Commissioned Report from DCE – Danish Centre for Environment and Energy

Marine mammals in Finnish, Russian and Estonian waters in relation to the Nord Stream 2 project

Expert Assessment

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Preface

This report was commissioned by Nord Stream 2 (through Rambøll) and constitutes expert assessments regarding marine mammals and intended as input to the Environmental Impact Assessment of the proposed Nord Stream 2 pipeline through Russian and Finnish waters.

The assessments build upon exsisting knowledge, summarized in the accompanying baseline report, and draws on distribution data for marine mammals obtained from HELCOM and directly from researchers, including DCE/Aarhus University, as well as exsisting knowledge regarding effects on marine mammals.Assessments of impact from underwater noise and sediment spill are based on predictive modelling of spatial extent of noise and sediment plumes conducted by Rambøll and documented in separate reports.

Conclusions in this report are not intended to stand alone, but should be read in proper context of the full environmental impact assessment of the project.

1. Introduction

1.1 Purpose and structure of this report

The purpose of this report is to assess the potential impacts on marine mammals in relation to the construction and operation of the Finnish and Russian sections of the proposed gas pipeline Nord Stream 2 (Nord Stream 2 Pipeline system – NSP2). The maximum impacts during construction without mitigation measuresand with mitigation measures are assessed.

The construction and operation may have impacts on marine mammals in Finnish, Estonian and Russian waters and in these waters, the most relevant marine mammal species are grey seal (*Halichoerus grypus grypus*) and ringed seal (*Pusa hispida botnica*) but also harbour porpoises are occasionally present (*Phocoena phocoena*).

This report is based on the following:

- The information and studies conducted during the Environmental Impact Assessments for marine mammals from Nord Stream (NSP).
- The information described in the NSP2 baseline report for marine mammals (Teilmann, Galatius, and Sveegaard 2017).
- The models on sedimentation and underwater noise in Russian and Finnish waters performed by Rambøll.
- Relevant literature. No new fieldwork was conducted.

The report describes the pressures related to the periods of construction, pre-commissioning, commisioning and operation of the gas-pipeline (chapter 2, 3, 4 and 5). This is followed by a chapter on interpretation of the EIA methodology in relation to marine mammals (chapter 6) . Chapter 7 assesses the sensitivity of marine mammals with regard to the potential impacts including criteria for noise levels. In chapter 8 the magnitude of impacts are assessed. Chapter 9 combines the information on sensitivity and impact magnitude in order to conclude on the overall significance of each impact during construction. Chapter 9 can be considered as a worst case assessment, since no mitigation measures is taken into consideration. Chapter 10 assesses impacts during operation by the combination of impacts magnitude and species sensitivity to the impacts. In Chapter 11, different methods potentially available on the market to mitigate the impacts of munition clearances are described on a general level. Chapter 12 focuses on the mitigation measures to which NSP2 has committed and how these can reduce the potential impacts during construction. A summary of the assessments described in chapter 9, 10 and 12 is presented in Chapter 13 and Chapter 14 provides an assessment of impact on Natura 2000 areas. Chapter 15 provides the conclusions of the assessment.

Assessment of impact during decommissioning are not included here, since this depends upon practice/methodology available at the time decommissioning becomes relevant (approx. 50 years from construction).

2. Introduction to impacts

The central question in the context of the NSP2 project and marine mammals answered in this report is whether the construction and operation of the pipeline will have an impact (positive or negative) on the individual animals as well as on the population (i.e. on abundance and distribution). Whether such an impact is acceptable or not is a political consideration, and is not addressed here.

Assessing the impact at the population level is often difficult unless all factors related to the population structure and abundance of the animals, as well as all other factors affecting their survival in relation to direct and indirect impacts are known. In this report, information on the animals using the impacted areas and the status of their populations are not well known and further data e.g., from further tagging of seals, habitat suitability modelling and abundance surveys would be of high relevance. The assessment of the impacts from the construction and operation of the pipeline is based on assumptions about links from immediate impact to population level consequences and hence associated with uncertainty.

The main pressures on marine mammals during construction of the gas pipeline are assumed to be underwater noise from munition clearances and construction activities, and sediment spill from seabed intervention activities.

Underwater noise is a potentially significant disturbing factor. The pipeline construction will consist of various noisy activities, such as pipelaying with operation of cranes and winches, anchor handling, and rock placement. The ship engines and propellers will also be a source of noise. Munitions have to be cleared from the seabed prior to construction to ensure a safe installation of the pipelines and this munition clearance has by far the largest impact on marine mammals including potential casualties and permanent hearing damage.

Sediment spill will occur primarily during munitions clearance, rock placement and dredging at the Russian landfall, but also from the pipe laying and anchor handling. The consequences of sediment spill on marine mammals relate to the increased turbidity of the water, possible release of toxic contaminants to the water column and a possible decrease in prey availability through secondary effects of the resuspended sediment on fish.

The main potential impacts during the pre-commissioning and commissioning phases are disturbances from ship traffic and other activities such as flooding, cleaning and gauging of the pipelines, system pressure tests, dewatering (only in Russia) and drying of the pipelines and filling the pipelines with natural gas.

The main pressures on marine mammals during operation of the pipeline are noise from the pipeline itself (due to flowing gas) as well as from service vessels. In addition, the project can potentially alter the benthic habitat, by introducing hard substrates (pipeline and scour protection) to the otherwise (in many places) soft bottom habitat.

In the following chapters each potential impact will be described.The impact methodology and terminology follows that of the national environmental impact assessment.

3. Potential sources of impacts during construction

3.1 Underwater noise

Many of the activities related to construction of the pipeline will generate underwater noise. The most significant ones are described below. Among these, munition clearance is by far the loudest activity.

3.1.1 Munition clearance

Underwater explosions, such as munition clearance, generate very large sound pressures with an extremely steep onset (shock wave). The peak pressure relates primarily to type and amount of explosives (higher peak pressure with higher detonation speed), but also water depth of the detonation is of importance (the deeper the water depth where the explosion is, the higher peak pressures are generated) and the chemical condition of the munition. The frequency spectrum of noise pulses from explosions is dominated by energy at low frequencies, also with a dependence on charge size. See e.g. Urick (1983) for methods to estimate peak pressure and power density spectrum from charge type and depth. An example spectrum from measurements on an actual explosion is shown in Figure 3-1. The peak energy is at very low frequencies, around the 63 Hz octave band and drops steeply with about 10 dB/octave at higher frequencies. The spectrum is also affected by charge weight and water depth (Urick 1983).

Under optimal conditions the noise from an explosion can be transmitted over distances of hundreds of kilometres due to the low frequency content and high source level. Actual transmission range depends, as with other types of sound, on the bathymetry, hydrography and sediment types at and around the detonation site. Transmission of noise from explosives is effectively reduced in shallow waters (tens of meters or shallower) due to the poor propagation of low frequencies in shallow water (Urick 1983).

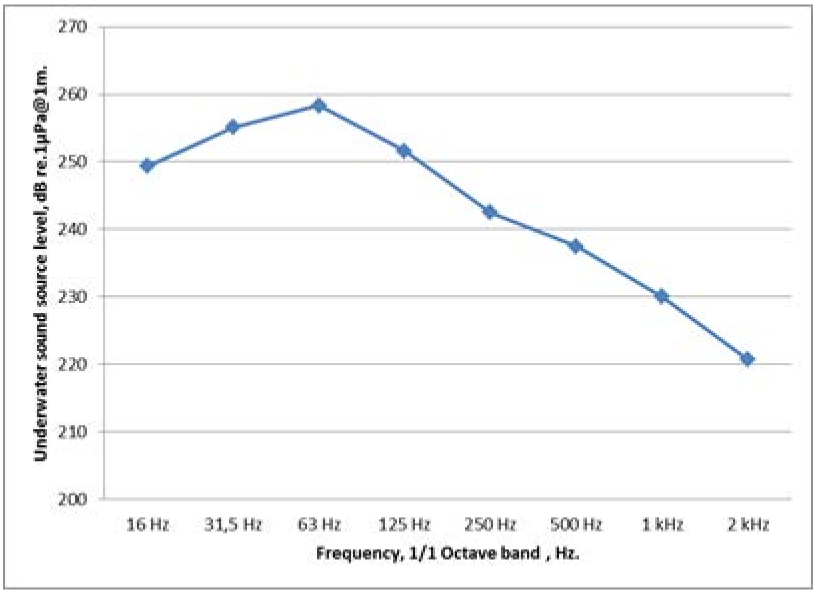

Figure 3-1 *Example of frequency spectrum of the pulse generated by an underwater explosion. Source levels expressed as octave band levels back-calculated to a distance of 1 m from the explosion (actual measurements, from Rambøll 2016d).*

The duration of a single explosion is less than a second, which means that for single explosions the main concern relates to immediate damage to tissue and hearing, whereas effects on for example behaviour is limited. Repeated explosions in the same area can change this and the cumulative effect of damage and behavioural disturbances must be considered in those situations.

