Underwater noise • Presence of the pipeline	Sections 9.10-9.14
Descriptor 5 Eutrophication: Human-induced eutrophication is minimised, especially	'Not good'[1]	Construction works, including pipe-lay trenching and rock installation, anchoring etc. will	• Physical disturbance of seabed • Suspended sediment	Sections 9.2 and 9.3

Descriptors based on the MSFD	Current environmental status	Relevance for the Baltic Pipe project	Potential impact	Sections in EIA with baseline and impact assessment
adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms, and oxygen deficiency in bottom waters.		cause temporary suspension of sediments, which can release contaminants and nutrients.	• Contaminants and nutrients	
Descriptor 6 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.	GES reached[2]	Rock installation and trenching will occupy the seabed and locally change the habitat conditions related to the seabed.	• Physical disturbance of seabed • Suspended sediment • Sedimentation • Contaminants and nutrients • Presence of the pipeline	Sections 9.1, 9.2 and 9.11.
Descriptor 7 Hydrographical conditions: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	Not known[4]	Temporary sediment dispersion during construction. Blocking effect from construction and presence of the pipelines.	• Suspended sediment • Discharge of hydrotest water • Change of hydrodynamics • Heat from the pipeline	Section 9.2
Descriptor 8 Contaminants: Are at levels not giving rise to pollution effects.	'Not good'[1]	Construction works, including pipe-lay, trenching, rock placement and anchoring will cause temporary suspension of sediments. Release of metals from anodes.	• Physical disturbance of seabed • Contaminants and nutrients • Release of contaminants from anodes	Section 9.3
Descriptor 9 Contaminants in seafood: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.	'Not good'[2]	Construction works with trenching and rock installation, anchoring etc. will cause temporary suspension of sediments. Release of metals from anodes.	• Physical disturbance of seabed • Contaminants and nutrients • Release of contaminants from anodes	Section 9.3
Descriptor 10 Marine litter: Properties and quantities of marine litter do not cause	Not known[4]	Not relevant because measures are taken to ensure that all waste will be brought	Not relevant	Not relevant

Descriptors based on the MSFD	Current environmental status	Relevance for the Baltic Pipe project	Potential impact	Sections in EIA with baseline and impact assessment
harm to the coastal and marine environment.		back to land for disposal.		
Descriptor 11 Energy including underwater noise: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.	Not known[4]	Areas with sensitive species occur in the project area.	• Underwater noise	Sections 9.12-9.13

1: Information from Basis Analysis for Danish Marine Strategy (Naturstyrelsen, 2012a)
2: Information from HELCOM (HELCOM, 2013b)
3: Information from HELCOM (HELCOM, 2017c)
4: No information available on GES from either Danish Marine Strategy or HELCOM. Current environmental status is therefore not known.

Based on the 'basis analysis' (Naturstyrelsen, 2012a), the Ministry of Environment and Food has established targets for the environmental conditions in Danish waters. The targets must ensure that the right balance between human use of the sea and a healthy marine ecosystem is reached. The targets deal with both the marine ecosystem and the human activities that affect it. Overall, the targets shall ensure GES in the Danish marine areas by 2020 (Naturstyrelsen, 2012b).

10.1.2 Impact assessment of descriptors

Based on the impact assessments provided in Chapter 9, the following sections discuss the potential for the Baltic Pipe project to prevent the achievement of targets or the long-term goal for GES for the descriptors in the MSFD during the construction and operational phases.

Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6)

The descriptors regarding Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6) all relate to biological diversity, including the distribution and abundance of species. The potential for the Baltic Pipe project to impact these three descriptors is therefore described collectively in this section.

The targets for reaching GES for the three descriptors are overall to maintain the biological diversity, population and habitat levels and to ensure that the structures and functions of ecosystems are sustained.

The relevant impacts from the Baltic Pipe project on these three descriptors may include physical disturbance of the seabed, increased concentrations of suspended sediment (SSC) in the water column, sedimentation, release of nutrients and contaminants from the sediment during construction work, generation of underwater noise, physical disturbance above water, the presence of the pipeline and the introduction of non-indigenous species (Table 10-2).

Table 10-2 Potential impacts on the descriptors for Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6).

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediment	X	
Sedimentation	X	
Contaminants and nutrients	X	
Underwater noise	X	
Physical disturbance above water	X	X
Presence of the pipeline		X
Non-indigenous species	X	

To assess how these potential impacts may affect the descriptors of Biodiversity, Food webs and Sea-floor integrity, the impacts on the different trophic levels in the marine ecosystem, e.g. benthic flora and fauna, fish, birds and marine mammals are relevant to include in the overall assessment for each descriptor. Impacts on phytoplankton, the lowest trophic level, from the Baltic Pipe project have been screened out (Section 9.10)

Physical disturbance of the seabed

The impacts of physical disturbance of the seabed on the benthic communities (flora and fauna) and fish has been assessed in Sections 9.11-9.12. The physical loss and physical damage of the seabed during the construction phase along the Baltic Pipe route will be of a temporary nature and highly localised to the immediate footprint of the pipeline, which in Danish waters corresponds to a total occupied area of 0.15 km^2. In addition, some of the sediment along the route is not presently colonised by benthic communities due to unfavourable abiotic conditions, especially a lack of oxygen. Anchor handling and the use of DP vessels will cause short-term physical disturbance of the seabed.

Impacts on benthic flora will be expected in Faxe Bugt at depths greater than 4 m during trenching and construction of an exit hole for tunnelling (Section 9.11). These impacts will relate especially to eelgrass, which have a long recolonization time (>10 years; FEMA, 2013a, Section 9.11) after detrimental impacts, whereas other observed algal communities with high growth rates are assessed to have a low sensitivity to this impact. To reduce the impact on the eelgrass beds, the excavated material will be moved to a temporary disposal area without a coverage of eelgrass (>7 m water depth). By placing the temporary disposal area for trenched material outside the area with eelgrass, the impact on eelgrass beds is effectively reduced, and therefore the impacts on benthic flora from the construction work is assessed to be minor and not significant.

Impacts on benthic fauna depend on their capability to recover and their recolonization rate. The duration of impact depends on the benthic community structure and may take from a few to several years. However, impacts from physical disturbance of the seabed will not result in changes in the benthic habitat type, and therefore the intensity of the impacts on benthic communities from the construction work is assessed to be medium and the impact is considered minor and not significant (Section 9.11).

Fish will be initially susceptible to showing avoidance behavior because of the physical disturbance of the seabed. However, the area surrounding the pipeline is homogenous, i.e. the impact will have no spatial influence on the overall habitat availability (local impact) and the impact is reversible and short-term. Therefore, the impact on fish habitats resulting from the construction work is assessed not to be significant (Section 9.12).

The impact from anchor handling on benthic flora and fauna and on fish is assessed to be minor and not significant due to the short-term impact from this activity.

Overall, impacts from the physical disturbance of the seabed on the descriptors Biodiversity (D1), Food webs (D4) and Sea-floor integrity are assessed to be not significant, based on the conclusions presented in Sections 9.10-9.13 and 9.16. Impacts on all trophic levels in the marine ecosystem have been assessed as not significant, and therefore, the overall effect on Biodiversity, Food webs and Sea-floor integrity is equally not significant.

Suspended sediment

Increased SSC may impact benthic flora and fauna through reduced growth of benthic flora due to reduced light availability; as well as reduced food availability due to blocking/closing of feeding apparatuses for filter-feeding benthic fauna species. SSC may impact fish communities by provoking avoidance, clogging of gills, reduction in feeding ability due to reduced visibility and reduced viability of pelagic fish eggs. Impacts on marine mammals from SSC can include visual impairment and behavioural impacts, such as avoidance of sediment plumes.

The impacts of increased SSC in the water column during construction activities on benthic flora and fauna, fish and marine mammals have been assessed in Sections 9.11-9.13. As the increase in SSC is temporary, with low concentrations reaching outside the construction site, impacts on the different trophic levels of the marine ecosystem, i.e. benthic flora and fauna, fish and marine mammals, have been assessed not to be significant, and therefore the impact of suspended sediment on the descriptors D1, D4 and D6 is not significant.

Sedimentation

Suspended sediment will re-deposit on the seabed and may potentially affect benthic flora and fauna as well as fish eggs and larvae at the seabed. Sedimentation can also influence the availability of food sources for fish by burying benthic fauna. Impacts from sedimentation on benthic flora and fauna and on fish have been assessed in Sections 9.11 and 9.12.

As re-suspension and sedimentation are naturally occurring, especially in shallow water, combined with a continuous natural level of sedimentation in the sea, it is generally assumed that the sensitivity of benthic flora and fauna to sedimentation is low. In combination with the minor intensity of sedimentation from Baltic Pipe construction activities, the impact of sedimentation on benthic fauna and flora and on fish is not significant, and thus no significant impacts are anticipated on the descriptors D1, D4 and D6.

Contaminants and nutrients

Impacts from contaminants and nutrients have been assessed in Sections 9.10-9.12 and no significant impacts on benthic flora and fauna, fish or marine mammals have been found. The potential release of contaminants and nutrients from the sediment during construction is further discussed in this section in connection with the descriptors D5 Eutrophication and D8/D9 Contaminants.

Underwater noise

The generation of underwater noise can potentially affect marine mammals and fish. In particular, marine mammals that use sound underwater for communication are sensitive to elevated underwater noise. The possible effects on marine mammals from elevated underwater noise may include masking of communication sounds or avoidance behaviour, while sound pulses have the potential to cause temporary or permanent damage to hearing apparatuses in marine mammals (Section 9.13). Underwater noise may impair the ability of fish to use biologically relevant sound e.g. acoustic communication, predator avoidance, prey detection and interpretation of the soundscape (Section 9.12). The impacts of the generation of underwater noise from construction activities has been assessed for fish and mammals in Sections 9.12 and 9.13, respectively.

As described in Section 5.1.5, the underwater noise generated from the construction activities will not be distinguishable from the background levels of underwater noise in the Baltic Sea (Section 9.5). In addition, underwater noise from construction activities, such as rock installation and ship traffic, will occur near the pipeline and the construction vessels. The duration will be immediate, and the generated underwater noise will cease after the activity has ended. Based on this, the immediate impact from underwater noise from construction activities on fish and marine mammals is not likely to be significant.

Unplanned events - underwater noise
In connection with the risk assessments (Chapter 4), it has been identified that munitions clearance of UXO may pose a risk during the construction phase. Based on the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapters 4 and 5).

Underwater noise from munitions clearance may potentially generate an impact on fish and marine mammals (Section 9.12. and 9.13).

For fish and marine mammals, there will be a significant impact on *individuals* in the event of munitions clearance, but no significant impact on *populations* of fish, seals or harbour porpoises, if no mitigation measures are applied.

To protect fish from significant impacts, the following mitigation measures will be applied:

- A sonar survey will be undertaken to identify shoaling or schooling fish in the area in order to assess whether the timing of the munitions clearance is suitable or if the detonation should be postponed.

To protect marine mammals from significant impacts, the following mitigation measures will be applied:

- Seal scarers – to scare away marine mammals near the munitions clearance area;
- Visual and acoustic observations – to ensure no marine mammals are close to the munitions clearance area;
- Seasonality - to ensure that munitions clearance is conducted at a time when the fewest individuals could potentially be affected.

The mitigation measures are described in detail in Sections 9.12 and 9.13. By using this combination of mitigation measures, the impact on *individuals* and *populations* of fish and marine mammals in the event of munition clearance is reduced to not significant.

Conclusion - Underwater noise
Underwater noise will not pose a risk of impacts on fish and marine mammals during construction activities, and the impact on the descriptors D1, D4 and D6 is therefore not significant. In the unlikely event that munitions clearance is necessary, the mitigation measures described above will ensure that there will be no significant impacts at the individual and population levels for fish and marine mammals. Hence, it is concluded that the will be no significant impacts from underwater noise on the descriptors D1, D4 and D6.

<u>Physical disturbance above water</u>

Physical disturbance above water relates to disturbance from construction-related activities above water and the presence of vessels during construction and operation, and the impact has been assessed in Sections 9.13 and 9.14 for marine mammals (seals) and seabirds.

Seals general are generally not considered sensitive to disturbance, and the impact from physical disturbance above water on seals is assessed to be not significant (Section 9.13). Physical disturbance above water may cause energetic cost for seabirds, as the birds will have to move away from the disturbance (i.e. by swimming, diving, and/or flying) and, therefore, will lose essential time for foraging and rest (Section 9.14). However, the disturbance above water from the presence of vessels and construction activities will have a short duration within any given location. Therefore, the disturbance of birds will be of minor intensity due to the short-term and local impact, and the impact from physical disturbance above water on seabirds is assessed to be not significant.

As there are no significant impacts from physical disturbance above water on either marine mammals or seabirds, there the overall effect on the descriptors D1, D4 and D6 is equally not significant.

<u>Presence of the pipeline</u>

The presence of the pipeline structures, including rock installations, will replace the existing benthic habitat within the footprint area. The pipeline presence may on the one hand result in a loss of infauna seabed habitat within the project footprint. On the other hand, the introduction of the pipeline may represent a new hard substrate ("artificial reef") for sessile organisms and benthic macroalgae (within the photic zone). The effect of the presence of the pipeline has been assessed for benthic flora and fauna in Section 9.11. Impacts from the presence of the pipeline on fish and marine mammals have been screened out (Sections 9.12 and 9.13).

Even though there will be a small negative impact from the pipeline due to the loss of soft seabed habitat, the introduced artificial reefs will change the existing habitats, with the potential for a minor degree of final positive impact (Section 9.11). As such, the impact of the presence of the pipeline on the local benthic flora and fauna is considered to be not significant.

In conclusion, the presence of the pipeline will not lead to significant impacts on the different trophic levels of the marine ecosystem, and the impact on descriptors D1, D4 and D6 is therefore not significant.

<u>Non-indigenous species</u>

The potential impacts from the introduction of non-indigenous species into the Baltic Sea during the construction phase are conservatively assessed to be negligible due to the implementation of standard mitigation measures (see Section 5.1.9). Non-indigenous species are further discussed under the descriptor for NIS (D2) below.

<u>Conclusion on impacts on descriptors D1, D4 and D6</u>

As described above and based on the assessments performed in Chapter 9, impacts that may affect Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6) have been assessed.

There will be no significant impacts on any of the trophic levels in the marine ecosystem, and thus no significant impacts on the descriptors Biodiversity (D1) or Food webs (D4) in relation to the Baltic Pipe project.

In relation to Sea-floor integrity (D6), particular focus has been given to benthic ecosystems (as described in Table 10-1), and in the impact assessment for benthic flora and fauna in Section 9.11, no significant impacts from the Baltic Pipe project have been found.

In the following table (Table 10-3), conclusions from the impact assessment are listed in regard to the most sensitive receptor (e.g. marine mammals for underwater sound).

Thus, the construction and operation of the Baltic Pipe project will not prevent or delay the achievement of targets or the long-term goal for GES for these descriptors.

Table 10-3 Impact significance from the potential impacts described in Table 10-2 (except non-indigenous species, which is described under descriptor D2) during the construction of the pipeline and after mitigation measures on the descriptors D1 Biodiversity, D2 Food webs and D6 Sea-floor integrity.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance of seabed	High	Moderate	Local	Long-term	Minor	Not significant
Suspended sediment	Low	Minor	Local	Immediate	Negligible	Not significant
Sedimentation	Medium	Minor	Local	Short-term	Minor	Not significant
Underwater noise - construction activities	Low	Low	Regional	Immediate	Negligible	Not significant
Physical disturbance above water	High	Minor	Regional	Immediate	Negligible	Not significant
Presence of the pipeline	High	High	Local	Long-term	Negligible	Not significant
Unplanned events– underwater noise	Low	Low-high	Regional	Immediate	Negligible	Not significant

Non-indigenous species (D2)

The target for reaching GES for the descriptor D2 is to reduce the introduction of NIS by vessel traffic. In the period 2011-2015, 14 new NIS have been introduced in the Baltic Sea, which means that the indicator for GES on descriptor D2, with the threshold of zero new introductions, has not been reached. The 14 species includes crustaceans, worms and several other animal groups. Two new algae species have also been observed (HELCOM, 2017c). The most probable vectors for NIS into the Baltic Sea are aquaculture and shipping, where NIS can be spread from e.g. ballast water or via attachments to ship hulls (HELCOM, 2017c).

The Baltic Pipe project has the potential to introduce NIS through vessel movements during construction and operation, as outlined in Section 5.1.9. Such introduction has the potential to threaten native species through competition for food and space.

The Ballast Water Management (BWM) Convention of the International Maritime Organization entered into force in September 2017 (IMO, 2017), and its further ratifications can be expected to decrease the pressure and risk of new introductions of NIS and other harmful organisms to the

Baltic Sea. To date, the HELCOM countries Germany, Russia, Denmark, Sweden and Finland have all ratified the convention (HELCOM, 2017c).

All vessels participating in the Baltic Pipe project will be requested to comply with the BWM Convention and the HELCOM Guide to alien species and ballast water management in the Baltic Sea (HELCOM, 2014a), see Section 5.1.9. Therefore, the risk of introducing NIS from Baltic Pipe project activities is very low.

Conclusion

In summary and based on the information presented in Section 5.1.9, the potential impacts from NIS during the construction phase are assessed to be negligible and will not result in significant impacts on D2 Non-indigenous species, Table 10-4. It can therefore be concluded that the Baltic Pipe projects will not prevent or delay the achievement of targets or the long-term goal for GES for Descriptor D2.

Table 10-4 Impact from NIS on the descriptor D2 Non-indigenous species.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Non-indigenous species	High	Minor	Local to regional	Long-term	Negligible	Not significant

Commercial fish and shellfish (D3)

The GES target for commercially exploitable fish and shellfish is to keep the spawning biomass at a sustainable level (Naturstyrelsen, 2012b). The commercial fishery is to be conducted after the principles of maximum sustainable yield.

Relevant potential impacts from the Baltic Pipe project on D3 are shown in Table 10-5.

Table 10-5 Potential impacts on the descriptor D3 Commercial fish and shellfish.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediment	X	
Sedimentation	X	
Contaminants and nutrients	X	
Underwater noise	X	

The impacts from physical disturbance of the seabed, suspended sediment, sedimentation and underwater noise on benthic fauna and fish have been assessed under the combined impact assessment for the descriptors Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6) (Section 10.1.2), and all potential impacts were assessed to be not significant.

Contaminants and nutrients

As outlined in Section 5.1.3, the release of contaminants and nutrients from the sediment during construction of the Baltic Pipe project are insignificant compared to the annual amounts entering the Baltic Sea.

Impacts from contaminants on benthic fauna have been screened out, as the species live in and on the seabed, from which the released contaminants originate, and thus there will be no additional risk of contaminant exposure for benthic fauna (Section 9.11).

Impacts from contaminants on fish have been assessed in Section 9.12. The majority of the potentially released contaminants are expected to remain associated with the particulate matter, meaning that the particles will settle on the seabed again within a short time span, see Section 5.1.3. The effects and impact of bioaccumulation of contaminants on fish are therefore assessed to be negligible and the impact is assessed to be not significant.

The impacts of the potential release of nutrients from the sediment during construction of the Baltic Pipe project have been assessed in Section 9.10. The effect of a potential release of nutrients from the sediment on phytoplankton growth is assessed to be negligible (Section 9.10), and thus further effects from the release of nutrients on higher trophic levels in the food chain are not anticipated. The potential release of nutrients from the sediment during construction is further discussed below in connection with descriptor D5 Eutrophication.

Conclusion

Some of the above-mentioned possible impacts (Table 10-5) may occur at the same time and can therefore potentially affect the same individuals simultaneously. However, no significant impacts from either one of the potential impacts or a combination of them are expected. Thus, potential impacts during construction and operation will not result in significant effects on the maintenance of spawning biomass at a sustainable level (Table 10-6).

In summary, it can be concluded that the Baltic Pipe project will not affect the achievement of the long-term goal for GES for Descriptor D3.

Table 10-6 Impact from contaminants and nutrients on the descriptor D3 Commercial fish and shellfish.

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Contaminants and nutrients	Low to high	Minor	Local	Short-term	Negligible	Not significant

Eutrophication (D5)

The GES target for D5 eutrophication is that the levels of nutrients in the water column within open Danish waters correspond to the accepted nutrient concentrations defined by the WFD (Naturstyrelsen, 2012b). The concentration of chlorophyll-*a* is used to evaluate the nutrient levels in Danish coastal waters, as it reflects the concentration of phytoplankton. With increasing amounts of nutrients, measured as total Nitrogen (N) and total phosphorus (P), the concentration of phytoplankton, and thus Chlorophyll-*a*, increases. This affects the water quality by limiting light conditions and eventually causing an increase in oxygen consumption during the decomposition of phytoplankton. The limits for reaching GES in regard to concentrations of Chlorophyll-*a* are given in Consolidated Act no. 1001 of 29/06/2016[72].

Potential impacts are shown in Table 10-7.

Table 10-7 Potential impact on the descriptor Eutrophication (D5).

Potential impact	Construction	Operation
Contaminants and nutrients	X	

[72] Consolidated Act no. 1001 of 29/06/2016 on monitoring of surface water, groundwater and protected areas and international protected areas (Bekendtgørelse om overvågning af overfladevandets, grundvandets og beskyttede områders tilstand og om naturovervågning af internationale naturbeskyttelsesområder).

Contaminants and nutrients

The relevant sources of impact from the Baltic Pipe project on descriptor D5 include the release of nutrients from the sediment due to physical disturbance of the seabed during the construction phase (Table 10-7). However, the release of contaminants and nutrients during the construction phase of the Baltic Pipe project is insignificant compared to the existing input of contaminants and nutrients from land-based sources. Therefore, in Sections 9.3 and 9.10, the transfer of nutrients from the sediments to the water column has been scoped out as a potential impact, as no impact on the phytoplankton biomass and no algal blooms are expected. Consequently, no impact on the degree of oxygen depletion in the bottom waters or related impacts on the pelagic or benthic communities are expected (see Section 9.11).

During the operational phase, no release of nutrients is expected, and thus no impacts are expected.

Conclusion

Based on the above, impacts during the construction and operation of the Baltic Pipe project will not result in significant impacts on the total N concentration in the water column, and will therefore not lead to increased concentrations of Chlorophyll-*a*. This leads to the conclusion that the Baltic Pipe project will not delay or prevent the achievement of the targets for reaching GES in regard to D5 eutrophication in Denmark (Table 10-8).

Table 10-8 Impact from contaminants and nutrients on the descriptor Eutrophication (D5).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Contaminants and nutrients	Low	Minor	Local	Short-term	Negligible	Not significant

Hydrographical conditions (D7)

Hydrographical conditions are characterized by the physical parameters of seawater: temperature, salinity, depth, currents, waves, turbulence and turbidity (related to the load of suspended particulate matter). They play a crucial role in the dynamics of marine ecosystems and can be altered by human activities, especially in coastal areas.

The target for GES for D7 Hydrographical conditions is to ensure that permanent alteration of hydrographical conditions do not adversely affect marine ecosystems. Impacts from construction activities on hydrographical conditions are regulated by individual permits adapted to the specific areas where the construction activities will take place. Thus, there is no need to develop general targets and indicators for D7. In general, it is considered that only localised permanent changes to hydrography will be permissable (Naturstyrelsen, 2012b).

The construction of the Baltic Pipe pipeline may interfere with the hydrography within Danish waters both during construction and operation, and the potential impacts are listed in Table 10-9.

Table 10-9 Potential impacts on the descriptors for Hydrographical conditions (D7).

Potential impact	Construction	Operation
Suspended sediment	X	
Discharge of hydrotest water	X	
Change of hydrodynamics		X
Heat from the pipeline		X

Suspended sediment

Sediment spill will increase the turbidity of the water due to increased amounts of suspended sediment. In addition, increased SSC can potentially result in the release of particle-associated contaminants to the water column as a result of the shift in the chemical environment when the particles are suspended in the water (Section 5.1.3).

The impacts of sediment spill from construction of the Baltic Pipe project have been assessed in Section 9.2. Sediment spill will only affect the water quality very locally and temporarily during the construction works, and the turbidity and concentrations of contaminants and nutrients will revert naturally and rapidly to their pre-impact status once the construction activities are completed. The impact will be low, immediate and of minor intensity, and therefore not significant.

Discharge of hydrotest water

As outlined in Section 5.1.11, there will be a discharge of hydro-test water from the pipeline to Faxe Bugt. This discharge has been assessed in Section 9.2, for potential impacts from the chemicals added to the hydrotest water and the oxygen levels in the discharged water. The water quality will only be impacted temporarily and locally and will revert naturally and rapidly to pre-impact status once the activities cease. Therefore, the impact from the discharge of hydrotest water is not significant.

Change of hydrodynamics

The pipelines could potentially cause a changed vertical mixing in the water column, an increased blocking of flow or a creation of a local dam, where anoxic conditions could develop. This could potentially lead to a change in hydrodynamics by affecting the flow of new deepwater masses into the Baltic Proper (Section 9.2.). The impacts from a possible change of hydrodynamics have been assessed to be not significant due to the negligible impacts on bottom flow or development of anoxic conditions (Section 9.2.)

Heat from the pipeline

The difference in temperature between the gas in the pipeline and the surrounding water and sediments will cause the exchange of heat between the gas and the surrounding seabed, through the pipeline walls. Analysis and monitoring from comparable offshore pipeline projects have shown that the temperature impact is small and local, with temperature changes only detectable at a maximum distance of approximately 0.5-1.0 m from the pipelines. The impact has been assessed in Section 9.2 to be not significant.

Conclusion

The hydrographical conditions are essential in determining the various habitats that are required for the different trophic levels in the marine ecosystem. Hydrographical conditions play an important role in the exchanges between the sea and the atmosphere and between the various water layers, which is important for the oxygen conditions throughout the water column.

Changes in the physical parameters of seawater due to impacts on the hydrographical conditions can then have an impact on the spawning, breeding and feeding areas of marine organisms.

The assessments in Section 9.2 show no significant effects from the potential impact listed in Table 10-9, which may affect the hydrographical conditions. Based on these assessments, no significant impacts on water turbidity, water temperature, oxygen conditions, salinity or water currents are anticipated, and therefore, the Baltic Pipe project will not result in significant impacts on hydrographical conditions (Table 10-10). In conclusion, the Baltic Pipe project will not delay or prevent the achievement of the long-term goal for GES for Descriptor D7.

Table 10-10 Impact significance from the potential impacts during the construction of the pipeline and after mitigation measures on the descriptor Hydrographical conditions (D7).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Suspended sediment	High	Moderate	Local	Long-term	Minor	Not significant
Discharge of hydrotest water	Low	Minor	Local	Immediate	Negligible	Not significant
Change of hydrodynamics	Medium	Minor	Local	Short-term	Minor	Not significant
Heat from the pipeline	Low	Low	Regional	Immediate	Negligible	Not significant

Contaminants (D8) and Contaminants in seafood (D9)

Contaminants (D8) and Contaminants in seafood (D9) are closely linked and have overlapping targets for reaching GES; therefore, they are described together in this section.

The target for reaching GES for contaminants in the marine environment (D8) is to keep the concentration of contaminants in water, sediments and living organisms within the limits defined by environmental standards of national legislation, including the Environmental Protection Act[73] and the Marine Environment Act[74]. The target for reaching GES in regard to contaminants in seafood (D9) is correlated with human health, which may not be negatively affected by contaminants in fish and shellfish (Naturstyrelsen, 2012b).

Contaminants may potentially be released from the Baltic Pipe project activities due to their release from sediments during the construction phase and release from anodes in the operational phase, as described in Section 5.1.3. The potential impacts on the descriptors for Contaminants (D8) and Contaminants in seafood (D9) is listed in Table 10-11.

Table 10-11 Potential impacts on the descriptors for Contaminants and Contaminants in seafood (D9).

Potential impact	Construction	Operation
Physical disturbance of sediments	X	
Contaminants and nutrients	X	
Release of contaminants from anodes		X

Management plans for all vessel activities ensure that no impacts on water quality will occur as a result of discharges from vessels.

In section 9.3, the potential impacts listed in Table 10-11 have been assessed.

Physical disturbance of seabed

Physical disturbance of the seabed will not lead to a significant release of contaminants, and the duration of a potential release will be short-term, with conditions returning to background levels when the construction work has finished.

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[73] Consolidated Act no. 966 of 23/06/2017 on protection of the environment (Bekendtgørelse af lov om miljøbeskyttelse)
[74] Consolidated Act no. 1033 of 04/09/2017 on protection of the marine environment (Bekendtgørelse af lov om beskyttelse af havmiljøet)

Contaminants and nutrients
When sediment is suspended in the water column during the construction phase, the contaminants and nutrients in the sediment can be reactivated. When reactivated, their chemical and biological availability will increase (HELCOM, 2010a). The duration of potential suspended sediment is short-term, and it is assessed that the concentrations of contaminants in the sediment will not change significantly during this period (Section 9.3).

Release of contaminants from anodes
As outlined in Section 5.2.5, sacrificial anodes mainly consisting of aluminium will be used as a back-up corrosion protection system in case of damage to the coating of the pipeline. It is assessed that the release of aluminium will be of such a small magnitude, that it will be indistinguishable from background concentrations.

Conclusion
Based on the assessments of the potential impacts listed in Table 10-11 (Section 9.3), no significant impacts on the descriptor Contaminants (D8) are anticipated. This is because any release and reactivation of chemicals from the sediment will be in connection with the construction phase and will therefore have a short-term duration. The release of contaminants from anodes will occur during the operational phase, but at concentrations which will be the same as background levels.

Regarding the descriptor Contaminants in seafood (D9), the impact from the release of contaminants in the sediment on benthic fauna has been screened out, since these organisms already live in or at the sediment and are thus naturally exposed to the potential chemicals found here (Section 9.11). The impacts from contaminants on fish have been assessed to be not significant in Section 9.12 due to the short-term exposure to the potential release and reactivation of chemicals. On this basis, no significant effects from the potential impacts listed in Table 10-11 on the descriptor Contaminants in seafood (D9) are anticipated.

The overall conclusion based on the assessments above is that the Baltic Pipe project will not significantly impact the descriptors D8 and D9 and will not prevent the achievement of the long-term goal for GES for these descriptors (Table 10-12).

Table 10-12 Impact significance from the potential impacts during the construction of the pipeline and after mitigation measures on the descriptors Contaminants (D8) and Contaminants in seafood (D9).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Physical disturbance of seabed	Medium	Medium	Local	Short-term	Minor	Not significant
Contaminants and nutrients	Medium	Minor	Regional	Short-term	Negligible	Not significant
Release of contaminants from anodes	Medium	Medium	Local	Long-term	Minor	Not significant

Energy and noise (D11)
The introduction of energy into the marine environment refers to light, electricity, heat, noise, electromagnetic radiation, radio waves and vibrations. Generally, the strongest effects from these activities on the marine environment are caused by underwater noise, and therefore the impacts on descriptor D11 is assessed by looking at the potential impacts from underwater noise generated by the project.

The target for GES for D11 Energy, is to keep the introduction of energy, including underwater noise, at levels that do not adversely affect the marine environment. The potential impacts for D11 is listed in Table 10-13.

Table 10-13 Potential impacts on the descriptors for Energy and noise (D11).

Potential impact	Construction	Operation
Underwater noise	X	

The possible sources of the generation of underwater noise in relation to the Baltic Pipe project are outlined in Section 5.1.5. Underwater noise may be generated from e.g. rock installation, trenching, dredging and potentially the unlikely event of munitions clearance, which is treated as an unplanned event. The generation of underwater noise can potentially affect fish and marine mammals; these impacts have been assessed in Sections 9.12 and 9.13.

<u>Underwater noise – construction phase</u>
As outlined under the assessment of underwater noise, the underwater noise generated from the construction activities will not have a significant effect on any of the trophic levels in the marine ecosystem.

Unplanned events - underwater noise
In the unlikely event of munitions clearance, the mitigation measures described under the assessment of impacts from underwater noise on descriptors D1, D4 and D6 will ensure that there will be no significant impacts at the population level for fish or marine mammals.

<u>Conclusion</u>
Since there are no significant impacts from underwater noise in the unlikely event of munitions clearance if mitigation measures are applied, it is concluded that the will be no significant impacts on fish or marine mammals from underwater noise from the Baltic Pipe project. In summary and based on the above, impacts during construction and operation (individually or in combination) will not result in significant impacts on the noise level underwater (criteria of D11).

On this basis, it is concluded that the Baltic Pipe project will not delay or prevent the achievement of the long-term goal for GES for Descriptor D11 (Table 10-14).

Table 10-14 Impact significance from the potential impacts on the descriptor Energy and noise (D11).