A considerable number of unexploded mines can be expected to be encountered in Finnish and Russian waters during construction of the pipeline. A large number of such mines were encountered during contruction of the Nord Stream pipeline and of these 56 were cleared in Finnish waters, while the rest were avoided through derouting, see Table 6-3. The proposed NSP2 route in Russian waters is located south of the NSP route.

3.1.2 Rock placement

Rock placement means that the pipeline remains on top of the seabed but is covered with (or supported by) a layer of rock (see specifics for the NSP2 project in the EIA report). Installation of subsea rock will take place by using a rock placement vessel with a fall pipe.

Noise measurement data indicate that the dominating underwater noise from rock placement activity is from the surface activities (ship motors, thrusters, conveyors, rock pouring) rather than the noise from the actual placement of the rock on the seabed.

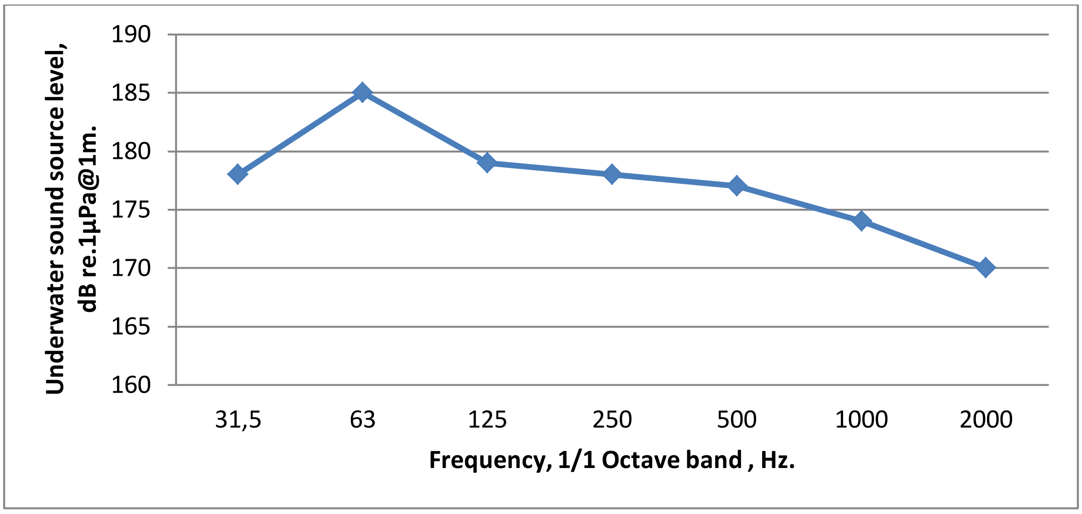

Figure 3-2 *Example of frequency spectrum from rock placement. Source levels expressed as octave band levels back-calculated to a distance of 1 m from the work site (from Rambøll 2016d).*

Source noise levels for vessels depend on the vessel size and speed as well as propeller design and other factors. There can be considerable variation in noise magnitude and character between vessels even within the same class. An example of frequency spectrum from rock placement is shown in Figure 3-2.

3.1.3Vibratory sheet piling

A cofferdam may be constructed around the pipeline where it leaves the Russian coast. This cofferdam will be constructed by steel sheet piles, which will be vibrated into the sea bed. This operation generates low levels of noise, with peak energy at the vibration frequency of the hammer, typically 20-30 Hz (Wyatt 2008; Rambøll 2016a).

Modelling results of propagation of underwater noise from munition clearance, rock placement and vibratory piling during construction of NSP2 are presented in chapter 8.

3.1.4 Pipe-laying /anchor handling

The noise emitted from pipe-laying and anchor handling is expected to be lower than that from rock placement and therefore noise from rock placement is used as worst case proxy for impacts on marine mammals from pipelaying and anchor handling activities.

3.1.5 Ship noise

Ship noise originates though several mechanisms. Large amounts of low frequency noise can be generated by the engine and propeller shaft, transmitted through the hull into the water. At higher frequencies the dominating source is cavitation around propellers, which can be very loud in case of high speed propellers on smaller vessels and damaged propeller blades. Additional sources of noise can be ancillary machinery, such as generators, hydraulic pumps, winches and ventilation systems.

In general there is a monotonic relationship between vessel speed and noise level: higher noise levels are generated at higher speed. This does not always hold, however. For ships with variable pitch propellers, where the speed of the ship is adjusted not only by the speed of the engine but also with the pitch of the propellers, it is possible to have a maximum in noise emission at intermediate speeds, caused by heavy cavitation due to a (deliberately) inefficient setting of the pitch. Also ships equipped with dynamic positioning systems can be very noisy at slow speed or while maintaining constant position, due to the rapidly changing speed of the powerful ducted propellers.

3.2 Sediment spill

Seabed disturbance through munition clearance, pipe-laying, anchor handling, rock placement and dredging can result in increased turbidity and creation of sediment plumes. Sediment plumes have the ability to extend the impact of seabed disturbance over larger areas that would otherwise remain unaffected physically. Research has shown that effects are generally short lived, lasting a maximum of two to three days and are confined mainly to an area of a few hundred metres from the point of discharge (Hitchcock and Bell 2004; Rambøll 2016c, 2016a), but sometimes plumes extending more than 10 km from the dredging site can form (Rambøll 2016a). Modelling results of sediment spill during NSP2 are presented in Chapter 8.

The main impacts on marine mammals from sediment spill are visual impairment, behavioural impacts such as avoidance of sediment plumes and health deterioration caused by mobilization of contaminants from the sediment into the food chain. Marine mammals are not affected directly by the suspended sediment, in contrast to fish, where suspended sediment can clog the gills with suffocation as a consequence.

3.3 Unplanned events - Oil spill

The event of an oil-spill caused by a collision or accident during construction work may impact marine mammals as would any other oil discharge at sea. The impact depends on the size of the oil spill, type of oil, weather conditions, etc.

The chemical constituents of spilled oil are poisonous and exposure to oil through ingestion or inhalation or from external exposure through skin and eye irritation, may thus harm marine mammals. Oil can also smother the fur of seals and thereby reduce their ability to maintain body temperatures.

3.4 Icebreaking caused by service vessels

A potential impact from the increased marine traffic e.g. by service vessels is the breaking of ice in the Gulf of Finland. Grey seal and ringed seal use the ice for breeding, resting and socializing and may thus be present and affected by the breaking of ice. The impact may range from disturbance of natural behaviour (short-term and low magnitude) to the potential collision with animals and death of seals pups by hypothermia, as their fur coat is not waterproof for the first months of their life, where they are restricted to stay on the ice (long-term and high magnitude).

However, NSP2 has committed to the following restriction (mitigation measure):

> *Construction activities such as pipe lay and rock placement are not foreseen in the winter ice conditions. Should work be performed in `marginal` winter ice then the necessary safety measures shall be implemented in conjunction with the maritime authorities, moreover, should there be a potential impact on breeding seals, the coordinating environmental authority shall be notified with supporting impact assessment and mitigation measures (OSP-016.3).*

This means that if icebreaking at some point is deemed necessary a separate impact assessment will be performed. Consequently, icebreaking is not discussed further in this assessment report.

4. Potential sources of impacts during pre-commissioning and commissioning

4.1 Pre-commissioning

Pre-commissioning refers to a series of activities carried out before the introduction of natural gas into the pipelines. Pre-commissioning serves to confirm the mechanical integrity of the pipelines and ensures they are ready for safe operational use with natural gas.

The offshore pipeline will not be pressure tested with water; only cleaning and gauging will be considered using dry air as a medium for propelling the PIGs (units for inspection and cleaning the pipeline from the inside). The pipelines will not be water filled and, consequently, no dewatering and drying are required. Leak detection shall be carried out by use of an inspection pig or alternatively by an external ROV survey in conjunction with the cleaning and gauging pigging operation. The dry cleaning and gauging pig train will be launched from Germany towards Russia. The medium used to propel the pig train will be dried with compressed air with water dew point below -60°C and maximum oil content of 0.01 ppm.

As no water is used, there will be no additives and no discharge. In accordance with this approach, hyperbaric tie-in operations may not be needed and at least one above water tie-in will be required for each pipeline.

None of the activities during the pre-commisioning phase are assessed to have a significant impact on marine mammals and are thus not further discussed although they are included in the summary tables in chapter 11.

4.2 Commissioning

Commissioning comprises all activities that take place after the pre-commissioning and until the pipelines are ready for gas filling and transport. After pre-commissioning the pipelines will be filled with dry air. To avoid an inflammable mixture of atmospheric air and natural gas, the pipelines will be partially filled with nitrogen gas (inert gas) immediately prior to natural gas-filling. The nitrogen gas will create a separation zone moving through the pipeline and as such act as a buffer between the atmospheric air and the natural gas, to ensure no interaction between gas and air during the gas-in phase (Nord Stream 2009).

None of the activities during the commisioning phase are assessed to have a significant impact on marine mammals and are thus not further discussed although they are included in the summary tables in chapter 11.

5. Potential sources of impacts during operation

5.1 Underwater noise

5.1.1 Noise from pipeline

Gas that flows through the pipeline will generate low levels of noise at low frequencies. The radiated noise power from the Nord Stream pipeline was estimated by modelling sound pressure at four different ranges from the compressor as part of the EIA for the project NSP (Nord Stream 2009) and is shown in Figure 5-1 for four different segments of the pipeline (measured as distance from the compressor station in Russia). The noise was quantified in the modelling as radiated noise power per meter pipeline (L_W) and converted to sound pressure levels knowing that the energy flux density I through an area of 1 m^2 is given as:

$$I = \frac{p^2}{\rho c} \qquad \text{Eq. 4}$$

Where p is the pressure and ρc is the acoustic impedance. Rearranging and adjusting for the surface area of a 1 m long cylinder with radius 1 m around the gas pipe gives the sound pressure level L_{eq}:

$$L_{eq} = 10\log_{10}(p^2) = L_w + 10\log_{10}\left(\frac{\rho c}{2\pi}\right) \qquad \text{Eq. 5}$$

Assuming $\rho c = 1.5\times106\ kgm^{-2}s^{-1}$ this gives a correction factor of 54 dB, which was added to the modelled levels from Nord Stream (Nord Stream 2009) to obtain sound pressure level.

In addition to the modelling actual noise levels were recorded at three different locations in the Gulf of Finland close to the Nord Stream pipeline to detect noise from operation of the pipeline (Lindfors, Meriläinen, and Mykkänen 2016). Very high levels of shipping noise was recorded at all three stations, so the pipeline noise could not be detected. Figure 5-1 shows the modelled noise levels together with ranges of recorded levels close to the NSP2 route. Added to the figure are also spectra of wind-generated noise in shallow water, measured in the Finnish Bay (Poikonen 2010).

Noise levels are highest close to the compressor (the main noise source) and at KP20 exceeds ambient noise at frequencies below approximately 500 Hz. Three different ambient noise spectra are shown in Figure 5-1, all derived from (Poikonen 2010). The lowest curve is the lowest level measured by (Poikonen 2010), under completely calm weather conditions; middle curve corresponds to approxiamtely 10 m/s average wind speed and the highest curve is the highest level measured by (Poikonen 2010), at wind speeds above 14 m/s. The hearing threshold of harbour seals (the only seal species where reliable low frequency audiograms are available) is about 60 dB re. 1 µPa under quiet conditions (Kastelein et al. 2009). This means that close to the pipeline at KP20 the noise could be expected to be more than 40 dB above ambient, under quiet conditions. Extrapolating from this to a predicted detection distance is difficult, as this depends critically on transmission loss properties, which again depends critically on bathymetry. However, as the pipeline is a cylindrical sound source, the transmission loss can be expected to follow a cylindrical loss closer than a spherical loss (Urick 1983), which means that the pipeline noise can be expected to be detectable above ambient out to distances of several kilometers from the pipeline. Detection distance will decrease with increasing ambient noise, but even at strong winds, above 14 m/s, the noise at KP20 should be detectable close to the pipeline.

Further from the compressor, such as at KP125 (still in Russian waters), the noise will be less audible and unlikely to be detectable at distances more than tens of meters from the pipeline, even under quiet conditions.

Noise levels in Finnish waters (KP493 and KP1135) are expected to be well below natural ambient and as the pipeline corridor runs close to the major shipping route in the Gulf of Finland, the ambient noise in this part is expected to be dominated by ship noise (as indicated by the measurements of Lindfors, Meriläinen, and Mykkänen 2016). Pipeline noise is thus expected to be inaudible, even very close to the pipeline, in Finnish waters.

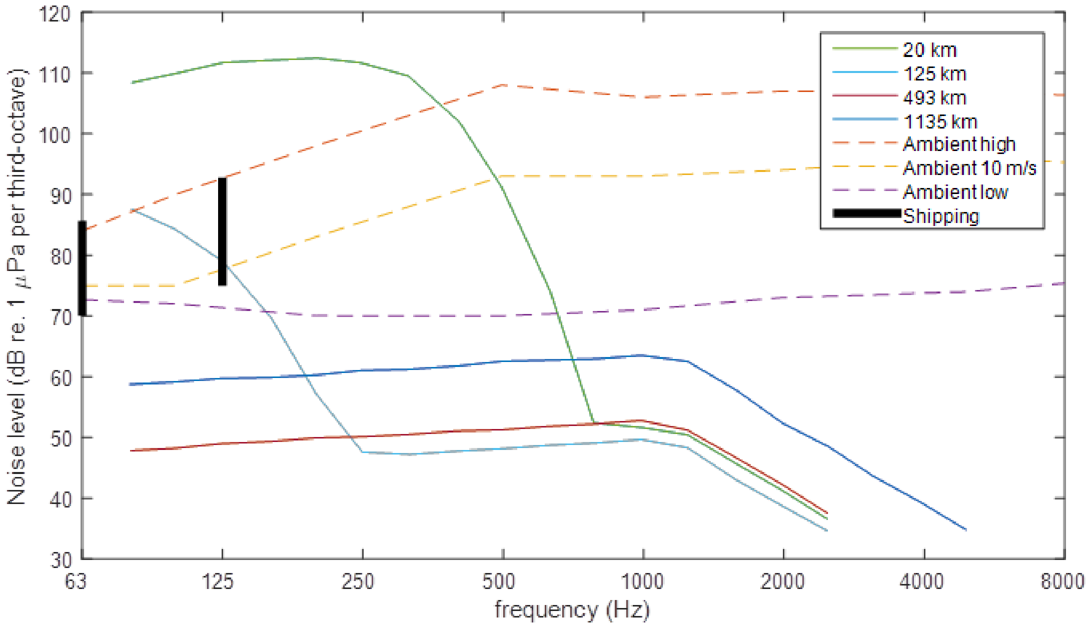

Figure 5-1 *Modelled radiated noise power from the Nordstream pipeline at four different Kilometer Points (KP 20 km, KP 125 km, KP 493 km and KP 1135 km) from the compressor station in Russia (kilometer points not directly comparable to Nordstream2, due to different routing). Added are also measured background noise levels (estimated ranges* L_{95}*-*L_5*) for two third-octave bands at 63 Hz and 125 Hz, indicated as black vertical bars. Modelled noise levels from Nord Stream (2009), shipping measurements from Lindfors, Meriläinen, and Mykkänen (2016) and ambient noise measurements from Poikonen (2010).*

5.2 Changes in the habitat

The introduction of hard bottom substrates, in form of the gas pipeline on the bottom represent a change in the habitat and may indirectly have a long-term effect by creating shelter for fish or by being colonised by algae and filter feeding epifauna and thereby create an artificial reef (Petersen and Malm 2006). The establishment of epibenthic communities on the hard substrates will increase the food available to fish. This means that the species composition around the pipeline may be altered and the number of individuals increased. Depending on the species, this may lead to an increase in the food available to marine mammals. For instance, Mikkelsen et al. (2013) examined the effect of construction of an artificial stony reef on the presence of harbour porpoises. They found that echolocation activity increased significantly after the reconstruction, likely as a result of increased prey availability. Whether colonised by flora and fauna or not, such reef structures are likely to attract fish, that will use the hard structures as shelter or hide-outs. This may locally increase the abundance of fish. However, whether this will have an impact on marine mammals in the area will depend on the environmental factors such as depth, sea bottom substrate and fish species composition.

5.3 Unplanned events

5.3.1 Potential gas release

During operation of the pipeline, there are a number of low risks which may result in pipeline failure and lead to subsea gas release such as corrosion, natural hazards, and external interference related to ship traffic such as dragged and dropped anchors.