	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Energy and noise	Low to high	Minor	Local	Short-term	Negligible	Not significant

10.1.3 Draft Danish Marine Strategy II

As mentioned in the introduction to MSFD, the Danish Marine Strategy II is in consultation. New targets for reaching good environmental status (GES) have been developed including indicators for assessing the GES. The current status for GES has also been described in the draft document. In Table 10-15 targets, indicators and GES have been summarised together with a short assessment of the impact from the Baltic Pipe project on the GES, based on assessments done for MSFD in Section 10.1.2 and the new targets and indicators. Only relevant targets and indicators are listed and assessed (e.g. by-catch, development of monitoring programmes etc. has not been mentioned).

Table 10-15 Description of Good Environmental Status (GES) with relevant criteria and statuses. Targets for good environmental status are from the draft Danish Marine Strategy (Miljø- og Fødevareministeriet, 2018).

Targets for Danish Marine Strategy	Indicators	Environ-mental status 2018-2024	Assessment
Descriptor 1 Biodiversity *Birds* 1.1 N.A. 1.2 Populations and habitats for birds are conserved and protected in accordance with objectives under the Birds Directive. 1.3 N.A. *Marine mammals* 1.4 N.A. 1.5. N.A. 1.6 Harbour porpoise, common seal and grey seal have achieved favourable conservation status according to the Habitats Directive. 1.7 N.A. *Fish* 1.8. N.A. 1.9 N.A. *Pelagic habitats* 1.10 The abundance of plankton follows the long-term average. 1.11 The Ministry of Environment and Food is tracking developments and improving the knowledge base Aabout plankton through monitoring.	By-catch of seabirds, marine mammals and sharks and skates (numbers)	*Birds* Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated. *Marine mammals* Habour seal: GES is reached. Grey seal and harbour porpoises: not good. *Fish* Not good. *Pelagic habitats* Not assessed	1.2 Birds protected under the Birds Directive will not be impacted by the project activities see 9.14.2, 9.12.2 and 10.3.2) 1.6 Marine mammals protected under the Habitats Directive will not be impacted by the project activities (see 9.14.2, 9.19.2 and 10.3.2) 1.10 The project will not impact plankton positive or negative (see 9.10.2 and 10.3.2) 1.11 The project will not hinder monitoring of plankton (see 9.30.2 and 10.3.2). Indicators: The project will not have influence on indicators (by-catch). Environmental status: The project will not impact the environmental status nor

Targets for Danish Marine Strategy	Indicators	Environ-mental status 2018-2024	Assessment
		All Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated.	hinder the target of reaching GES.
Descriptor 2 Non-indigenous species 2.1 The number of new non-indigenous species introduced through ballast water, ship fouling, and possibly other human activities is decreasing (D2C1). 2.2 N.A. 2.3 N.A.	The number of new marine NIS Distribution of round goby	Not good. Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated.	2.1 The project will not add risk of introducing NIS (see 5.1.9 and 10.3.2). Indicators: The project will not add to the number of NIS nor change the distribution of round goby. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 3 Commercial fish and shellfish 3.1 Denmark is working to ensure that an increasing number of commercial fish stocks are managed in accordance with the MSY principles in the EU Common Fisheries Policy. 3.2 Denmark is working to ensure a decrease in the number of commercial fish stocks for which the current fishing pressure is greater than the FMSY. 3.3 Denmark is working to ensure a decrease in the number of commercial fish stocks for which the current spawning biomass is less than the MSY Btrigger.	The share of commercial fish stocks; which is regulated after MSY principles, where the fishery mortality is over F_{MSY}, where spawning stock biomass is below MSY $B_{trigger}$.	Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated.	3.1-3.3 The Baltic Pipe project will not impact the commercial fish and shell fish stocks (see 9.12.2 and 10.1.2, Commercial fish and shellfish (D3)). Indicators: The project will not have influence on the indicators. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 4 Food webs 4.1 As environmental targets for pressures and state under the other descriptors are achieved, it is expected that the balance in the marine food web will improve. 4.2 N.A. 4.3 The Ministry of Environment and Food is tracking developments through monitoring.	See indicators for descriptor 1 biodiversity	See Descriptor 1 biodiversity.	4.1 The Baltic Pipe project will have no significant impact on the trophic levels of the marine ecosystem (see 9.10 to 9.17 and overall assessment 10.1.20 - Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6)). 4.3 The project activities will not hinder monitoring in Faxe Bugt nor in the Arkona Basin (9.30.2).

Targets for Danish Marine Strategy	Indicators	Environ-mental status 2018-2024	Assessment
			Indicators: see Descriptor 1 biodiversity. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 5 Eutrophication 5.1 Coastal waters: Target loads and needs for measures are determined for fjords, estuaries and coastal waters in accordance with the Water Framework Directive and are stated in the Danish river basin management plans. 5.2 N.A. 5.3 Open marine areas outside coastal waters: The Baltic Sea, the Danish Straits and the Kattegat: Danish inputs of nitrogen and phosphorus (TN, TP) comply with the maximum accepta-ble inputs stipulated under HELCOM. 5.4 N.A. 5.5 N.A.	Load inventories from HLECOM fron TN and TP. Concentrations of nutrients in the water column. Concentrations of Chl *a* in the water column. Concentration of oxygen in the bottom of the water column.	Not good Threshold values There is no timeline for when GES for each criterion is reached.	5.1 and 5.3 The project will not contribute to the eutrophication status of the Baltic Sea (see 9.2, 10.1.2-Eutrophication (D5)) Indicators: The project will not add TN, TP to Faxe Bugt or Arkona Basin, or change the concentration of Chl *a* or oxygen in the project area. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 6 Sea-floor integrity *Losses and physical impacts* 6.1 N.A. 6.2 N.A. 6.3 N.A. 6.4 In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority is encouraging assessment and reporting to the Danish Environmental Protection Agency (EPA) (monitoring programme) of the extent of physical loss and physical disturbance of broad habitat types on the sea-floor. Assessment and reporting is completed if it is required by legislation, if it is part of initiatives in an EIA, or if the Danish EPA notifies that such information is to be submitted to the Danish EPA. *Habitat types on the sea floor* 6.5 N.A. 6.6 The marine habitat types under the Habitats Directive are achieving favourable conservation status according	*Losses and physical impacts* Data regarding loss and disturbance of seabed. *Habitat types on the sea-floor* Extent of habitat loss is calculated in km^2 and as a share of total area.	Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated.	*Losses and physical impacts* 6.4 No significant impact on the benthic habitats along the pipeline route have been identified (see 9.11.2, 10.1.2-Biodiversity (D1), Food webs (D4) and Sea-floor integrity (D6)). The final footprint on the habitat types on the seabed will be provided to the authorities when 'as built' documentation is available. *Habitat types on the sea-floor* 6.6. The project in Danish waters will not have impact on the habitats designated according to the Habitats Directive (see 9.19.2. Indicators: The final footprint on the habitat types on the seabed will be provided to the authorities when 'as built'

Targets for Danish Marine Strategy	Indicators	Environ-mental status 2018-2024	Assessment
to the time horizon laid down in the Habitats Directive. 6.7 N.A. 6.8 N.A. 6.9 N.A.			documentation are available. The impact is assessed as not significant. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 7 Hydrographical conditions 7.1 Human activities that are particularly associated with physical loss of the sea-floor, and which cause permanent hydrographical changes -only have local impacts on the sea-floor and in the water column, and -are designed to take account of the environment and what is technically possible and financially reasonable to prevent harmful effects on the seabed and in the water column. 7.2 In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority is encouraging reporting to the Danish Environmental Protection Agency (EPA) (monitoring programme) of hydrographical changes and the adverse effects of these. Assessment and reporting are completed if it is required by legislation, if it is part of initiatives in an EIA, or if the Danish EPA notifies that such information is to be submitted to the Danish EPA.	Area of hydrographical changes. Area per habitat type which is negatively impacted by hydrographical changes.	Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated.	7.1-7.2 The project will not have significant impacts on hydrographical conditions, which can influence sea-floor or water column (see 9.2.2, 9.3.2 and 10.1.2). Indicators: The project does not have negative impacts to indicators. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 8 Contaminants *Concentrations and health of species* 8.1 Coastal and territorial waters: Discharges of contaminants into water, sediment and living organisms may not lead to breaches of the environmental quality standards applied in current legislation (D8C1 and D8C2). 8.2 Emissions, discharges and losses of PBDE and mercury have ceased or been phased out. 8.3 N.A. 8.4 N.A. 8.5 N.A. *Acute pollution incidents* 8.6 The spatial extent and duration of acute pollution events is gradually reduced as much as possible through prevention, monitoring and risk-based scaling of	*Concentrations and health of species* Concentrations of contaminants in fish and mussels *Acute pollution incidents* Amount of illegal amount of oil spill from ships. Number of dead/killed	*Concentrations and health of species* Not good GES will not be reached before 2020. *Acute pollution incidents* It is expected that GES is partly reached by 2020 in Baltic Sea region.	*Concentrations and health of species* 8.1 Discharges from the project will not lead to breaches of environmental quality standards (see 9.2.2). 8.2 Project will not emit PBDE or Mercury. *Acute pollution incidents* 8.6 Risk assessments have been done and emergency preparedness described (Chapter 4). 8.7 The project will not pose risk to marine mammals and birds (Chapter 4). Indicators: The project will not give rise to significant

Targets for Danish Marine Strategy	Indicators	Environ-mental status 2018-2024	Assessment
contingency and response facilities (D8C3). 8.7 Adverse effects on marine mammals and birds from acute pollution events are being prevented and minimised as much as possible. For example, this may be secured by means of floating booms as well as through contingency plans for marine mammals and birds injured in oil spills (D8C4). 8.8 N.A.	birds as a consequence of significant acute pollutant incidents.		loads of contaminants, and will hence not impact fish or mussels (see 9.11.2 9.12.2 and 10.1.2-Contaminants (D8) and Contaminants in seafood (D9). The project will comply with legal requirements and hence not add to the indicator for acute pollution incidents. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 9 Contaminants in seafood 9.1 The trend in total Danish dioxin emissions into the air is not increasing significantly. 9.2 N.A. 9.3 N.A. 9.4 N.A.	Early emission of dioxins Concentrations of lead, cadmium, mercury, dioxin, and dioxin like PCB non-like dioxin PCB and benz(a)pyrene in the species of fish and shellfish which is chosen under marine strategy II.	GES is reached for several contaminants. GES is not reached for PCB and dioxin in all fish species.	9.1 Project will not emit dioxins (5.1.8), which can impact seafood. Indicators: The project will not release contaminants, which can lead to contaminants in fish and shellfish (indicators). Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.
Descriptor 10 Marine litter 10.1 -10.7 N.A: Not relevant because measures are taken to ensure that all waste will be brought back to land for disposal.	Not relevant	Not relevant	Not relevant
Descriptor 11 Energy including underwater noise 11.1 (D11C1) As far as possible, marine mammals under the Habitats Directive are not exposed to impulsive sounds that lead to permanent hearing loss (PTS). The limit value for PTS is currently assessed as 200 and 190 dB re.1 uPa2s SEL for seals and porpoise, respectively (the best knowledge currently available is on these species). However, it is likely that these limits will be revised as new knowledge on this field	Number of activites is files Number of impulse noise or sound pressure measured over the frequency	Threshold values has ot yet been determined, hence timeline for when GES is reached cannot be evaluated.	11.1, 11.2 Underwater noise modelling for UXO clearance has been prepared based on recommendations of threshold values from DCE. Threshold values are lower than indicated in Mitigation measures will be applied to reduce significant impacts on marine mammals (5.1.5, 9.13.2, 10.1.2-Energy and noise (D11)).

Targets for Danish Marine Strategy	Indicators	Environ-mental status 2018-2024	Assessment
becomes available. The values are the sound-exposure level accumulated over two hours. 11.2 (D11C1) Human activities causing impulsive sound are planned in such a way that direct adverse effects on vulnerable populations of marine animals from the spatial distribution, temporal extent, and levels of human impulsive sound are avoided as far as possible and such that these effects are assessed not to have long-term adverse effects on population levels. This could be ensured by carrying out the activity with relevant mitigation measures or by assigning it to periods of the year or to geographical areas in which the potential harm to animals is limited. 11.3 N.A. 11.4 N.A. 11.5 (D11C1) In connection with licensing offshore activities that require an environmental impact assessment (EIA), the approving authority encourages reporting to the Danish Environmental Protection Agency (EPA) (monitoring programme) of registrations of impulse noise. Assessment and reporting are completed if it is required by legislation, if it is part of initiatives in an EIA, or if the Danish EPA notifies that such information is to be submitted to the Danish EPA. 11.6 N.A. 11.7 N.A.	band 10 Hz-10kHz.		11.5 Assessments of impacts from underwater noise have been done (see 9.12.2, 9.13.2 and 10.1.2-Energy and noise (D11)) Indicator: The project will live up to the requirements stated for reporting of indicators for Descriptor 11, which will be specified in the final version of the Danish Marine Strategy II. Environmental status: The project will not impact the environmental status nor hinder the target of reaching GES.

10.1.4 Overall impact assessment of Baltic Pipe on MSFD

The overall conclusions regarding the impacts from the Baltic Pipe project on the descriptors in the MSFD, based on the assessments in Chapter 9 and in the sections above corresponding to impact assessments for each descriptor, are shown in Table 10-16. There will be no significant impacts on any of the 11 descriptors in the MSFD nor in the draft Danish Marine Strategy II from the Baltic Pipe project, and the project will not delay or prevent the achievement of the long-term goal for GES for any of the listed descriptors.

Table 10-16 Overall impact significance on the descriptors in the MSFD.

Descriptor	Severity of impact	Significance	Transboundary
D1, D4 and D6	Negligible to minor	Not significant	No
D2	Negligible	Not significant	No
D3	Negligible	Not significant	No
D5	Negligible	Not significant	No
D7	Negligible to minor	Not significant	No
D8 and D9	Negligible to minor	Not significant	No
D10	Not relevant	Not relevant	No
D11	Negligible	Not significant	No

10.2 Water Framework Directive

10.2.1 Baseline

The EU Water Framework Directive (WFD) is aimed at protecting and improving the water quality of streams and lakes, transitional waters (estuaries, lagoons, etc.), coastal waters and groundwater in all EU countries. The WFD also covers transitional and coastal waters up to one nautical mile off the coast for ecological status and 12 nautical miles (i.e. territorial waters) for chemical status (Figure 10-1). The Directive sets the framework for a range of environmental objectives and outlines the overall administrative structure for planning and implementing measures and for monitoring the aquatic environment.

The WFD came into force on 22 December 2000, and as noted in Section 7.6, the WFD has been implemented in Denmark through the Consolidated Act on Water Planning[75] and associated administrative orders. The Danish Ministry of the Environment (the authority responsible for implementing the WFD), published a management plan for each sub-region covering the period 2015 – 2021 in June 2016 in accordance with the legislation. The management plan for the Water Area District of Sjælland includes the main water area 2.6 "Østersøen" (which includes Faxe Bugt (SVANA, 2016a)) and the management plan for the Water Area District of Bornholm, which includes the main water area 3.1 Bornholm (SVANA, 2016b).

The environmental objective for the coastal waters in Denmark is to reach good ecological status (GES) by 2021, as stated in the Consolidated Act no. 1522 of 15/12/2017[76]. Good ecological status in relation to the WFD is determined by the ecological status of the key biological factors chlorophyll content, depth limit of eelgrass and DKI index for benthic fauna.

As outlined in Section 9.2, eutrophication will generally cause an increase in phytoplankton primary production, which will result in increased turbidity and an increase in sedimentation of organic matter to the seafloor. This may in turn cause oxygen depletion due to oxygen consumption caused by mineralisation and degradation of organic matter. Ultimately, hypoxia or anoxia may result, which can exert pressure on marine life, especially benthic fauna.

A more detailed description of the quality elements[77] of the coastal waters is presented in Chapter 9; the biological elements (phytoplankton, flora and fauna), the hydromorphological elements (bathymetry, seabed and water conditions) and the physical-chemical elements (water

[75] Consolidated Act no. 126 of 26/01/2017 on water planning *(Bekendtgørelse af lov om vandplanlægning)*.

[76] Consolidated Act no. 1522 of 15/12/2017 on environmental targets for surface waters and groundwater (Bekendtgørelse om miljømål for overfladevandområder og grundvandsforekomster)

[77] Consolidated Act no. 1001 of 29/6/2016 on monitoring on surface waters, groundwater and protected areas conditions etc. *(Bekendtgørelse om overvågning af overfladevandets, grundvandets og beskyttede områders tilstand og om naturovervågning af internationale naturbeskyttelsesområder)*, Annex 3.

transparency, temperature, oxygen conditions, salinity and nutrient levels, together with heavy metals and organics pollutants). The baseline description forms the basis for the assessments and the analyses of the potential impacts on the environmental objectives.