In the event of gas release, marine mammals within the gas plume or the subsequent gas cloud may die if positioned directly in the plume or flee from the influenced area and thereby causing a behavioural effect (Nord Stream 2008).

6. Assessment methodology

The EIA for the NSP2 project in Finland contains a description of the methodolgies used and guidelines for how they should be interpreted for different receptors (Rambøll 2016b). This methodology is also implemented for the assessment of impacts in Russian waters. In this chapter, this methodology is interpreted in relation to marine mammals.

The overall aim of an EIA is to assess the significance of the impact. This is done by combining the sensitivity of the receptor with the magnitude of the impact (Table 6-1). Most assessments will follow the methodology of Table 6-1, but in some cases expert opinion are applied to deviate from the table. Such cases are explained thoroughly in the text. For unplanned impacts the overall significance is further combined with the likelihood of the impact actually occuring to assess the total significance.

The assessment covers both the construction and operation phases. The construction phase assessment is firstly carried out without considering any mitigation measures and secondly considering the mitigation measues that will be implemented during NSP2. The assessment methodology is identical for Finnish and Russian waters.

Table 6-1 Indicative table of the methodology to evaluate overall significance of an impact (From Rambøll 2016a). Negative impacts to the left, positive impacts to the right.

Impact significance		Impact magnitude						
		High	Medium	Low	None or negligible	Low	Medium	High
Sensitivity of receptor	Low	Moderate	Minor	Minor	None or negligible	Minor	Minor	Moderate
	Medium	Major	Moderate	Minor	None or negligible	Minor	Moderate	Major
	High	Major	Moderate	Moderate	None or negligible	Moderate	Moderate	Major

Sensitivity of marine mammals

The Finnish EIA describes sensitivity in the following way: “Sensitivity of an impacted target (e.g. organism, site, area) describes its susceptibility to any change caused by project or ancillary activities” and “Various criteria are used to determine the sensitivity including, among others, resistance to change, adaptability, rarity, diversity, value to other resources/receptors, naturalness, fragility and whether a resource/receptor is actually present during the active phase of the project”. And furthermore, “Regulations and social values should also be used to determine sensitivity.”

When assessing sensitivity of marine mammals in relation to the type of impact, the main focus have been on biology (physiological impact), population status (declining/stabile/increasing), abundance, vulnerable periods (e.g. breeding or moulting season), protection status (national and international), and distribution (their presence during the impact). The assessment methodology of marine mammal sensitivity have been summarized in Table 6-2

For information on population status, abundance, distribution and protection status the information described in the baseline report (Teilmann, Galatius, and Sveegaard 2017) were used.

Sensitivity and impact magnitude should ideally be assessed independently. However, this is not posible for all inputs to sensitivity, as they are often linked. The assessment of animal presence during the impact (especially munition clearance) requires input of spatial extent of the impact (The impact area). The spatial extent should be assessed on a more general scale than for example the extent of the models of noise and sediment spill. Consequently, the Finnish part of the NSP2 route were divided into four zones according to the population status and distribution of especially ringed seals, paying attention to the density of munitions and munitions identified and cleared during NSP. Each zone, except for the western part, thus contains at least one position where sound exposure from munition clearance was modelled (points M1-M4). The four zones were 1) the Inner Gulf of Finland (M1-2 area), 2) the Central Gulf of Finland (M3 area), 3) the Outer Gulf of Finland (M4 area) and 4) the Western Finnish waters (see Figure 6-1). Number of ordnances found and detonated, respectively, in the four areas are listed in Table 6-3.

Table 6-2 Assessment categories and methodology of sensitivity for marine mammal populations. All marine mammals in the Baltic are internationally and nationally protected, so this is identical for all sensitivity categories.

Low	The population is stable and the abundance is increasing. The impact area does not include nationally or regionally important areas (used for breeding, feeding or migration). Marine mammals only occur in low density. The marine mammal species is not sensitive to environmental changes i.e. their biology (physiology or behavior) is not or only temporarily affected by the impact.
Medium	The population is stable. The impact area includes parts of nationally or regionally important areas (used for breeding, feeding or migration). Marine mammals only occur regularly (= medium density). The biology of the marine mammal species are moderately affected by the impact.
High	The population is decreasing and/or the abundance is low. The impact area includes nationally or regionally important areas (used for breeding, feeding or migration). Marine mammals occur in high densities within the impact area. The marine mammal species is highly sensitive to environmental changes i.e. their biology (physiology or behavior) is severely affected or damaged by the impact.

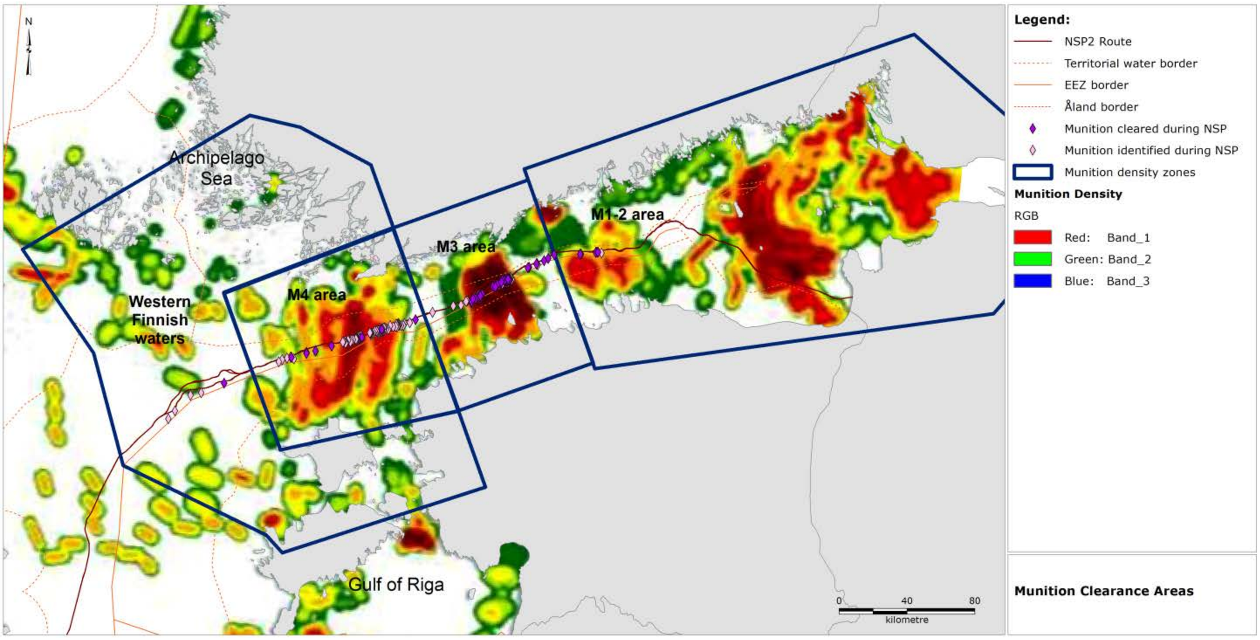

Figure 6-1 *Sensitivity assessment zones in the Finnish part of the NSP2 route 1) the M1-2 area (Inner Gulf of Finland), 2) The M3 area (Central Gulf of Finland), 3) M4 area (Outer Gulf of Finland) and 4) Western Finnish waters. Zones are divided according to the density of munitions cleared during NSPas well as munitions identified, but not cleared (UXO's).*

In relation to munition clearance, area 4) "the western Finnish waters", is considered of low impact until it has been further clarified whether munition are located along the NSP2 route and munition clearance noise models have been produced accordingly. For the three other areas, however, it is clear that munition clearance will be performed and consequently it was decided to assess sensitivity within each areas based on buffer zones along the NSP2 route. The buffer zones were calculated based on the maximum extent of the TTS and PTS zones for explosions at the four Finnish positions M1 through M4 (from Rambøll 2016a and Table 8-1) (Figure 6-2). The buffer zones are refered to as "impact area" in the sensitivity assessment.

Table 6-3 *Number of identified and cleared unexploded ordnances during NSP in the four different areas shown in Figure 6-1.*

Munition	Outside	M4	M3	M2-1
Cleared	1	7	42	6
Identified	5	139	181	7

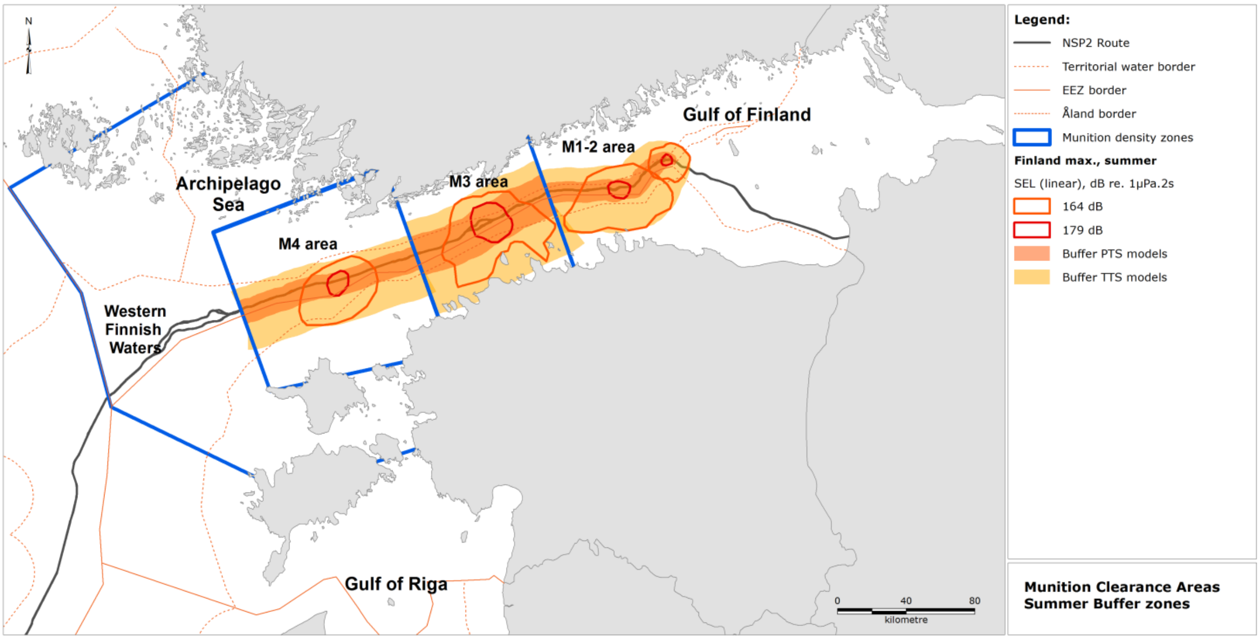

Figure 6-2 *The buffer zones based on the maximum and mean extent of the TTS and PTS zones for explosions at the four Finnish positions M1 through M4 (from Rambøll 2016a and Table 8-1).*

In Russian waters, the modelled extent of noise from the three examples of munition clearance overlaps considerably and together covers most of the potential impact area. Thus, creating buffer zones to identify potential zones of impact between the modelled munition clearance models, was not required.

The sensitivity should, where possible, be assessed in quantifiable terms i.e. number of animals affected. In Finnish and adjacent waters, the existing data on distribution and abundance of seals comes from aerial surveys and satellite tracking while the data for porpoises comes from passive acoustic monitoring and opportunistic sightings. Both methods used for seals are potentially very usefull if data is sufficient to inform about spatial and temporal distribution as well as abundance in the areas concerned. This is, however, not the case in the study area (Finnish, Russian and Estonian waters): Survey data does not cover all areas and seasons and more satellite taggings of both seal species are needed in order to represent the populations adequately. This could be overcome by producing a species distribution model or a habitat suitability model based on the existing telemetry data, which could be useful for future assessments. However, currently the data for grey seal and ringed seal are insufficient for quantifying the magnitude of change, and the impact magnitude has thus been assessed qualitatively based on the available raw data and expert opinion. The passive acoustic monitoring data for porpoises has been used to create a distribution map for the entire Baltic Sea (SAMBAH 2016). This model is included in sensitivity assessment together with opportunistic sightings.

Impact magnitude

The methodology from the Finnish EIA has been applied to the assessment in both Finnish, Russian and Estonian waters and the described impact magnitude "*Magnitude of the change* is a measure of intensity, direction (direct/indirect), spatial extent and duration of the change caused by the project." And "In general, the spatial extent of the particular impact can be ranged as local, regional, national or transboundary. The duration of the impact can be categorized temporary, short-term or long-term. The spatial extent of the impact varies from local where only the waters directly above or in the near vicinity of the pipeline are affected to large scale impacts affecting several hundred square kilometres. Finally, the magnitude of the change for every examined impact will be assessed into subclasses *high, medium, low* and *negligible*.” The general method for assessing the impact magnitude are summarized in Table 6-4.

Table 6-4 Assessment categories and methodology of impact magnitude for marine mammal populations.

No or negligible	No detectable impacts on marine mammals.
Low	Impacts are of low intensity, the spatial extent is small and/or the duration is short (hours). Impacts are reversible and do not lead to any permanent change.
Medium	Moderate impacts on marine mammal species. Impact time is from days to weeks. Limited spatial extent. Some impacts may be irreversible.
High	Significant long-lasting (months) or permanent impacts on marine mammals (i.e. high intensity) Large geographical extent. Most impacts are irreversible.

Assessment levels

For the three marine mammals we have opted to assess the impacts of munition clearance on two scales:

1. Significance at the population level in relation to seal distribution and abundance.
2. Significance at the individual level: although injury to or death of individual seals may not impact populations and the environment significantly, individual injuries to or deaths of large mammals may have profound ethical implications.

Cumulative impact from repeated exposures to explosions is assessed both at the level of individuals (of particular importance for TTS/PTS and behavioural reactions) and at the population level. Cumulative impact at the population level arises because for each additional explosion, there will be a risk that one or more animals are injured by the noise and thus even if a single explosion is assessed to have insignificant impact on the population, the cumulated risk will at some point become so large that the impact must be considered above insignificant. Quantifying this realtionship is extremely difficult, as it must rely on very accurate knowledge of the risks involved and the behavior of the animals. The phenomenon is illustrated in its most simple form in Figure 6-3 where the cumulative probability that one or more animals are injured, given knowledge of the probability (p) for a single explosion and assuming that the risk does not change from one explosion to the next. In reality the risk could increase (if distant animals are attracted by one explosion, increasing the number of exposed animals for subsequent eplosions) or decrease (due to a deterrence effect of the explosion, where animals exposed once stay clear of the general area).

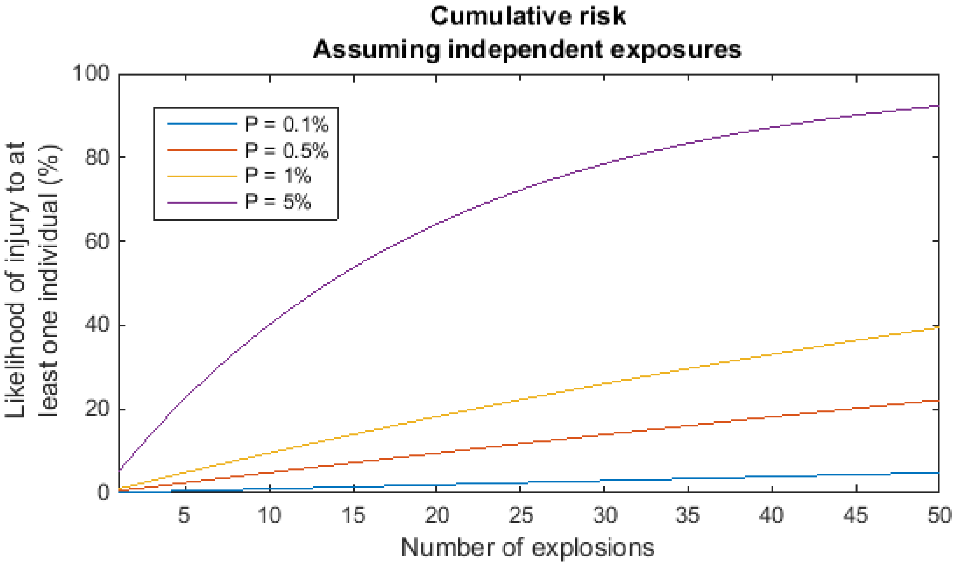

Figure 6-3 Cumulative risk that at least one animal is injured from repeated explosions, given that the risk for a single explosion (P) is constant and exposures can be considered independent events. In this case $\boldsymbol{P(N) = 1 - (1 - P)^N}$.

7. Sensitivities of marine mammals

Noise, sediment spill, turbidity, ship traffic and changes in the habitat may have either a negative or positive impact on the behaviour of marine mammals by either detering or attracting the animals from the site of impact or by disturbing the normal behaviour e.g. foraging or socializing. For instance, during visual boat surveys harbour porpoises have been shown to either dive down or swim away when the boat is less than 50 m away (SCANSII 2008). It is also likely that marine mammals will move away from the area when hearing an unfamiliar or loud noise or experiencing visual impairment or increased turbidity caused by sediment spill. In addition, there are more specific effects of noise and sediment spill.