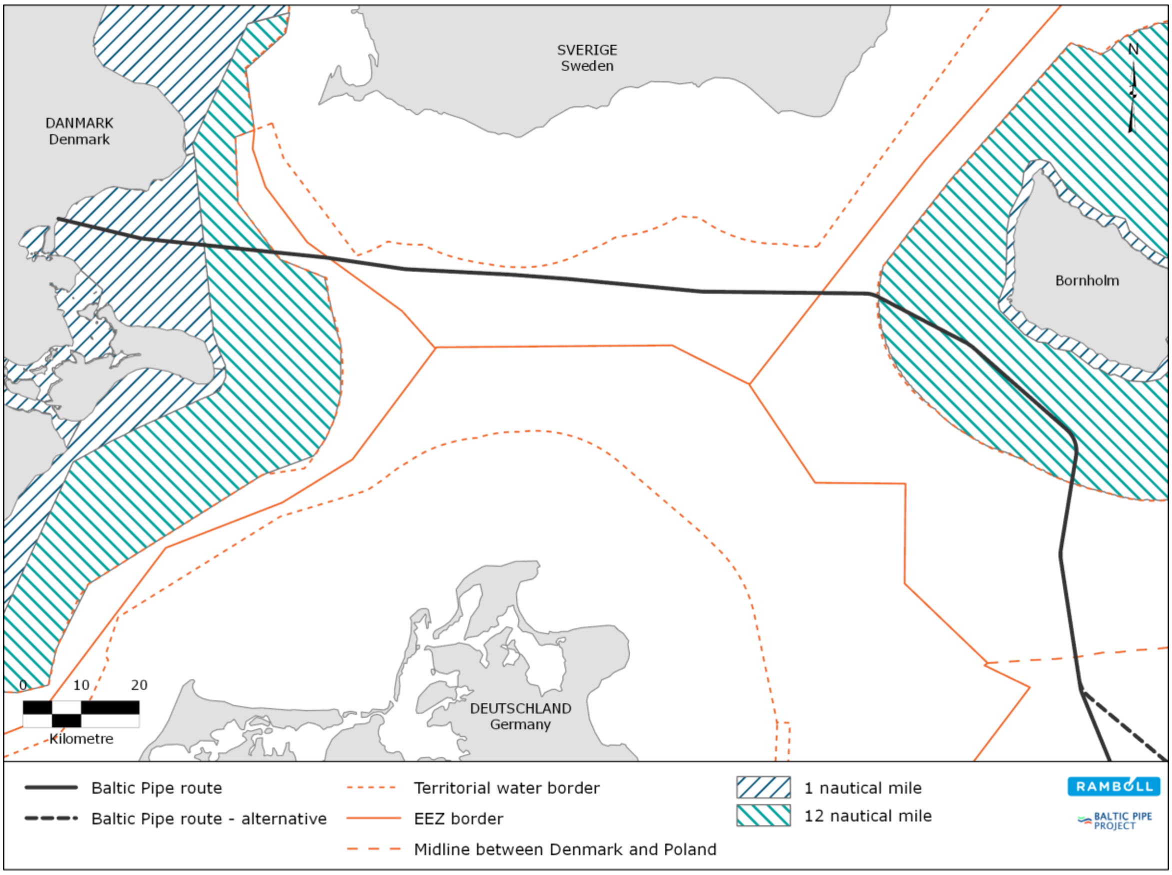

Figure 10-1 WFD coverage area, with zones showing the 1 nautical mile zone and 12 nautical mile zone in Danish waters.

Management plans for area 2.6, Østersøen (Baltic Sea), and for area 3.1, Bornholm, are both of relevance to the Baltic Pipe project, particularly the 1 nm and 12 nm zone in the Baltic Sea in Faxe Bugt and the 12 nm zone near Bornholm (Figure 10-1).

The current ecological status of the 1 nm zone in Faxe Bugt is moderate, based on measurements of depth limits of eelgrass Z*ostera marina*, which has not reached the depth limit of 8.1 m defining the lower depth limit for GES for eelgrass in this area[78]. The ecological status regarding concentrations of chlorophyll and benthic fauna in Faxe Bugt is considered "good", while the chemical conditions are unknown. Since GES relating to the 1 nm zone in the WFD is a result of the sum of all ecological and chemical indicators, GES for Faxe Bugt is moderate, equivalent to "not good" (Miljø- og Fødevareministeriet, 2016; SVANA, 2016b).
GES for the 12 nm zone at Bornholm is only related to the chemical status. The current chemical status within this 12 nm zone is "good" based on measurements of benzo(a)pyrene and fluoranthene levels in mussels (SVANA, 2016b). Benzo(a)pyrene and fluoranthene are on EU

[78] Consolidated Act no. on monitoring of surface water, groundwater and protected areas and international protected areas (Bekendtgørelse om overvågning af overfladevandets, grundvandets og beskyttede områders tilstand og om naturovervågning af internationale naturbeskyttelsesområder). (Depth limits for eelgrass in area OW3b, listed in app. 10)

prioritized list of chemicals, and threshold values for concentrations of these substances in biota can be found in Consolidated Act. no. 1625 of 19/12/2017[79]

10.2.2 Impact assessment

The planned Baltic Pipe project enters the 1 and 12 nm zones of Denmark in Faxe Bugt and the 12 nm zone at Bornholm (Figure 10-1).

The defining parameters for the 1 nm zone include the ecological status for the parameters eelgrass, chlorophyll and benthic fauna, as well as the chemical status. The defining parameter for the 12 nm zone is the chemical status. For the 1 nm zone, the main pressures on the marine environment in relation to the WFD comprise eutrophication (particularly related to nitrogen) and contaminants (e.g. metals). The following section assesses the potential for the Baltic Pipe project to impact (enhance) existing pressures. The potential impacts on the WFD are listed in Table 10-17.

Table 10-17 Potential impacts on the WFD.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediment	X	
Contaminants and nutrients	X	
Release of contaminants from anodes		X
Discharges to sea	X	

The following potential impacts have been scoped out:

- **Potential impacts on phytoplankton** (which corresponds to the WFD indicator chlorophyll) from the Baltic Pipe project have been screened out in Section 9.10. Thus, no significant impacts on the concentrations of chlorophyll will occur due to the Baltic Pipe project, and the project will not enhance the existing pressure from eutrophication on chlorophyll concentrations.

<u>Physical disturbance of seabed</u>

Impacts of suspended sediments on the WFD parameters eelgrass and benthic fauna have been assessed in Section 9.11 and assessed in relation to the MFSD under the assessments of descriptor D1, D4 and D6 (Section 10.1.2).

The assessments have shown that physical disturbance of sediments will not result in a significant impact on the depth limit of eelgrass, as the dredged materials from tunnelling will be deposited at 7 m depth, were no eelgrass is present. On this basis, there will be no significant impacts from physical disturbance of the seabed on the WFD indicator eelgrass and no enhancement of the primary existing pressure from eutrophication on the depth limit for eelgrass.

Impacts from the physical disturbance of the seabed will not result in changes in the benthic habitat type, and therefore the intensity of the impacts on benthic communities from the construction work are assessed to be not significant (Section 9.11). Based on this, there will be no significant effects from the physical disturbance of the seabed on the WFD indicator benthic fauna and no enhancement of the primary existing pressure on benthic fauna from eutrophication and the associated risk of hypoxia.

[79] Consolidated Act. no. 1625 of 19/12/2017 on determination of environmental targets for streams, lakes, transitional waters, coastal waters and groundwater (Bekendtgørelse om fastlæggelse af miljømål for vandløb, søer, overgangsvande, kystvande og grundvand).

<u>Suspended sediments</u>
As the increase in SSC will be temporary and with low concentrations outside the construction site, impacts on eelgrass and benthic fauna have been assessed not to be significant (Section 9.11). Based on this, there will be no significant effects of suspended sediment on the WFD indicators eelgrass and benthic fauna and no enhancement of existing pressures from eutrophication.

<u>Contaminants and nutrients</u>
The release of contaminants from the seabed sediments has been assessed in Section 9.3. and no significant impacts on the levels or toxicity of chemicals due to reactivation are expected during the construction of the Baltic Pipe project. Since there will be no addition of chemicals to the Baltic Sea due to the construction of the Baltic Pipe project and no significant enhancement of bioavailable chemicals that could affect the different trophic levels in the marine ecosystem (Section 9.3), there no significant impacts from contaminants and nutrients on the chemical status within the areas covered by the WFD are anticipated.

<u>Release of contaminants from anodes</u>
The concentrations of aluminium released to the water column as a result of anode degradation during the operational phase will generally be indistinguishable from background concentrations (Section 5.1.3) and impacts on the chemical status within the areas covered by the WFD are therefore assessed to be not significant.

<u>Discharges to sea</u>
As outlined in Section 5.1.11, discharges to sea will take place as part of the pre-commissioning activities. Potential impacts from discharges to sea have been assessed in Section 9.2. The water quality will only be impacted temporarily and locally by the decrease in oxygen concentration caused by the discharge of pressure test water and will revert naturally and rapidly to pre-impact status once the activities cease. The chemicals that may be used in the pressure test water are classified as PLONOR, i.e. causing little or no harm to the environment and not resulting in a significant impact on the levels of contaminants in the water. Based on these assessments, the impacts of discharges to sea on water quality are not significant. There will be no significant effects on oxygen content, which could possibly affect the key factor benthic fauna, and no significant effect on the levels of contaminants.

10.2.3 Overall impact assessment of Baltic Pipe on WFD

Based on the assessments of the potential impacts listed in Table 10-18, no significant impacts are anticipated on the indicators chlorophyll, eelgrass or benthic fauna. Thus, the Baltic Pipe project will not affect the target of reaching GES for these parameters.

Overall, it is concluded that the Baltic Pipe project will not have a significant impact on the water quality and thus will not affect the possibility of attaining good ecological and chemical status within the 1 nm and 12 nm zones in the main water area of 2.6 Østersøen and 3.1. Bornholm, as shown in Table 10-18. Impacts will not be transboundary.

Table 10-18 Overall impact significance for the indicators of the WFD after implementation of mitigation measures for potential impacts on eelgrass.

Indicator	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Chlorophyll	Low	Minor	Local	Short-term	Negligible	Not significant
Eelgrass	High	Minor	Local	Long-term	Minor	Not significant
Benthic fauna	Low	Minor	Local	Short-term	Minor	Not significant
Chemical status	Low	Minor	Local to regional	Short-term to permanent	Negligible	Not significant

10.3 HELCOM Baltic Sea Action Plan

10.3.1 Baseline

The Baltic Marine Environment Protection Commission - Helsinki Commission, in short called HELCOM, was established in 1974. As noted in Section 7.4.4, HELCOM is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, known as the Helsinki Convention of 1992.

In 2007, the HELCOM Baltic Sea Action Plan (BSAP) was adopted by the HELCOM members, and the plan has since been updated regularly. The BSAP is an ambitious programme to restore the good ecological status of the Baltic marine environment by 2021 (HELCOM, 2007).

The vision for the BSAP is to ensure a healthy environment in the Baltic Sea, with diverse biological components functioning in balance, resulting in good environmental/ecological status, and further supporting a wide range of sustainable human economics and social activities (HELCOM, 2007).

The main goals and objectives 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
- has environmentally friendly maritime activities.

As for the MSFD, the BSAP adopts an ecosystem approach, which focuses on how human activities impact the marine environment and the marine ecosystem (HELCOM, 2007).

The status for eutrophication and hazardous substances (contaminants) in relation to the Baltic Sea has been assessed in the first version of the report on the state of the Baltic Sea (HELCOM, 2017c). While inputs of nutrients from land have decreased, the effects of these measures are not yet generally reflected in the status of the marine environment. Levels of contaminants are elevated and continue giving cause for concern; however, acute pollution events from oil spills have decreased.

Biodiversity and maritime activities are also focus areas in the BSAP. Impacts from the Baltic Pipe project in regard to the focus area Maritime Activities, can be linked to eutrophication, contaminants and non-indigenous species.

10.3.2 Impact assessment

In the following section, the potential for the Baltic Pipe project to impact the BSAP focus points eutrophication, contaminants, biodiversity and marine activities via the sources of impact identified in Table 10-19 is assessed.

Table 10-19 Potential impacts on the BSAP.

Potential impact	Construction	Operation
Physical disturbance of seabed	X	
Suspended sediment	X	
Contaminants and nutrients	X	
Non-indigenous species	X	
Underwater noise	X	

Physical disturbance of seabed, Suspended sediment and Contaminants and nutrients

Impacts from the physical disturbance of the seabed and suspended sediment relate to the indicator eutrophication in the BSAP, while impacts from contaminants and nutrients relate to both the indicators eutrophication and hazardous substances.

Potential impacts from the Baltic Pipe project regarding eutrophication and hazardous substances have already been assessed in Sections 9.2 and 9.3, and in Section 9.10, the potential impacts on phytoplankton from the Baltic Pipe project have been screened out.

As for the MSFD (Section 10.1.2 under the assessment of impacts on descriptors D5 and D8/D9) and the WFD (Section 10.2.2), it is concluded that the Baltic Pipe project will not result in the release of contaminants and nutrients that are distinguishable from the high background concentrations in the Baltic Sea. In addition, the Baltic Pipe project will not result in the enhancement of bioavailable chemicals. Thus, the Baltic Pipe project will have a negligible and not significant impact on the level of eutrophication and hazardous substances in Danish waters and the project will not act as a barrier in preventing the Member States from reaching the target for eutrophication or hazardous substances in the BSAP.

Non-indigenous species

As outlined in Section 10.1.2 (under the assessment for descriptor D2) the potential impacts from the introduction of NIS into the Baltic Sea during the construction phase are conservatively assessed to be negligible due to the implementation of standard mitigation measures (Section 5.1.9). Thus, the Baltic Pipe project will have a negligible and not significant impact regarding the introduction of NIS into the Baltic Sea. On this basis, the potential impact of NIS on the biodiversity in the Baltic Sea will not be significant.

Underwater noise

Sources of underwater noise in relation to the Baltic Pipe project have been described in Section 5.1.5. Underwater noise from vessels will be indistinguishable from background noise, while construction activities such as rock installation may potentially impact fish and marine mammals. However, as outlined in the impact assessments on underwater noise in relation to fish (Section 9.12) and marine mammals (Section 9.13), as well as for the descriptor D11 Energy and noise in the MSFD (Section 10.1.2), no significant impacts from underwater noise during the construction phase are likely to occur on the populations of fish or marine mammals.

<u>Unplanned events – underwater noise</u>

In the unlikely event of munitions clearance, there is a risk of impacts on fish and marine mammals. However, when mitigation measures are implemented (Section 9.12, 9.13 and

Section10.1.2 under the assessment for descriptor D11), there will be no significant effects on populations of either fish or marine mammals.

Based on the impact assessments regarding underwater noise, the Baltic Pipe project will not have a significant impact on the amount of underwater noise in the Baltic Sea.

10.3.3 Overall impact assessment of Baltic Pipe on BSAP

Based on the above assessments of the impacts listed in Table 10-19 no significant impacts from the Baltic Pipe project on the focus areas eutrophication, hazardous substances, biodiversity and marine activities is anticipated. Thus, the Baltic Pipe project will not affect the target of reaching GES for these parameters.

Overall it is concluded that the Baltic Pipe project will not have significant impact on the main goals and objectives of the BSAP (Table 10-20).

Table 10-20 Overall impact significance on the goals of the Baltic Sea Action Plan.

BSAP goal	Sensitivity	Magnitude of impact			Severity of impact	Significance
		Intensity	Scale	Duration		
Eutrophication	Low	Minor	Local	Short-term	Negligible	Not significant
Hazardous substances	Low to high	Minor	Local	Short-term	Negligible	Not significant
Biodiversity	Low	Minor	Local to regional	Short-term to permanent	Negligible	Not significant
Marine Activities	Low	Minor	Local to regional	Short-term to permanent	Negligible	Not significant

11. CUMULATIVE IMPACTS

Cumulative environmental impacts can be defined as effects on the environment, which are caused by the combined results of activities from the present project activity in combination with other projects. The project itself may generate insignificant impacts, but in combination with similar projects cause a significant impact on one or more environmental receptors.