In this chapter, the sensitivity of harbour porpoises, grey seals and ringed seals is assessed, based on the method described in Section 6.1. Sensitivity assessments are – except where described otherwise - identical for Finnish, Estonian and Russian waters.

7.1 Underwater noise

Underwater noise is well known as a source of impact on the marine ecosystem, including marine mammals (e.g. Tyack 2009; National Research Council 2005). This impact can occur through a number of processes and usually three main issues are considered:

- Physical injury (incl. blast injury) and hearing loss (incl. PTS/TTS)
- Disturbance of animal behaviour
- Masking of relevant sounds to the animal

In addition to the above three issues, are more general physiological reactions to noise such as elevated stress hormone concentrations in the blood following exposure to loud noise (Romano et al. 2004) and possibly also cronic stress due to long term exposure. However due to the limited number of experimental studies physiological impacts are most often excluded from impact assessments. A fourth type of impact is also often considered: the zone of audibility (Richardson et al. 1995), which is simply the zone where the noise is audible above ambient noise. However, the fact that a noise can be heard does not by itself imply an impact and is thus not considered further in this context.

In terms of severity, there is a gradual transition from temporary heearing loss (TTS, see 7.1.2) over permanent hearing loss (PTS, see 7.1.2) to acoustic trauma and tissue damage (Figure 7-1). Some authors, such as von Benda-Beckmann et al. (2015), provide estimates of these transition borders, aligned along a common SEL axis. As acoustic trauma appears to be better correlated with acoustic impulse than SEL (Yelverton et al. 1973; Lance et al. 2015) this direct alignment along a common axis is considered very difficult from a quantitative point of view and has thus not been attempted. In the end, only three levels, translated into impact ranges, are thus considered: Onset of TTS, Onset of PTS and onset of tissue damage. It is important to keep in mind that the effects are graded and not discrete and that thresholds are statistical too. Thus at sound exposures right around the threshold for TTS as an example, there is an increased risk that some animals will develop small amounts of TTS and as the sound exposure increases, the risk and the severity of the TTS increases.

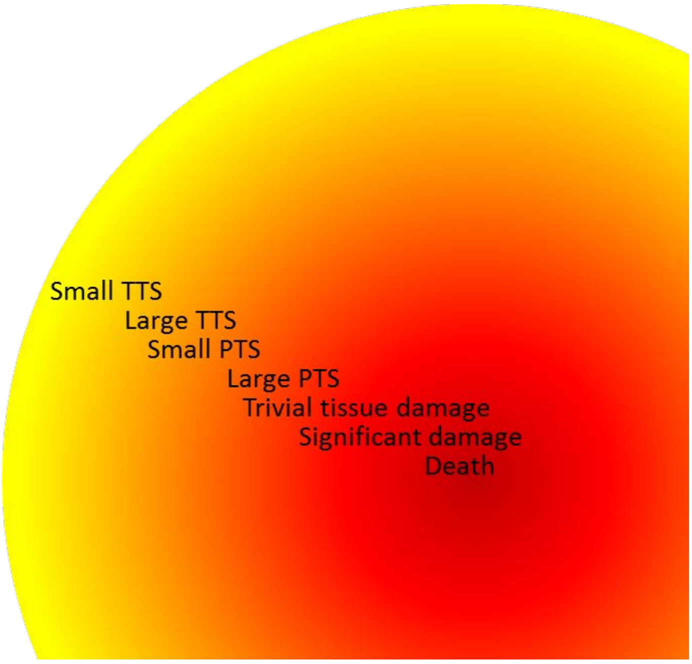

Figure 7-1 *Schematic severity scale, away from sound source. The exact distribution of transitions away from the center depends critically on the type of sound involved and is not to scale. Note that the area exposed to low levels is much larger than the area exposed to high levels.*

7.1.1 Blast injury (caused by munition clearance)

At close range the shock wave from an explosion can cause tissue damage. Tissue damage arises because of differential acceleration of tissue with different density and can thus literally tear tissue apart, leading to anything from insignificant small bleedings to death. The relevant metric used to judge the risk of tissue damage is *acoustic impulse*, measured in Pa·s (see footnote[1]) and is effectively the time integral of the positive pressure pulse of the shock wave. Exposure limits have been determined by Yelverton et al. (1973) through a series of experiments with live sheep and dogs submerged in a lake. As the most significant factor for scaling impact from one animal to another appears to be the lung volume the thresholds are considered to be transferable to small marine mammals, such as seals and porpoises. Yelverton et al. (1973) derived four limits, listed in Table 7-1.

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[1] Note that this unit is different from the unit for acoustic pressure (Pa) and the unit for Sound Exposure Level (SEL, Pa^2s). These units are not related in simple ways and it is thus not possible to convert between them in a simple way and hence also not permissible to compare them directly. This also means that the extent of the blast injury zone must be modelled separately from the TTS/PTS-zones, described in section 7.1.2. An example of such modelling is shown in section 9.1.1.

Table 7-1 *Blast injury thresholds for mammals. From* Yelverton et al. (1973). Note that harbour porpoises, as all cetaceans, have no functional ear drum.

Acoustic impulse	**Description**
280 Pa·s	No mortalities, but frequent incidence of moderately severe blast injuries, including ear drum rupture. Animals considered capable of recovering on their own.
140 Pa·s	High incidence of slight blast injuries, including ear drum rupture.
70 Pa·s	Low incidence of trivial blast injuries. No ear drum rupture.
35 Pa·s	Safe level

A recent review and compilation of a large number of human medical cases involving blast injury (Lance et al. 2015) reviewed safety limits for human divers. This study included a sufficient number of cases to derive proper risk functions (475 individual exposures, dating back to WW2 and a substantial number of which were fatal). The resulting thresholds for a 10% chance of (recoverable) injury and fatal injury was 30 Pa·s and 240 Pa·s, respectively. The injury threshold thus corresponds well with that of Yelverton et al. (1973), whereas the threshold for fatal injuries is substantially lower than what can be derived from Yelverton et al. (1973), as it is comparable to the latters threshold for moderately severe, but survivable injuries. It is unknown to what degree the human data (Lance et al. 2015) and the data from dogs and sheep (Yelverton et al. 1973) can be compared and which of the two datasets is best transferable to marine mammals.

Figure 7-2 shows an example of estimation of a blast injury zone around a 300 kg mine detonated at 40 m depth, illustrating that the blast injury zone can extend many kilometers out from the blast site.

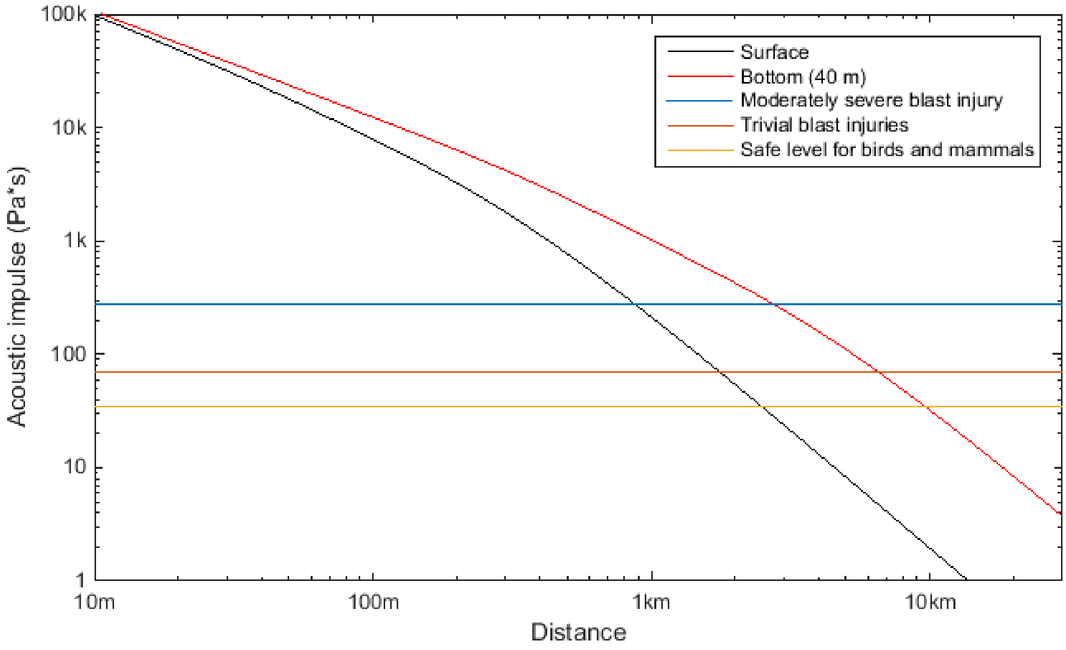

Figure 7-2 *Example of estimated acoustic impulse with range for a 300 kg detonation (mine + donor charge) at the bottom at a depth of 40 m. Black line is for animals at the surface, red line close to the bottom. Three horizontal lines indicate the injury thresholds defined by Yelverton et al. (1973). A worst case scenario is assumed in which the total charge explodes together with the donor charge and that the explosion is with access to open water (directly on the sea bed). Predictions and injury thresholds from Yelverton et al. (1973) (See).*