This chapter describes the existing and/or approved projects, which can have potential cumulative impacts with construction and/or operation of the Baltic Pipe. These projects are shown in Figure 11-1 and listed in Table 11-1. In addition to the existing and/or approved projects, an assessment of the potential cumulative impacts for the three sections of the pipeline (Denmark; Sweden and Poland) have been done in Section 11.4.

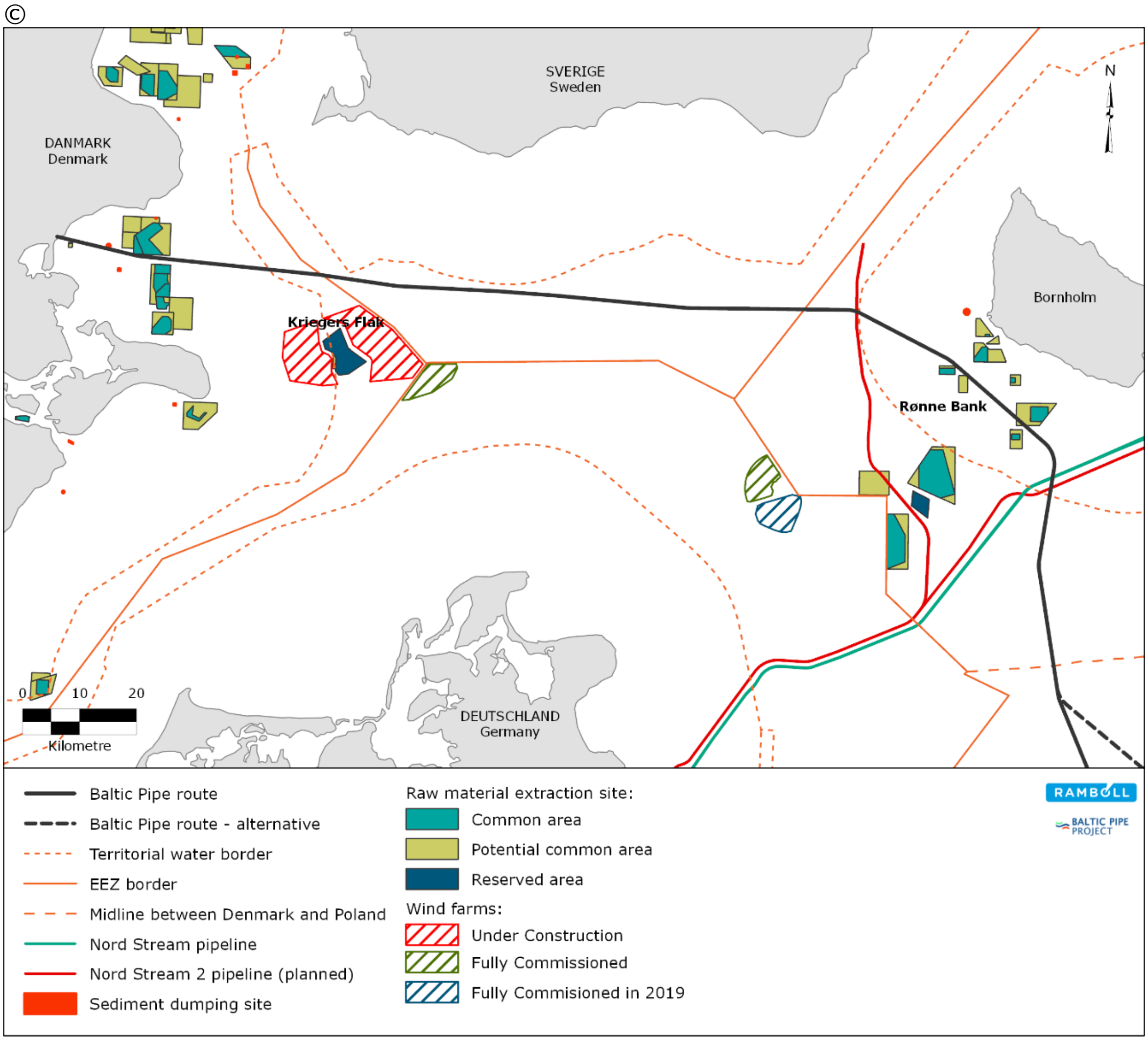

Figure 11-1 Areal restrictions (known projects) for the Arkona Basin.

In the southwestern part of the Baltic Sea, numerous activities, areal restrictions and projects are identified, comprising:

- Raw material extraction sites;
- Sediment dumping sites;
- Offshore wind farms;
- Infrastructure projects.

Projects are deemed relevant to include in this assessment based on:

- The timeframe of the project (both the life cycle and the potential impacts);
- Whether the project is placed within the same geographical area as the Baltic Pipe project;
- Whether the impact type is similar to the impacts for the Baltic Pipe project or can have an impact on the same receptors as the Baltic Pipe project.

Projects have not been included if they are outside the geographical boundary of potential impact (Chapter 5), if there are no impacts on the environment.

Table 11-1 Plans and projects in Danish waters and adjacent waters relevant in connection with construction and operation of the Baltic Pipe.

Project	Location	Shortest distance to pipeline	Timeframe of project	Included in assessment	Reasoning
Raw material extraction sites					
Potential common areas	-	-	Not active sites, bit can be in the future	No	As the sites are not currently active, they are not included in the assessment.
Krieger's Flak	Krieger's Flak	8.5 km	Sep 2017 - Sep 2027 potentially for a longer period	Yes	See assessment below
520-AA, DA, EA, EB, EC, EF, EG, FA Common areas	Faxe Bugt	0.2 km	No specific timing – potentially all year	Yes	See assessment below
526-CA, DA, EA, HA, IA, JA Common areas	Between Bornholm and Rønne Banke	0.5 km	No specific timing – potentially all year	Yes	See assessment below
Dumping sites					
Sandhage Rende (K_046_01)	Faxe Bugt	2.8 km	All year	No	Potential cumulative impacts include: • Suspended sediment; • Physical disturbance above water.

Project	Location	Shortest distance to pipeline	Timeframe of project	Included in assessment	Reasoning
					In the dumping permission, it is specified that the material planned for dumping is the same type of sediment as at the dumping site, and that the sediment is not contaminated. The permit is valid for 5 years (2016-2020) and allows for 75,000 m^3 dumped material. Only a very limited amount of suspended sediment and increased ship traffic will potentially coincide with BP construction activities. It is therefore not likely that there will be cumulative impacts from this activity and the project.
Faxe Ladeplads (K_046_03)	Faxe Bugt	0.1 km	All year	No	Potential cumulative impacts include: • Suspended sediment; • Physical disturbance above water. In the dumping permit, it is specified that the material planned for dumping is the same type of sediment as at the dumping site, and that the sediment is not contaminated. The permit is valid for 5 years (2017-2022) and allows for 100,000 m^3 (20,000 m^3/year) dumped material. Only a very limited amount of suspended sediment and increased ship traffic will potentially coincide with BP construction activities. It is therefore not likely that there will be cumulative impacts from this activity and the project.
Offshore wind farms (OWF)					
OWF Wikinger (DE)	SW of Rønne Banke	25.5 km	Existing	No	Due to the distance between the pipeline and the OWF, the site is not included in the assessment.

Project	Location	Shortest distance to pipeline	Timeframe of project	Included in assessment	Reasoning
OWF EnBW Baltic 2 (DE)	Krieger's Flak	13.1 km	Existing	No	Due to the distance between the pipeline and the OWF, the site is not included in the assessment.
Arkona OWF (DE)	SW of Rønne Banke	33 km	Fully commissioned in 2019	No	Due to the distance between the pipeline and the OWF, the site is not included in the assessment.
Krieger's Flak OWF (DK)	Krieger's Flak	5.3 km	Under construction February 2018-2022	Yes	See assessment below
Other infrastructural projects					
Various sea cables	-	Multiple cables (Section 9.27)	Existing	No	Multiple existing cables will be crossed by the pipeline. Potential cumulative impacts include: • Presence of the pipeline (reduced water depth; changed habitat; changes in local water currents). Construction of crossings will be planned so impacts on environmental receptors will be limited. Impacts will be local, and the cumulative impacts on environmental receptors are not likely to be significant.
Nord Stream (NSP)	South of Bornholm	Crossing	Existing	Yes	See assessment below
Nord Stream 2 (NSP2)	To alternatives; west and south-east of Bornholm	Crossing	Permit for construction not yet obtained in Danish TW	Yes	See assessment below

11.1 Raw material extraction sites

Raw material extraction sites (Table 11-1) can have a cumulative impact with the Baltic Pipe construction activities.

The site Krieger's Flak is reserved for construction activities[80], primarily for the Fehmarn Belt Fixed Link. Dates for offshore construction are not fixed, and at present, there are no valid permits for extraction for this project. In addition, The Danish Road Directorate has permission to extract raw materials at Krieger's Flak for use in construction of the Storstrøm's Bridge (permission no. 552-AB). The permission runs from 1 September 2017 to 1 September 2027.

[80] BEK 136 af 01/02/2012 - Bekendtgørelse om reservation af råstoffer i områder på Kriegers Flak og Rønne Banke.

Other raw material extraction sites (Table 11-1) are found in the relatively close vicinity of the pipeline. Details of extraction activities are not available and can change during the construction period due to the status of the extraction sites.

Cumulative impacts from all types of raw material extraction sites can occur from:

- Suspended sediment;
- Physical disturbance above water.

Assessments of the potential cumulative impacts are shown in Table 11-2.

Table 11-2 Cumulative assessment for raw material extraction sites and the Baltic Pipe.

Potential impact	Impacts from raw material extraction sites	Impacts from the Baltic Pipe	Cumulative assessment
Suspended sediment (construction and operation)	*Construction: n.a.* *Operation:* Modelling of sediment dispersion of increased SSC performed in connection with an EIA for sand extraction in the Arkona Basin (e.g. Rønne Banke and Krieger's Flak, (FEMA, 2013c; FEMA, 2013d)) has shown that the spill is limited and mostly found in concentrations above 2 mg/l inside the extraction sites. Concentrations of 2 mg/l seen outside the extraction sites are quickly dispersed (i.e. within 2-3 days).	*Construction*: Results from the modelling of sediment spill are shown in Section 5.1.2. The spill is limited in intensity, scale and duration, as in most of the area, the duration of SSC above 10 mg/l is less than one day, and SSC above 10 mg/l occurs in no areas for a period of more than 4 days. *Operation: n.a.*	Modelling results for the construction of the Baltic Pipe and the known sediment dispersion caused by extraction activities show that there is a potential for coinciding sediment dispersion from both projects. As the suspended sediment from both the extraction activities and the construction activities are very limited in intensity, scale and duration, a significant cumulative impact on environmental receptors is not likely to occur.
Physical disturbance above water (ship traffic, noise, light etc.) (construction and operation)	*Construction: n.a.* *Operation:* Ship traffic from extraction activities will occur within the extraction area and along the route to the destination harbour. The impact is hence local and limited to these locations.	*Construction*: Ship traffic from construction activities will occur along the pipeline route and between the designated harbour (which is to be determined) to the route. The impact is hence local and immediate. *Operation:* Maintenance traffic during operation will be limited to a couple of times of year and is not likely to have any significant cumulative impact.	Extraction activities and construction and operational activities can potentially coincide, but as both activities have a low intensity and impacts are limited to the close vicinity of the activities and are of short-term nature, significant cumulative impacts are negligible and not likely to be significant on environmental receptors.
Underwater noise (construction and operation)	*Construction: n.a.* *Operation:* Underwater noise from will arise during extraction activities. Depending on the selected dredging method, noise levels can vary from only perceptible near the site (max 1 km) to farther away (CEDA, 2011). As the	*Construction*: As described in Section 5.1.5, the underwater noise generated from the construction activities will not be distinguishable from the ambient noise levels, as the background levels in the Baltic Sea, where there are already large volumes of ship traffic, are relatively high	Cumulative impacts on receptors such as marine mammals and fish from underwater noise from extraction activities and the Baltic Pipe project are not likely to occur, as the level of underwater noise will remain within the background level. Impacts are not likely to be significant.

Potential impact	Impacts from raw material extraction sites	Impacts from the Baltic Pipe	Cumulative assessment
	background level of underwater sound in the Baltic Sea is very high, noise from dredging activities is often not distinguishable from the background levels.	(Section 9.5). The duration will be immediate and will cease after the activity has ended. *Operation:* There are no impacts from underwater noise during operation.	

Conclusion

Based on the assessments in Table 11-2, impacts on receptors due to a cumulative impact from raw material extraction and the Baltic Pipe project will be negligible and hence not significant.

11.2 Offshore wind farms

11.2.1 Krieger's Flak

Construction of the OWF Krieger's Flak (DK) is ongoing until 2022. So far, the foundations for the transformer stations have been established (2018), but further detailed plans for the construction works offshore for this project are not known. Pipeline construction works for the Baltic Pipe landfall and offshore components are planned to start in October 2020, with operation of the pipeline commencing in March 2022, so an overlap between the construction works can occur, and a cumulative risk is present. Cumulative impacts may arise from the following potential impacts:

- Suspended sediment;
- Underwater noise;
- Physical disturbance above water.

In Table 11-3 the potential cumulative impacts and the related assessments are presented. The assessments are based on information from previous sections in Chapter 9.

Table 11-3 Cumulative assessment between OWF Krieger's Flak and the Baltic Pipe.

Potential impact	Impacts from Krieger's Flak	Impacts from the Baltic Pipe	Cumulative assessment
Suspended sediment (construction)	*Construction:* Establishment of foundations 2019-2020, with mono-piling and establishment of foundations, where sediment dispersion can take place. In the EIA for the OWF, the sediment dispersion was modelled (NIRAS & COWI 2015), and the results show that sediment dispersion will be local and short-term. *Operation: n.a.*	*Construction*: The results from modelling of sediment spill are shown in Section 5.1.2. The spill is limited in intensity, scale and duration, as in most of the area the duration of SSC above 10 mg/l is less than one day, and SSC above 10 mg/l occurs in no areas for a period of more than 4 days. *Operation: n.a.*	The potential impact due to dispersed sediment from both projects would still be of low intensity, immediate to short-term and local to regional. As such, a significant cumulative impact is not likely to occur, especially due to the expected duration and concentrations of the suspended sediment.

Potential impact	Impacts from Krieger's Flak	Impacts from the Baltic Pipe	Cumulative assessment
Underwater noise (construction)	*Construction:* Establishment of foundations 2019-2020, with mono piling and establishment of foundations. Impacts on fish (local) and marine mammals (local-regional) are expected during construction (NIRAS & COWI 2015). *Operation: n.a. (due to the distance between the two projects)*	*Construction*: Offshore and nearshore construction is planned to start in April 2020, with operation of the pipeline in June 2022. As described in Section 5.1.5, the underwater noise generated from the construction activities are not distinguishable from the ambient noise levels, as the background levels in the Baltic Sea, where there are already large volumes of ship traffic, are relatively high (Section 9.5). The duration will be immediate and will cease after the activity has ended for all environmental receptors. Impacts from underwater noise will be of negligible to minor impact severity and not significant for all receptors. *Operation:* There are no impacts from underwater noise during operation.	As impacts from construction activities for the Baltic Pipe project are local and immediate, the cumulative impact with the construction of Krieger's Flak is of minor impact severity and not significant.
Physical disturbance above water (construction and operation)	*Construction*: Construction work will take place in the period 2019-2021, where ship traffic will be continuous. Underwater noise due to ship traffic is assessed as minor due to the temporary and local character and insignificant contribution to the already heavily trafficked area (NIRAS & COWI 2015). *Operation:* Details about ship traffic activities for maintenance are not known.	*Construction*: Impacts from physical disturbance above water is related to seals and birds. Impacts due to the Baltic Pipe project on these two receptors are assessed as negligible/minor and not significant. *Operation:* Maintenance traffic during operation will be limited to a few times per year and is not likely to have any significant cumulative impact.	Ship traffic from construction works on both projects could potentially be cumulative, but details on activities are not known. As ship traffic will be local for both projects and as ship traffic to/from harbours will travel along already existing ship routes, cumulative impacts are not likely to occur.

Conclusion

Based on the assessments in Table 11-3, impacts on receptors due to a cumulative impact from the construction of the OWF Krieger's Flak and the Baltic Pipe project will be negligible and hence not significant. If munitions clearance (both projects) should be unavoidable and coincide with pile driving activities for Krieger's Flak, a potential cumulative impact on marine mammals could occur. As the timing of these activities is not known, it is not possible to draw conclusions on the significance of the resulting potential impact.