Animals closer to the bottom are more severely affected than animals closer to the surface and thus the extent of the impact zone differs with depth of the animals. The number of affected animals N_{total}, can be estimated from the density of animals per volume of water, within each of *n* depth layers, each spanning *d* meters vertically.

$$N_{total} = \sum_n D_i d \pi r_i^2 \qquad \text{Eq. 1}$$

Where D_i is the volume density of animals and r_i is the extent of the impact zone, both in depth layer *i*. If we assume animals to be evenly distributed with depth, then N_{total} is given as

$$N_{total} = \pi \frac{D}{n} \sum_n r_i^2 \qquad \text{Eq. 2}$$

Where D is the more conventional density of animals expressed as animals per square kilometer of sea surface. By rearrangement we can define the equivalent radius of the impact zone, r_{eq}

$$r_{eq} = \sqrt{\frac{1}{n} \sum_n r_i^2} \Leftrightarrow N_{total} = D \pi r_{eq}^2 \qquad \text{Eq. 3}$$

This equivalent radius expresses the radius of an area where impact is constant with depth and the same number of animals is affected by the noise as in the more realistic scenario with increasing impact with depth. For the example shown in **Error! Reference source not found.** the equivalent radius is 5 km. The majority of the actual detonations are likely to be considerably smaller than 300 kg (Rambøll 2016d), and the blast injury zone is thus considered to be within the PTS-zone. The two types of impact are however assessed seperately.

The actual impact of an explosion will depend critically on the number of animals present within the zones of impact at the time of detonation.

A marine mammal exposed to moderately severe blast injuries will recover on its own, and no long term effects are expected. It is however possible that the injuries will decrease the fitness for a period of time or even cause reproduction failure (miscarriages) for a season. Consequently the impact of moderately severe injuries may have an affect on very small threathened populations such as the Baltic harbour porpoise or the ringed seal in the inner Gulf of Finland.

The sensitivity of both seal species in the impact area to blast injury is assessed as **high** on the individual level because of the risk of fatal injuries and the high likelyhood of seals being present in the area. On a population level, the sensitivity for blast injury is identical to the sensitivity of PTS – see section 7.1.4.

The sensitivity of harbour porpoises to blast injury on both population and individual level is assessed as **low** due to the very low density in Finnish, Estonian and Russian waters.

7.1.2 Hearing threshold shift (TTS/ PTS)

For marine mammals it is generally accepted that the auditory system is the most sensitive organ to acoustic injury, meaning that injury to the auditory system will occur at lower levels than injuries to other tissues (see e.g. Southall et al. 2007). Furthermore, noise induced threshold shifts are likewise accepted as precautionary proxies for more widespread injuries to the auditory system. Noise induced threshold shifts are temporary reductions in hearing sensitivity following exposure to loud noise (For example commonly experienced by humans as reduced hearing following rock concerts etc.). Temporary threshold shifts (TTS) disappear with time, depending on the severity of the impact. Small amounts of TTS will disappear in a matter of minutes, extending to hours or even days for very large TTS. A schematic illustration of the time course of TTS is shown in Figure 7-3. The amount of TTS immediately after end of the noise exposure is referred to as initial TTS. It expresses the amount by which the hearing threshold is elevated and is measured in dB. The larger the initial TTS, the longer the recovery period.

At higher levels of noise exposure the hearing threshold does not recover fully, but leaves a smaller or larger amount of permanent threshold shift (PTS), see Figure 7-3. This permanent threshold shift is a result of damage to the sensory cells in the inner ear (Kujawa and Liberman 2009). An initial TTS of 50 dB or higher is generally considered to constitute a significantly increased risk of generating a PTS (Ketten 2012). Lower levels of TTS can, if repeatedly induced, also lead to PTS (Kujawa and Liberman 2009), which is also well known in humans. This cumulative effect has, however, not been included in the assessment, as there is no experimental evidence from marine mammals that can help quantify this effect.

In order to evaluate the output of the exposure model in terms of impact on animals, it is required to have thresholds for TTS and PTS to compare against. Deriving such has been the subject of a large effort from many sides (see reviews by Finneran 2015; Southall et al. 2007). No current consensus on general thresholds for TTS and PTS can be said to exist. Matters are simplified somewhat, however, if one restricts to only one type of sound, such as airgun noise or pile driving noise and limits the discussion to only species for which sufficient data is available. A comparatively large effort has gone into investigating TTS caused by low frequency noise, including from pile driving, in harbour seals and harbour porpoises, as these species are key species in many impact assessments. TTS is in general localised to frequencies around and immediately above the frequency range of the noise which caused the TTS. This means that TTS induced by low frequency noise typically only affects the hearing at low frequencies (Kastelein et al. 2013).

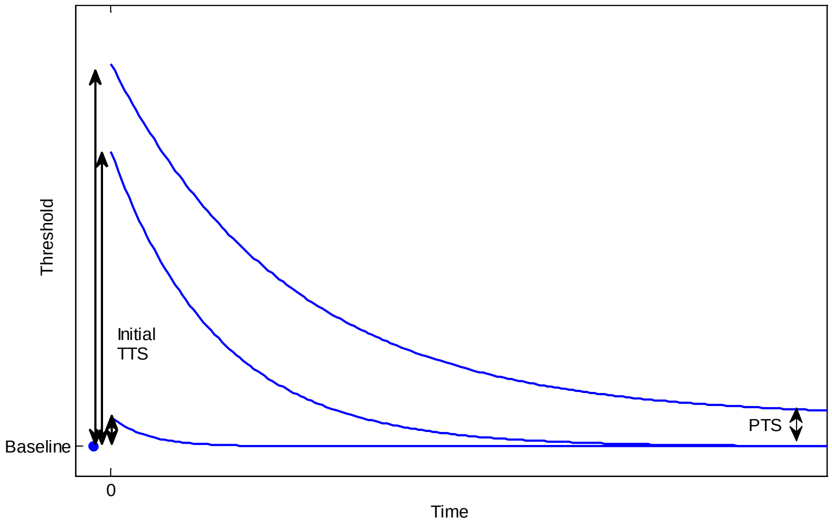

Figure 7-3 *Schematic illustration of the time course in recovery of TTS. Zero on the time axis is the end of the noise that caused the TTS (often referred to as the fatiguing noise). Gradually the threshold returns to baseline level, except for very large amounts of initial TTS where a smaller permanent shift (PTS) may persist. From Skjellerup et al. (2015). As the figure is schematic, there are no scales on the axes. Time axis is usually measured in hours to days, whereas the threshold shift is measured in tens of dB.*

As PTS thresholds for ethical reasons cannot be measured deliberatly in experiments, the agreed approach to estimate thresholds for PTS is by extrapolation from TTS thresholds to the noise exposure predicted to induce 50 dB of TTS and thus a significant risk of PTS. This extrapolation is not trivial, however, as it is complicated by the fact that the relationship between exposure and amount of initial TTS is not proportional (see e.g review by Finneran 2015). Thus, one dB of added noise above the threshold for inducing TTS can induce more than one dB of additional TTS, see Figure 7-4. The slope of the TTS growth-curve differs from experiment to experiment and slopes as high as 4 dB of TTS per dB of additional noise has been observed in a harbour porpoise (Lucke et al. 2009).

Two aspects of TTS and PTS are of central importance. The first aspect is the frequency spectrum of the noise causing TTS/PTS, which leads to the question of how to account for differences in spectra of different types of noise through frequency weighting. The second aspect is the cumulative nature of TTS/PTS. It is well known that the duration of exposures and the duty cycle (proportion of time during an exposure where the sound is on during intermittent exposures, such as pile driving) has a large influence on the amount of TTS/PTS induced, but no simple model is available that can predict this relationship.