11.3 Pipelines

11.3.1 Nord Stream

The Nord Stream Pipeline (NSP) is a gas pipeline established in 2010-2012 and running through the Baltic Sea from Russia to Germany. The pipeline will be crossed by Baltic Pipe in the sea south of Bornholm. Potential impacts during operation of NSP and the construction and operation of the Baltic Pipe include:

- Presence of pipelines;
- Physical disturbance above water.

Table 11-4 presents the potential cumulative impacts and the related assessments. The assessments are based on information from the previous sections in Chapter 9.

Table 11-4 Cumulative assessment for Nord Stream on receptors for the Baltic Pipe.

Potential impact	Impacts from Nord Stream	Impacts from Baltic Pipe	Cumulative assessment
Presence of pipeline (operation)	*Construction: n.a.* *Operation:* The pipeline is buried in the seabed in many areas but will in some areas be above seabed level and have created a new hard substrate (where blue mussels are the primary fauna (Rambøll O&G / Nord Stream AG, 2014a)). As the pipeline is buried in large parts of the route, impacts on commercial fisheries are not significant.	*Construction: n.a.* *Operation:* Most of the pipeline will be buried partially or entirely into the seabed, and therefore the pipeline will not change the bathymetry of the seabed. Impacts on marine life and commercial fisheries are assessed to be of negligible and minor severity, respectively.	The cumulative impact on the marine environment will be very local around the crossing of the two pipelines, and not significant. The impact on commercial fisheries will also be local and have only a negligible impact. The cumulative impact is assessed as negligible and not significant.
Physical disturbance above water (operation)	*Construction: n.a.* *Operation:* Maintenance traffic will be limited to inspection vessels operating periodically and is not likely to have any significant impact on receptors.	*Construction*: Offshore and nearshore construction is planned to start in April 2020, with operation of the pipeline in June 2022. *Operation:* Maintenance traffic during operation will be limited to a few times per year and is not likely to have any significant impact on receptors.	Physical disturbance above water is not likely to have any significant cumulative impact as it will be immediate, local and with no or only minor impact.

Conclusion

Based on the assessments in Table 11-4, impacts on receptors due to a cumulative impact from the operation of NSP and the construction and operation of the Baltic Pipe project will be negligible and hence not significant.

11.3.2 Nord Stream 2

NSP2 is a planned gas pipeline running from Russia to Germany through Danish waters (Figure 11-1). Permits for construction have not yet been given by the Danish authorities, but applications for two alternatives in Danish waters have been submitted.

Construction works offshore are planned to run from 2018 to 2019 (third quarter) in the Danish sector for the south-eastern alternative. No construction plans have been published for the north-western alternative. As the Baltic Pipe seabed intervention works offshore have been planned to start in September 2020, there is no risk of cumulative impacts from construction works. Should the timeframe of the two projects change, this evaluation must be updated.

During the operational phase, potential cumulative impacts relate to the crossings of the pipelines. Here rock installations will be placed and will create a new structure on the seabed. Impact on the physical-chemical, biological and socio-economic environments have been assessed (Chapter 9). None of the potentially impacted receptors are assessed as significant. Impacts will be very local around the crossing of the two pipelines, and not significant for the marine environment.

The impact on commercial fisheries will also be local and have only a negligible impact.

The cumulative impact is assessed as negligible and not significant.

11.4 Baltic Pipe entire route

In the previous section cumulative impacts have been assessed in relation to other plans and projects in the Baltic Sea Region. In principle, given the size of the Baltic Pipe project, cumulative impacts can also arise within the project itself when all impacts of the three countries are superimposed.
The potential for such cumulative impact depends on:

- The timeframe of the construction in the different sections of the project;
- Whether the impact type in the one section is similar to the impacts for the remaining sections or can have an impact on the same receptors.

Analysing the envisaged timeframe for the construction works (see Chapter 3) it is revealed that only landfall construction in the nearshore areas in Denmark and Poland will occur simultaneously. Both activities cause small scale disturbance of nearshore habitats. However, the nearshore habitats are different in Poland and Denmark, and none of the potential impacts will be of a transboundary character. Cumulative impacts on equal receptors can be excluded.

Offshore construction is planned as a continuous process starting from the nearshore section in either Denmark or Poland terminating at the other nearshore section.

Significant impacts on environmental receptors from short-term potential impacts such as sediment dispersion, underwater noise, presence of vessels etc. have not been identified in Denmark and are hence not foreseen for Sweden and Poland as the impact intensity will be of same character. As impacts will not occur simultaneously the impact is not likely to be cumulative.

Long-term or permanent impacts, such as seabed intervention work and presence of pipeline can have a local impact on environmental receptors, which is assessed not significant in the Danish EIA. By considering the entire route the absolute size of the impact is scaled up. However, as the reference area is equally scaled up, the significance is not changed, and cumulative impacts on the environment from the project as a hole can be excluded.

11.5 Unplanned events

In connection with the risk assessments (Chapter 4), it has been identified that clearance of UXO may pose a risk during the construction phase. Based on the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapter 4 and 5).

Munitions clearance can potentially have a cumulative impact with other activities that generate high levels of underwater noise. The only other project for which this is possible is the establishment of the OWF Krieger's Flak, where pile driving of foundations gives rise to high levels of underwater noise.

Simultaneous construction by pile driving activities (Krieger's Flak) and a potential munitions clearance (Krieger's Flak and the Baltic Pipe) could potentially have a cumulative and significant impact on marine mammals. As assessed in Section 9.13 the risk of blast injury is reduced to a negligible level if mitigation measures are applied. In addition, the zone of PTS is reduced to a moderate, but not significant, impact on marine mammals, if seal scarers are applied.

As the timing of pile driving and the potential and unplanned event of munitions clearance are unknown, it is not possible to conclude on the likelihood of a cumulative impact on marine mammals.

11.6 Conclusion

Overall, cumulative impacts from existing and planned projects and the planned project activities for the Baltic Pipe project are not likely to have a significant impact on the marine environment (Table 11-5).

Table 11-5 Overall conclusion for the cumulative assessments in connections with construction and operation of Baltic Pipe.

Projects	Timeframe of project	Cumulative assessment
Baltic Pipe	**Construction: April 2020 – June 2022*** **Operation: 2022-2072**	**-**
Raw material extraction sites	No specific timing – potential all year	Negligible/not significant
Krieger's Flak OWF (DK)	Construction: Feb 2018 to 2022	Negligible/not significant
Nord Stream (NSP)	Existing	Negligible/not significant
Nord Stream 2 (NSP2)	**	Negligible/not significant

* As cumulative impacts are potentially only occurring offshore, only offshore construction is outlined (Section 3.6 – Project description).

** Construction permit not granted in Denmark.

12. TRANSBOUNDARY IMPACTS

A transboundary impact is an impact caused by the project, which extends across national borders. The transboundary impact on the environment is assessed in accordance with Danish EIA law (Section 20(4), Section 38 and Annex 7(5)[81]).

Within the project area, Denmark shares borders with Sweden, Germany and Poland, which are the countries in which a potential transboundary impact are most likely to occur. Impacts on a more regional/global scale will also be addressed, if relevant.

In this chapter, a summary of the transboundary impacts for each of the receptors that have been identified in Chapter 9 as transboundary in nature, are summarised and assessed.

In addition to this transboundary chapter, which has its basis in the Danish EIA law, an Espoo process is being held parallel to the EIA processes in Denmark, Sweden, and Poland. See Chapter 7 for more details on the Espoo process.

12.1 Transboundary impact assessment for planned project activities

Potential impacts, which have been identified as having a transboundary nature are presented in Table 12-1.

Table 12-1 Potential impacts with a transboundary nature, together with the receptor affected by the potential impacts. In addition, it is indicated whether a significant transboundary impact has been identified (in Chapter 9).

Receptor	Potential impact	Construction	Operation	Transboundary impact significance
Climate and air quality (offshore)	Emissions to air (CO_2 emissions)	X	X	Not significant
Climate and air quality (onshore)	Emissions to air (CO_2 emissions)	X	X	Not significant
Commercial fisheries	Safety zones Restriction zone Presence of pipeline Physical disturbance above water	X	X	Not significant

The following potential impacts, which could have a transboundary character, have been identified as not being transboundary in nature:

- Suspended sediment;
- Sedimentation;
- Contaminants and nutrients;
- Underwater noise;
- Physical disturbance above water.

The potential transboundary impacts on the receptors identified in Table 12-1 are assessed in the sections below.

[81] Consolidated Act no. 1225 of 25/10/2018 on environmental assessment of plans and programmes and specific projects (EIA) *(bekendtgørelse af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM)).*

12.1.1 Climate and air quality (offshore)

CO_2 emissions from construction of the Baltic Pipe in the Danish part of the Baltic Sea will account for approximately 0.7% of the total annual Danish CO_2 emissions, compared to 2016 emissions, and for approximately 1.9% of CO_2 emissions from vessels in the Baltic Sea. CO_2 emissions from operation are assessed to be negligible, as the yearly emissions will constitute less than 0.003‰ of the total annual emissions from vessels operating in the Baltic Sea and even less of the total annual Danish CO_2 emissions. The overall contribution of the CO_2 emissions from the Danish offshore Baltic Pipe is assessed to be not significant, as the duration is long-term (though in very minor quantities), and the impact is of minor severity at the local scale and negligible in a transboundary context. Detailed assessments of onshore climate and air quality are provided in Section 9.4.

The CO_2 emissions from the total Baltic Pipe project in Denmark will be assessed jointly in the Environmental Impact Assessment for the Baltic Pipe project – Introduction and overall conclusion report.

12.1.2 Climate and air quality (onshore)

Onshore, the yearly emissions of CO_2 will constitute approximately 0.001% of the total annual Danish CO_2 emissions, and hence the CO_2 emissions from onshore construction are considered negligible, both locally and in a transboundary context. Detailed assessments for onshore climate and air quality are provided in Section 9.8.

The CO_2 emissions from the total Baltic Pipe project in Denmark will be assessed jointly in the Environmental Impact Assessment for the Baltic Pipe project – Introduction and overall conclusion report.

12.1.3 Commercial fisheries

All Baltic coastal states, except Russia, are members of the European Union, with their fisheries activities being regulated by the EU Common Fisheries Policy. In 2006, the EU and Russia agreed to a bilateral framework fisheries agreement. Potential impacts on commercial fisheries of all nationalities fishing in Danish waters, can be impacted in the same way as the Danish commercial fisheries.

Given the imposition of safety zones around project-related vessels, the restriction zone around the pipeline and the presence of the pipeline on the seabed, the Baltic Pipe project will affect the fishable area available for the Baltic coastal states. However, once the pipeline is constructed, it will occupy less than 1% of the total fishable area in the Arkona and Bornholm Basins, see Table 9-125, so even though there will be a transboundary (socio-economic) impact for fisheries of other nationalities fishing in Danish waters, the impact will not be significant. Detailed assessments for commercial fisheries are provided in Section 9.25.

12.2 Transboundary impacts from unplanned events

12.2.1 Underwater noise

In connection with the risk assessments (Chapter 4), it has been identified that munitions clearance of UXO may pose a risk during the construction phase. Based on the route design strategy, munitions clearance is dealt with as an *unplanned event* (see Chapters 4 and 5).

Table 12-2 Potential impacts with a transboundary nature for unplanned events. In addition, it is indicated whether a significant transboundary potential impact has been identified (in Chapter 9).

Receptor	Potential impact	Construction	Operation	Transboundary impact significance
Marine mammals	Underwater noise	X		Not significant
Natura 2000	Underwater noise	X		Not significant

As assessed in Section 9.13 Marine mammals and in the Natura 2000 assessment, Section 9.19.2 (Natura 2000 screening - Sydvästskånes utsjövatten) there is a risk of a transboundary impact, as impacts from underwater noise in the event of munitions clearance can potentially be transboundary, depending on the location of a potential clearance site in Faxe Bugt (Section 5.1.5). Therefore, the clearance site could potentially be close to the Swedish border and hence the underwater propagation could cross into Swedish waters. Assessments and conclusions are the same as those made in relation to Danish waters.

The overall conclusion is that if mitigation measures are implemented, the impact on individual harbour porpoises and seals can be reduced to a negligible impact severity for blast injury; a moderate impact severity for PTS on an *individual* level and minor impact severity on a *population* level; and a minor impact severity for TTS and behavioural responses. For detailed assessments, please consult Sections 9.13 and 9.19.2.

13. MITIGATION MEASURES

This chapter provides an overview of the mitigation measures and common practise or regulatory measures applied for the Baltic Pipe project. The mitigation measures and common practise or regulatory measures are divided in four different types:

- Mitigation measures applied for the planned parts of the project;
- Mitigation measures applied for unplanned events;
- Mitigation measures that already have been implemented in the project design;
- Common practise or regulatory measures.

13.1 Mitigation measures for planned projects activities

The identified mitigation measures in Chapter 9 concerning planned project activities are presented in Table 13-1:

Table 13-1 Identified mitigation measures in Chapter 9.

Receptor	Mitigation measure
Airborne noise	**Noise barriers and noise insulation** Tunnelling and pre-commissioning as onshore activities will take place outside of regular working hours, where the applied noise level guiding limit value of 40 dB(A) will be exceeded. The noise level must be lowered by between 10 and 15 dB to comply with the guiding limit value. A combination of the following mitigation measures is expected to reduce the noise level sufficiently: • Sound insulation of the stationary machinery (generators and pumps); • Use of less noisy machinery, and; • Stacking of metal shipping containers or large size straw bales atop one another to a sufficient height; usually two or three layers resulting in a combined height of 5-7.5 m.

13.2 Mitigation measures for unplanned events

If munitions clearance needs to take place (as an unplanned event), there could potentially be an effect on fish and marine mammals at the individual level (Sections 9.12 and 9.13). Therefore, the suggested mitigation measures have been listed in Table 13-2.

Table 13-2 Suggested mitigation measures in the event of munitions clearance.

Receptor	Mitigation measure (unplanned event)
Fish	**Sonar survey** A sonar survey to identify shoaling or schooling fish in the area should be carried out by a work boat to assess whether the timing of the munitions clearance is suitable or if the detonation should be postponed. This assessment can be helpful to protect groupings of fish populations that may be present in the area.
Marine mammals Annex IV species – harbour porpoise (offshore)	**Marine Mammal Mitigering** An overall UXO specific marine mammal mitigation plan includes mitigation measures such as the use of marine mammal observers (MMOs), Passive Acoustic Monitoring (PAM) and acoustic deterrent devices.

Receptor	Mitigation measure (unplanned event)
	Visual observations and PAM Visual monitoring by a MMO will be undertaken from the source vessel (on a suitable viewing platform). Visual monitoring should be restricted to periods of good visibility during daylight hours, as visibility decreases during poor weather or lighting conditions. If marine mammals are present prior to munition clearance, the detonation should be postponed. Visual observations prior to munitions clearance do not guarantee that marine mammals are not affected, as marine mammals may stay below the surface and hence remain undetected for long periods. However, a visual survey prior to clearance can help to protect animals, which are sighted. Acknowledged guidelines from JNCC should be applied as good practice for visual observation methodologies (JNCC, 2017). PAMs are hydrophones deployed into the water column, and the detected sounds are processed using specialised software. PAM is implemented as a supplement to the visual observations done by the MMO. **Seal scarer** Seal scarers are acoustic deterrent devices, which will be used to deter seals and harbour porpoises from sites where munitions clearance must take place. The range, or the efficiency of the devices depends on the type of scarer and the setup. Harbour porpoises react stronger to seal scarers than seals (Hermannsen *et al.,* 2015). A setup of monitoring and deterrent devices like the one used on NSP2 will be used, see Section 9.13.2, Underwater noise. **Seasonality** To avoid impact on the endangered Baltic Sea harbour porpoise population, the additional use of seasonality could be added, where munition clearance could be done during the summer period, if reasonal practically. If this measure is followed, the risk of blast injury and PTS for the endangered Baltic Sea population is negligible. It should be emphasized that seasonality as mitigation measure is only functional for the Baltic Sea population.

13.3 Mitigation measures implemented in the project design

The project design and the pipeline route selection are generally based on the consideration of reducing impact from the project on the environment. In Chapter 6, Alternatives, a thorough description of the route selection, including some of the environmental considerations incorporated, is outlined. In Table 13-3, other significant mitigation measures or project optimisations implemented in the project design to reduce the environmental impacts are presented.

Table 13-3 Examples of mitigation measures implemented in the project design.

Receptor	Mitigation measure
Benthic habitats, flora and fauna	**Disposal area for trenched material at 7 m sea level** As part of the tunnelling activities nearshore, trenched material from the exit point of the tunnel boring machine and trenched material from the associated transition zone at approximately 4 m water depth will be transported to a temporary disposal area on the seabed at a water depth of a minimum of 7 m in order to minimise the potential impact on eelgrass.

Receptor	Mitigation measure
	Restoration of seabed To reduce the impact on the seabed from TBM and the associated transition zone, the seabed will be restored to its pre-impact condition.
Landscape Protected areas, natural habitats, flora, and fauna (onshore) Biodiversity (onshore) Hydrography and water quality	**Tunnelling** Tunnelling has been determined as the preferred construction method at the landfall over excavation. The height of the cliff at Faxe S is 15-17 m, and excavation would leave a large mark in the landscape which is not easily reinstated. Furthermore, excavation volumes would be excessive, causing a significant disturbance to the cliff and, moreover, sediment dispersion from the shallow-water excavation works. By using tunnelling, the cliff as a natural habitat and potential breeding site for sand martins remains undisturbed.

13.4 Common practice or regulatory mitigation measures

The Baltic Pipe project will, naturally, comply with the applicable regulation in force and with common practise industry norms, some of which also contribute to mitigation of the environmental impacts from the project. As a part of this compliance, an environmental management plan will be developed. The regulatory or common practise mitigation measures listed in Table 13-4 are examples that preferentially could be part of the environmental management plan. However, it should be emphasised that the list is not exhaustive.

Table 13-4 Examples of regulatory or common practise mitigation measures (not exhaustive).

Receptor	Mitigation measure
Commercial fisheries	**Economic compensation of fishermen** Compensation will be a measure to reduce the economic impact on fishermen fishing in areas that will be temporarily closed due to the safety zones imposed around the construction vessels.
Shipping and shipping lanes Commercial fisheries	**Information about construction activities** In cooperation with the contractor and the Danish Maritime Authority, the developer will announce the planned periods of construction activities.
Population and human health Tourism and recreational areas	**Economic compensation of land owner** The land owner of the work site used during construction at Faxe S will be compensated.
	The following measures should be applied during construction on land: • Fencing the work site; • Avoid lighting which dazzles the nearest neighbors; • Maintain access to Skansestien; • Prevent the spread of contaminated soil, e.g. in the form of dust during excavation or transport;

Receptor	Mitigation measure
	• In areas of work, measures to prevent spillage of oil / petroleum products from construction machinery, mobile refueling plants and the like (e.g. drip trays) should be implemented; • Handle waste according to applicable regulation; • Use recyclable materials when possible and recycle all potential recyclable waste fractions; • Information should be provided to local citizens, recreational harbours, recreational sailors, local divers, anglers and organizers of special activities at Feddet/Strandegård about possible inconvenience from activities during construction (not as a standard, but when the activity changes and the duration); • Construction related traffic will be assigned routes to use, appointed by the local authorities and the police, to minimise the impact for neighbours and other users of the roads; • Along the route used by construction-related traffic, signs warning about the construction activities will be posted.
Biodiversity (offshore)	**The Ballast Water Management Convention** The Ballast Water Management (BWM) Convention aims to prevent the spread of harmful aquatic organisms from one region to another (non-indigenous species (NIS)) by establishing standards and procedures for the management and control of ships' ballast water and sediments. All vessels participating in the Baltic Pipe project will be requested to comply with the BWM Convention and the HELCOM Guide to alien species and ballast water management in the Baltic Sea.
	Light reduction Electric lighting on ships poses a collision risk for nocturnal migrants because it may attract birds and/or bats. Decreasing illumination and restricting the spectrum of light is an approach to reducing impacts on biological resources while still maintaining safe operations.
Biodiversity (onshore)	**Light reduction** For the sake of wildlife, all lights at the work site should be focussed at the work site and turned off when no work is being done. Yellow and orange light can be used instead of white, as it attracts fewer insects and thus fewer bats to the construction site.
Emissions to air (offshore)	**SO_X and NO_X emission control areas (SECA and NECA)** The International Maritime Organization (IMO) has designated the Baltic Sea as an Emission Control Area (ECA) from 2015 under Regulation 14 of the MARPOL Convention Annex VI to limit the emission of SO_X (also known as SECA) and from 2021, the Baltic Sea is designated under Regulation 13 of MARPOL Convention Annex VI to limit the emission of NO_X (also known as NECA). The ships and fuel used as part of the construction activities for the Baltic Pipe project will be required to live up to legislation in force, including the legislation as a result of the designated NECA and SECA areas.

Receptor	Mitigation measure
Emissions to air (onshore)	**Euronorm stage IIIA** To limit the emissions to air, construction equipment covered by the European emission standards (in Denmark known as Euronorms) for engines in non-road machinery, e.g. dredgers and dozers, should as a minimum live up to stage IIIA.
	Reducing emissions A general recommendation is to prevent idling of engines in order to reduce emissions at the work site.
Archaeology (onshore)	**The Museum Act** Part of the Museum Act applies to construction activities. The responsible museum (Museum of Southern Denmark) has prepared a statement in accordance with to the act about the risk of meeting archaeological objects during construction of the project. Based on this statement, the museum will make a preliminary study of the areas affected by the construction activities. Furthermore, the Museum Act § 27 applies at all times, which means that construction activities should be stopped if archaeological objects appear during construction.
Archaeology (offshore)	The handling of marine archaeology will be based upon the final evaluation of potential cultural heritage objects along the preferred route for the offshore pipeline, which is in process. The Viking Ship Museum (VIR) is responsible for this evaluation. Furthermore, the Museum Act § 29h applies at all times within 24 nautical miles from land, which means that construction activities should be stopped if archaeological objects appear during construction.

14. MONITORING PROGRAMME

In accordance with the Consolidated Act on Environmental Assessment[82] Annex 7(7), a proposal for an environmental programme can be prepared in connection with an EIA if such monitoring is relevant for the project.

The purpose of a monitoring programme is to reduce the environmental impact as much as possible and to ensure that implemented mitigation measures are functioning according to plan. In addition, a monitoring programme can be used to monitor the change to a receptor impacted to some degree by the project.

In the following paragraphs, a proposal for a monitoring programme is presented. The detailed planning and execution of the programme will be established in consultation with the competent authorities. During this dialogue with the authorities, monitoring locations, procedures, and periods will be decided.

The proposal for receptors/parameters that could be monitored is based on:

- The impact assessment, hence the potentially significant impacts on receptors caused by the project;
- Experience from similar projects, hence the expected outcome of the project;
- Implementation of mitigation measures, to ensure that these measures are functioning according to plan.

The impact assessment, including the modelling results of sediment spill, show that the project will generate only limited impacts on the marine environment. It is therefore suggested to include offshore monitoring of:

- Sediment spill (water quality/turbidity);
- Reestablishment of the seabed in the temporary footprint area in Faxe Bugt (seabed and eelgrass);
- The effect of mitigation measures in the event of munitions clearance (observations of marine mammals).

14.1 Construction

14.1.1 Sediment spill

The purpose of the monitoring will be to survey the concentration and extent of the sediment spill.

A setup for monitoring of the sediment spill during construction should be prepared. This will be to verify the modelled sediment spill and to ensure that the spill does not exceed the expected concentrations during construction. These results will hence validate that the conditions used for the modelling (spill percentage, trenching intensity, amounts etc.) are within the same range as expected and that the basis for the EIA is still valid. Validation of the modelling inputs will in turn support the conclusions of the assessment of impacts on water quality and other receptors.

[82] Consolidated Act no. 1225 of 25/10/2018 on environmental assessment of plans and programmes and specific projects (EIA) *(bekendtgørelse af lov om miljøvurdering af planer og programmer og af konkrete projekter (VVM))*.

14.1.2 Unplanned events - effect of mitigation measures in the event of munitions clearance

The purpose of the monitoring will be to ensure that the implemented mitigation measures are sufficient to protect marine mammals from underwater noise impacts arising from munitions clearance.

Monitoring of marine mammals should be implemented by the use of visual observers to ensure that seals and harbour porpoises are properly scared out of the zone of physical injury before munitions clearance, hence securing their protection from significant impacts.

14.2 Operation

14.2.1 Reestablishment of the seabed in Faxe Bugt

The purpose of the monitoring will be to ensure the restoration of the seabed in the temporary footprint area in Faxe Bugt at the tunnelling pit area and transitions zone.

The seabed will be restored after construction works in Faxe Bugt. Monitoring of the seabed by divers can be performed to ensure that the restored seabed areas are suitable for the re-establishment of eelgrass and benthic fauna.

14.3 Justification for monitoring programme

Experience from Nord Stream, which is currently the only operational pipeline system in the Baltic Sea, and where an extensive monitoring programme has been completed, has shown that no significant or measurable impacts were observed on fish along the pipeline; benthic fauna; water quality; hydrography; or socio-economic receptors, such as commercial fisheries and marine archaeology (Rambøll O&G/Nord Stream AG, 2011a; 2011b; 2012; 2013b; 2014b and 2015). It should be emphasized that Nord Stream consists of two pipelines with a larger pipe diameter. The potential for impact on the seabed is therefore significantly lower for the Baltic Pipe.

15. GAPS AND UNCERTAINTIES

According to the EIA legislation, an EIA report must contain a description of the most important gaps and uncertainties in the data and methods applied for calculating and assessing the environmental impact of the project.

In the following, the gaps and uncertainties are described for the project in general and for the specific models and calculation methods applied. Overall, it is considered that none of the listed gaps and uncertainties will lead to significant changes in the environmental assessments of the Baltic Pipe project for the Danish part in the Baltic Sea, and that they correspond to the degree and proportion of similar offshore pipeline projects.

15.1 General uncertainties

There are general uncertainties related to the project design and the baseline data.

15.1.1 Design of the Baltic Pipe project

Deficiencies in the current knowledge base about the project relates primarily to the fact that all details of the entire Baltic Pipe project have not yet been decided at the time of finalisation of this EIA. There may be adjustments or changes in the project design and in organising the construction activities, including the applied construction methods. Additionally, further technical studies may be implemented when a more detailed project design becomes available. Therefore, information presented in the EIA about pipeline length, trenching length and location are based on the current design and may be subject to minor changes. Furthermore, all numbers presented in the EIA about e.g. use of materials, rock volumes and emissions from the project are approximate estimates based on the current knowledge at the time of the EIA.

In the EIA report, on this basis, and where there are uncertainties regarding the final project design and methods, a worst-case approach has been applied. This means that the conclusions of the EIA report are sufficiently robust to account for project adjustments in the upcoming detailed design phase.

15.1.2 Baseline data

The baseline has been prepared using desktop studies of scientific literature, technical reports of available data covering the project area (from e.g. authorities), together with field surveys, where results add new information and/or can confirm already existing information. The baseline data are considered sufficient as a basis for the description of the baseline in the EIA and a valid basis for the assessments.

For harbour porpoises (assessed in the sections on marine mammals and Annex VI species offshore), there are gaps in the survey data from the second quarter of 2018, which means that the verification of SAMBAH data is limited to the period November to February. This is, however, not considered an important uncertainty, as SAMBAH data are scientifically grounded and highly accepted. Furthermore, SAMBAH data cover the area included in the baseline well.

15.2 Uncertainties for models and calculations

Modelling and calculations have been undertaken for sediment dispersion, underwater noise, airborne noise, air quality and emissions.

15.2.1 Sediment dispersion

The sediment dispersion model is based on a theoretical calculation model supplied with physical input parameters. These input parameters are current fields, spill originating from the proposed construction methods and the physical properties of the spilled material.

Current fields are based on “historical” situations (hindcast) of characteristic hydrographic conditions as they most likely could be under a future construction phase. Actual conditions can be different during the construction of the Baltic Pipe project. The given model results are considered as a realistic extent of the impact, but a specific impact cannot be determined.

As input for the sediment dispersion model, spill percentages from the different types of offshore construction activities used in the project are defined. The applied spill percentages are based on empirical data and literature studies. However, the actual spill percentage will depend on the equipment used for the task, in combination with the type of seabed.

Physical properties of the sediment mainly correlate with settling velocity, which again is a matter of grain size distribution. The samples collected from boreholes were not analysed when the modelling was initiated, and consequently, specific grain size distributions were not available along the route. However, assumptions on the type of seabed material was based on dedicated surveys along the route. This information was transformed into a grain size distribution based on experience. The assessed grain size distributions were biased towards fine-grained sediments, which is considered conservative.

15.2.2 Underwater noise

The underwater noise propagation model is based on a theoretical calculation model supplied with physical input parameters such as salinity and temperature data, seabed conditions, and bathymetry. If the physical measures are correct, the theoretical results are considered credible, which is the case for the current project. Measurements of underwater noise from munitions clearance, however, may result in varying noise levels due to other physical properties not included in the calculation model, e.g. waves at the surface, partial detonation and/or the munition being embedded in the seabed.

During the gathering of physical measurements for the underwater noise propagation model, it was identified that salinity and temperature data for the position off Bornholm were not present in the available data set. Therefore, measurement data from adjacent sites has been utilized as a qualitatively acceptable replacement.

Information regarding the seabed conditions between about 5 m depth and the pre-Quaternary surface present at approximately 25 m depth at Faxe and 10 m depth off Bornholm has not been possible to gather. Qualitative assumptions have been made for the unknown layers in between the surface conditions and the pre-Quaternary layer.

The quality of the results from the underwater noise propagation model is not considered to be compromised due to the utilization of the above-mentioned assumptions regarding input parameters.

15.2.3 Airborne noise

The noise calculations for airborne noise are associated with some uncertainty. Both the calculation model itself, but also the assumptions about individual noise sources and construction descriptions are subject to uncertainty. The uncertainty regarding the determination of noise during the construction phase was estimated on the present basis to be ± 5-7 dB. However, it should be emphasized that the assumptions used in this study are generally conservative, i.e. considered worst-case.

15.2.4 Air quality modelling

Modelling of the air quality at the landfall was undertaken with the latest version of the OML model (version 6.2). The OML model is based on historical meteorological data from Kastrup, and thus not on the actual meteorological conditions at the landfall. The modelling results are, however, considered sufficient for assessing the impact from the project, as the OML model is the most well-recognised programme for modelling the spread of air emissions in Denmark.

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APPENDIX A - HEALTH, SAFETY AND ENVIRONMENTAL MANAGEMENT SYSTEM

The Project has adopted OHSAS 18001 Occupational Health and Safety Management System and ISO 14001 Environmental Management System as the basis for the management of Occupational Health Safety and Environmental in projects.

Throughout all phases of the Project, GAZ-SYSTEM will ensure that effective, practical and achievable measures which provide for the safeguard of the health, safety and welfare of employees and others, and for the protection of the environment, are in place.

GAZ-SYSTEM will achieve the HSE plan by the implementation of objectives, business processes and health, safety and environmental standards and procedures. These will be verified by review, audits and reporting on safety performance.

To implement HSE plan the following major points will be actioned;

- Make the HSE Policy publicly available;
- Communicate to, and involve our staff, workforce, contractors by participation and consultation, and provide an effective system of communication throughout the company;
- Clearly assign responsibility and accountability for the organisation, activities and arrangements to implement the HSE policy;
- Ensure that HSE issues are planned and managed with the same priority as other business activities;
- Procure and install properly designed and engineered facilities, plant and equipment and commission them for safe operation;
- During the Project design and installation phases, evaluate, through applying the principles of hazard identification and risk assessment, cost effective means to reduce inherent health, safety and environmental risks to attain the lowest reasonable practical level.
- Ensure that safe working conditions are provided, and that safe and environmentally sound processes and procedures are followed at all Project work locations for the protection of people, including the public, who may be affected directly or indirectly by Project activities;
- Assess the impact of activities on the environment and put in place measures and procedures to prevent or minimise damage, discharges and harmful emissions;
- Comply with relative statutory requirements;
- Utilise contractors who have a track record of commitment to recognised HSE standards, and integrate these contractors into the Project organisation to ensure effective operations or deliverable;
- Report and investigate incidents including those with the potential to result in injury to people, damage to plant and equipment, and harm to the environment;
- Develop Emergency Response plans adequate to meet identified emergency scenarios;
- Maintain effective systems for monitoring, performance measurement, audit and review in relation to health, safety and the environment;
- Learn from the active audits and reviews and reactive investigations to strive for continuous improvements in HSE performance.

Project HSE Plan identifies the necessary Project health, safety and environmental related processes and activities, extending throughout the design activities, procurement, manufacture, construction, installation and commissioning phases.

Complementary to this plan will be the Contractors' health, safety and environmental management plans, which will demonstrate the details of how the Contractors will meet the requirements outlined in this document, and specifically detailed in their respective contracts. Contractors will be required to produce their own HSE Plans prior to the commencement of any worksite activities.

The CONTRACTOR shall demonstrate that it's Health, Safety and Environmental Management System;

- Complies with the requirements of OHSAS 18001 / ISO 450001 Occupational Health and Safety Management and ISO 14001 Environmental Management System;
- Is aligned with the requirements of this specification and the CONTRACT;
- Is functioning in accordance with CONTRACTORs own procedures;
- Complies with all relevant national and international legislation, laws, regulations, codes, as they apply.

The principle elements that should be covered in the CONTRACTOR Health and Safety Management Plan in alignment with International Standards are presented below.

Table – Principal Elements in the HSE Management System.

HSE Management Plan Element	Addressing
Leadership and commitment;	Top-down commitment and company culture, essential to the success of the system
Policy and strategic objectives;	Corporate intentions, principles of action and HSE aspirations
Organisation, resources and documentation;	Organisation of people, resources and documentation for sound HSE performance
Evaluation and risk management;	Identification and evaluation of HSE risks relating to operations, products and services, and development of risk-reducing measures
Planning and procedures;	Planning the conduct of work operations, including planning for change and emergency response
Implementation and monitoring;	Execution and monitoring of operations, and how corrective action should be taken when necessary
Auditing and reviewing.	Periodic assessment of system performance, effectiveness and fundamental suitability

Emergency response plan

Gaz-System will maintain, as part of HSE Plan, emergency response plan dedicated for the Baltic Pipe Project and will ensure that in case of emergency all relevant parties will be informed and involved.

The emergency plans and procedures existing on construction sites and vessels, including arrangements for medical treatment shall be detailed within a contractor’s health, safety and environmental plan. Emergency plans and necessary actions will be clearly communicated to the workforce.

Prior to mobilisation of rigs and vessels, the necessary combined operations bridging documents will be developed between the relevant parties.

It is required that all involved Contractors will have procedures in place to test their emergency response plans and these shall be described within the safety and environmental plan. During a relevant work phase a joint emergency exercise may be held for the host installation (if necessary) for Contractors to test their plans, including the stated interface arrangements and communications

References

PL1-GAZ-10-S00-KA-00001-EN: Project Health Safety and Environment Plan. Rev. 0, 11 January 2019.

PL1-GAZ-10-S00-SA-00001-EN: Contractor HSEQ Requirements SpecificationRev. 0, 11 January 2019.

APPENDIX B – SUMMARY OF UXO STRATEGY

General

The Baltic Sea has a history of significant naval importance and the presence of munitions remains a legacy of World War I (WWI) and World War II (WWII). Based on this, there is a risk for the project of encountering and potentially interfering with munitions during the installation works, which must be managed.

The overall strategy for mitigating the risks posed by UXOs for the Baltic Pipe project is based on the following key steps:

Step	Description	Status / Timing
1	**UXO Desktop Study** to provide a preliminary assessment of the threats	Complete
2	**Pipeline route survey** to provide better definition of conditions along the route and preliminary identification of "targets" for further inspection	On-going
3	**Detailed UXO risk assessment** to clearly define the UXO / CWA threat and tolerability level along the pipeline route	On-going
4	**Dedicated UXO survey** to provide detailed geophysical mapping and final identification of potential UXOs within the installation corridor	Planned, prior to installation works
5	**Mitigation works** in case UXOs are identified within the installation area	Planned, prior to installation works

UXO Desktop Study

A desktop study has been performed as part of the early design works (Rambøll, 2018k). The purpose of the study was to provide a preliminary assessment of the likely threats and the locations of the key threat areas relative to the pipeline route corridor. The study was prepared using information from relevant public authorities and commissions, public domain studies, expert reviews and consultations.

The study identified the main threats from munitions in the Baltic Sea consist of the following:

- Conventional munitions - Munitions containing explosives, used in wartime or for post-war training purposes. These consist of sea mines, depth charges, torpedoes, aerial bombs, artillery shells etc.
- Chemical munitions - Munitions containing chemical warfare agents which were mainly disposed of (dumped) following WWII.

The main risk areas include:

- British mine gardens from WWII;
- German mine areas from WWII;
- Soviet mine fields from WWII;
- Expected shooting range from Stevns Fortet;
- Military practice areas (currently in use); and
- Areas where chemical munitions may have been dumped.

These areas are displayed relative to the pipeline route in the following figure.

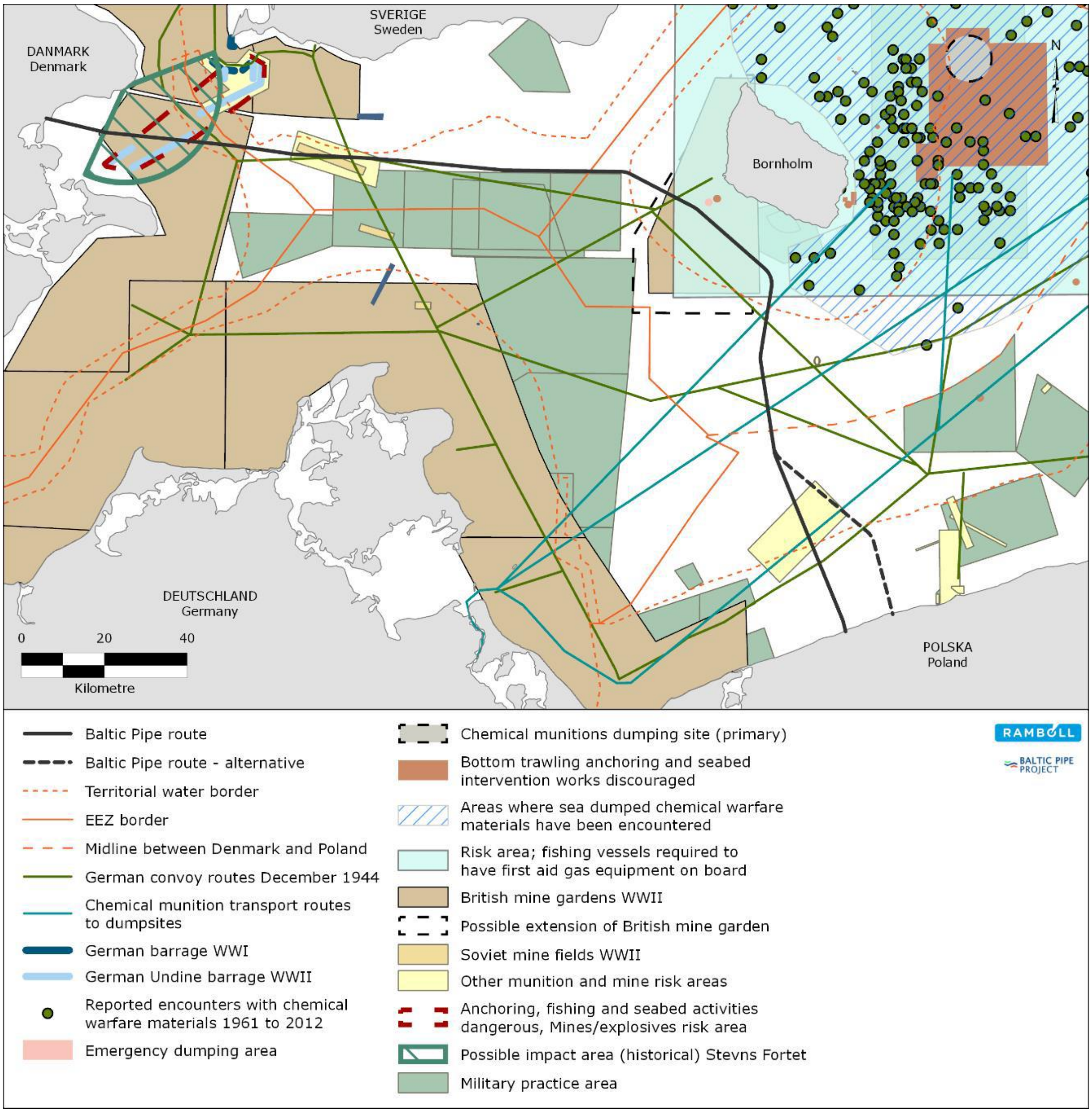

Figure - Overview map of munitions risk areas (Rambøll, 2018k). The areas are approximations only, based on the available information, including information from HELCOM, 2013c.

The figure indicates that the pipeline route traverses key risk areas, as follows:

- British minefields and German barrage area on approach to the Danish landfall in Danish EEZ and territorial waters
- Soviet minefields and other munition risk areas in Swedish EEZ
- British minefields in Danish territorial waters near Bornholm
- Munition risk area on approach to the Polish landfall in Polish EEZ and territorial waters.

The pipeline route also passes an area of reported emergency chemical munition dump site near Bornholm, although the route corridor does not overlap this area. The pipeline route avoids overlap with the military practice areas (naval exercise areas and artillery exercise areas).

Pipeline Route Survey, including geophysical survey

As part of the Pipeline Route Survey, a geophysical survey has been performed along the entire pipeline corridor to inform engineering activities. The survey width was in general 500m wide, but up to 1,000m wide in specific areas. The survey works included:

- Multi-beam echo sounder survey – for mapping bathymetry;
- Side scan sonar survey – for mapping seabed geology and objects on the seafloor;
- Magnetometer survey – for mapping objects of ferrous material, including crossing infrastructure;
- Seismic reflection survey – for sub-bottom profiling of the seabed geology.

Geophysical investigation has been carried out along 1 centre line, 2 inner wing lines of 50 m, and then wing lines 100 m for the remainder of the survey corridors. The outcome of this survey has been used to provide preliminary identification of "targets" of interest to the project, such as crossing infrastructure, boulders and man-made objects. These targets include items of ferrous composition that could potentially be UXOs; even though the survey line distance with the magnetometer is considered too wide for detailed UXO detection.

Based on this, visual inspection of the relevant "targets" has been performed via ROV. No positive identification of UXOs has been confirmed based on this survey information. However, a more detailed survey campaign consisting of much denser survey lines with the magnetometer is planned to provide further confirmation for UXO identification based on the selected pipeline route. This is described under "Dedicated UXO Survey" below.

Detailed UXO Risk Assessment

To address some of the limits associated with the UXO desktop study, a detailed UXO risk assessment has been performed by nominated experts in this field as part of the detailed design work.

The general scope of this assessment, which primarily is concerned with H&S risk, includes:

- Collection of additional information (including non-public as available) to supplement the information identified in the desktop study;
- Detailed identification of the UXO threats (ordinance types, dimensions, nominal charge, materials, probability of encounter, likelihood of UXO detonation, effects and consequences of UXO detonation);
- Consideration of geology along the route and potential for burial or migration of UXOs;
- Assessment of UXO risk along the pipeline route for different seabed activities during pre-construction and pipeline installation works;
- Definition of the risk tolerability level (As Low as Reasonably Practicable (ALARP));
- Definition of smallest UXO Item for ALARP sign-off; and
- Risk Mitigation to meet ALARP.

The detailed risk assessment will be used to guide the scope of the dedicated UXO survey and mitigation works.

Dedicated UXO Survey

A dedicated UXO survey will be performed prior to seabed intervention and pipeline installation works. The purpose of this survey is to provide a fully detailed, final confirmation there are no UXOs within the final pipeline installation corridor, or to identify any UXOs that require mitigation measures.

The survey will cover the full extent of the area of seabed that may be interfered with during installation and operation of the pipeline. This includes the installation corridor and construction related areas of interference such as pipelay anchoring patterns and dredging spoil grounds and nearshore tunnelling.

The survey activities will include:

- Geophysical survey (magnetometer / gradiometer) for the entire installation corridor (and other areas) with a grid sufficient for detailed data coverage; and
- ROV inspection of relevant potential UXO (pUXO) targets including potentially buried pUXOs, and visual confirmation of target being UXO or not.

The outcome of the survey will be identification of any UXOs that require mitigation works (if any).

The survey will be performed based on the final pipeline route and definition of anchor patterns and dredging methods employed by the installation contractor. The survey will be performed prior to any works being carried on in the relevant areas, with enough time to allow for mitigation works in case this is required (not expected).

The survey may be performed in separate parts as appropriate, as the final pipeline route may be surveyed before the installation contractor has defined the anchor patterns.

UXO Mitigation Works
If an UXO is identified within the works corridor during the dedicated UXO survey, appropriate mitigation measures will be employed prior to installation works in the area:

- Around each UXO that has been mapped but not been ROV inspected, if any, an Exclusion Zone will be determined based on the local risk parameters and seabed conditions. This avoidance zone is designed to avoid disturbance of the item.
- Around each UXO that has been identified, if any, a Safety Zone will be determined based on the local risk parameters and seabed conditions. This safety avoidance zone is designed to protect both project and third-party personnel, vessels and equipment should the item detonate.
- The risk of having to clear munitions is primarily mitigated, if practical possible, by re-routing the pipeline to avoid munitions objects visible at the seabed. Where it is not practicable to mitigate the risk by re-routing, UXOs will require removal / detonation (clearance) to mitigate the threat. Based on the route design strategy, munition clearance is dealt with as an unplanned event.
- The final parts of the detailed UXO survey is deliberately planned to be surveyed relatively late in the pre-investigation process – to obtain an almost final route centre, and to obtain most relevant survey data as fishermen could have dragged items into the corridor, or storms/seasonal changes could have altered the seabed. Moreover, as UXO ALARP Certificates is usually only valid for ½ year due to potential changes of the seabed and presence of new items not previously detected.

Munitions objects are, as far as reasonably practicable, avoided by re-routing. If re-routing is not possible, there is a risk that munitions clearance will have to take place. In such a situation, the below listed mitigation measures will be applied.

Unplanned Event (UXO Clearance) – Mitigation Measure

If munitions clearance needs to take place (as an unplanned event), there could potentially be an effect on fish and marine mammals at the individual level. Therefore, the suggested mitigation measures have been listed in the table below.

Table - Suggested mitigation measures in the event of munitions clearance.

Receptor	Mitigation measure (unplanned event)
Fish	**Sonar survey** A sonar survey to identify shoaling or schooling fish in the area should be carried out by a work boat to assess whether the timing of the munition's clearance is suitable or if the detonation should be postponed. This assessment can be helpful to protect groupings of fish populations that may be present in the area.
Marine mammals Harbour porpoise (offshore)	**Marine Mammal Mitigation** An overall UXO specific marine mammal mitigation plan includes mitigation measures such as the use of marine mammal observers (MMOs), Passive Acoustic Monitoring (PAM) and acoustic deterrent devices. **Visual observations and PAM** Visual monitoring by an MMO will be undertaken from the source vessel (on a suitable viewing platform). Visual monitoring should be restricted to periods of good visibility during daylight hours, as visibility decreases during poor weather or lighting conditions. If marine mammals are present prior to planned munition clearance, the detonation should be postponed. Visual observations prior to munitions clearance do not guarantee that marine mammals are not affected, as marine mammals may stay below the surface and hence remain undetected for long periods. However, a visual survey prior to clearance can help to protect animals, which are sighted. Acknowledged guidelines from JNCC should be applied as good practice for visual observation methodologies (JNCC, 2017). PAMs are hydrophones deployed into the water column, and the detected sounds are processed using specialised software. PAM is implemented as a supplement to the visual observations done by the MMO. **Seal scarer** Seal scarers are acoustic deterrent devices, which will be used to deter seals and harbour porpoises from sites where munitions clearance must take place. The range, or the efficiency of the devices depends on the type of scarer and the setup. Harbour porpoises react stronger to seal scarers than seals (Hermannsen *et al.,* 2015). **Seasonality** To avoid impact on the endangered Baltic Sea harbour porpoise population, the additional use of seasonality could be added, where munition clearance could be done during the summer period, if reasonably practical. If this measure is followed, the risk of blast injury and PTS for the endangered Baltic Sea population is negligible. It should be emphasized that seasonality as mitigation measure is only functional for the Baltic Sea population.

The outcomes of the detailed risk assessment will also be used to guide any additional considerations or mitigating measures that should be employed by the project.

Involvement of Danish Authorities

In case there is a need to detonate UXOs this will have to be done by the Danish Explosive Ordnance Disposal Team.

References

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