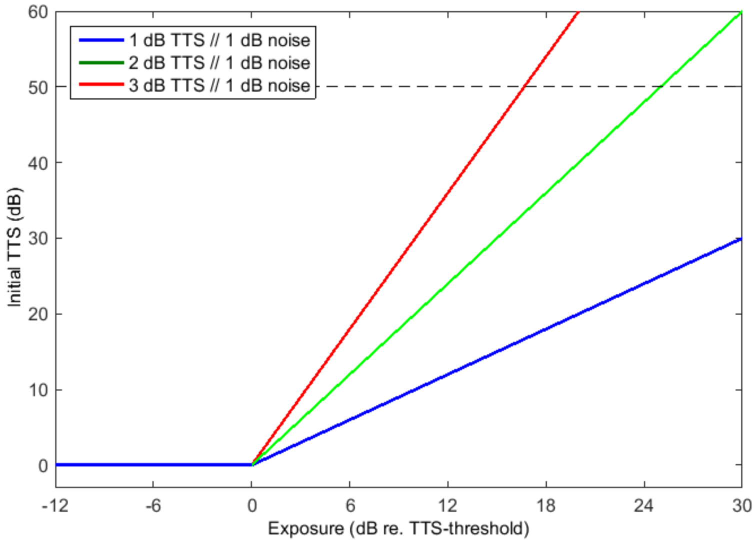

Figure 7-4 *Schematic illustration of the growth of initial TTS with increasing noise exposure. Three different slopes are indicated. Note that the real curves are not necessarily linear. Broken line indicate threshold for inducing PTS, assumed to be at 50 dB initial TTS. From Skjellerup et al. (2015).*

Importance of frequency

Substantial uncertainty is connected to the question of how the fact that animals do not hear equally well at all frequencies should be handled when assessing risk for inflicting TTS and PTS. Southall et al. (2007) proposed that frequencies should be weighted with a fairly broad weighting function (M-weighting) which only removes energy at very low and very high frequencies, well outside the range of best hearing for the animals. Separate weighting functions were developed for different groups of marine mammals. Others have proposed a more restrictive weighting with a weighting filter function resembling the inversed audiogram (e.g. Terhune 2013; Tougaard, Wright, and Madsen 2015) or other intermediate weightings, with increased emphasis on higher frequencies over lower, less audible frequencies (Finneran and Schlundt 2013). As long as this remains unsettled it is unclear how frequency weighting should be performed and much caution should be taken when extrapolating results from one frequency range to another (Tougaard, Wright, and Madsen 2015). The approach taken in the following is thus to restrict extrapolation across frequencies and use unweighted levels from the same frequency range as the assessed noises (explosions and rock placement). This approach will limit possible errors caused by an improper weighting of signals (Tougaard, Wright, and Madsen 2015).

Equal energy hypothesis

A substantial effort has gone into quantifying sound levels required to elicit TTS in marine mammals. The initial experiments were primarily conducted on bottlenose dolphins, belugas and sea lions (all reviewed by Southall et al. 2007), but recently also a large number of results are available from other species, most notably harbour seals and harbour porpoises (see comprehensive review by Finneran 2015). The initial recommendations of Southall et al. (2007) reflected an uncertainty as to what single acoustic parameter best correlated with amount of TTS induced and resulted in a dual criterion: one expressed as instantaneous peak pressure and another as acoustic energy of the sound (integral of pressure squared over time, see below). In the reviews of Tougaard, Wright, and Madsen (2015) and Finneran (2015) this uncertainty is no longer present and it is generally accepted that everything else being equal the amount of TTS correlates better with the acoustic energy than with the peak pressure. The acoustic energy is most often expressed as the sound exposure level (SEL), given as:

$$SEL = 10\log\int_0^T \frac{p^2(t)}{p_0^2}dt \quad \text{Eq. 3}$$

Where p(t) is the instantaneous pressure at time t of a signal of duration T and p_0 is the reference pressure (1 µPa, in water). The unit of SEL is thus dB re. $1\mu Pa^2 s$. It is possible to show that this unit is indeed a unit of energy, being proportional to Jm^{-2} by means of a constant depending on the acoustic impedance of water.

The integration period T should equal the duration of the fatiguing noise up to some limit. This limit is debated. In human audiometry it is customary to use 24 hours, in conjuction with the sensible assumption that people are often exposed to loud noise during their workday and then spend the night resting in a quiet place. This assumption is less relevant for marine mammals, but the 24 h maximum was retained by Southall et al. (2007), stressing that it is likely to be very conservative (in the sense that it leads to overprotection). For exposures with a known duration less than 24 hours the actual duration should of course be used, as was done below with the rock placement noise (SEL integrated over 2 hours).

The long-term effects of various degrees of permanent hearing loss on long-term survival and reproductive success of marine mammals is unknown and it is thus difficult to assess the population effects. As PTS is graded, there is a lower level, where the hearing loss is so small that it is without long-term consequences for the animal, but for very large hearing losses the ability of the animal to carry out its normal range of behaviours will be affected and hence its fitness lowered. As there is very limited experimental evidence on this question and the general relationship between magnitude of exposure and degree of hearing loss, even for humans. Consequently, it is not possible to quantify these relationships in a meaningful way beyond extrapolating thresholds for development of the lovest levels of PTS based on TTS thresholds, as done below. Therefore it must be stressed that there is a considerable uncertainty connected to the assessment of impact of PTS on seals and porpoises.

PTS primarily affects hearing around and slightly above the frequency range of the damaging sound, i.e. low frequencies in case of noise from underwater explosions. mainly decreases hearing of the low frequencies. All Baltic species of seals use underwater calls in the low frequency range (e.g. Bjørgesæter, Ugland, and Bjørge 2004), which means that substantial PTS in this range could reduce communication abilities of affected seals, which again potentially could impact mating behaviour, but the degree of such a potential impact cannot be assessed. Porpoises use sounds for echolocation at much higher frequencies (above 100 kHz) and echolocation is thus likely not affected by even large PTS at lower frequencies. Porpoises are likely, however, to use hearing at lower frequencies for passive acoustic orientation (auditory scene analysis), which would potentially be affected by a low frequency hearing loss. As for the seals, however, the degree and significance of such a potential impact cannot be quantified.

7.1.3 TTS and PTS in harbour porpoises

Several studies on TTS in harbour porpoises are available. One study is relevant for explosions, namely the study of Lucke et al. (2009). Lucke et al. (2009) measured TTS induced by exposure to single airgun pulses, generated from a small 20 in^3 sleeve gun at a received SEL of 164 dB re. 1 μPa^2s. This threshold is markedly lower than other thresholds for TTS measured by repeated pulses (Kastelein et al. 2015 measured TTS induced by a 1h sequence of pile driving pulses) or longer sounds (Kastelein et al. 2012; Kastelein et al. 2013; Kastelein et al. 2014). The difference is likely due to the impulsive nature of the airgun pulse of Lucke et al. (2009). Different observations support that thresholds for single pulses, intermittent noise and continuous noise cannot be compared directly and thus that the simple assumption that total noise SEL determines the TTS induced (the *equal energy hypothesis* described above) does not hold for all sounds. See e.g. Finneran et al. (2010) for an example of differences in thresholds between single pulses, repeated pulses and continuous noise. The recent demonstration of a rapid reduction in hearing sensitivity in dolphins after being conditioned to a loud noise by a warning signal (Nachtigall and Supin 2014) also means that the noise exposure experienced by the inner ear to a single transient noise could be significantly higher than to a longer noise or a repeated series of pulses. Thus, as transients from explosions are single pulses it appears prudent to use the only threshold derived from a single pulse stimulus, i.e. the threshold of 164 dB re. $1\mu Pa^2s$ from Lucke et al. (2009), as also used by von Benda-Beckmann et al. (2015) in their assessment of impact from munition clearance on porpoises in the southern North Sea.

For continuous noise, such as noise from rock placement, it is more appropriate to derive a TTS threshold from the numerous studies using fatiguing noise of various durations (Kastelein et al. 2012; Kastelein et al. 2013; Kastelein et al. 2014). These studies have been condensed into one threshold of 188 dB re. $1\mu Pa^2s$ by Finneran (2015).

A threshold for inducing PTS in high-frequency cetaceans, including harbour porpoises, was proposed by Southall et al. (2007). However, this threshold was based solely on experimental data from mid-frequency cetaceans (bottlenose dolphins and beluga) and is no longer considered representative. Only one study is directly relevant to PTS and this was performed on a sister species to the harbour porpoise, the finless porpoise. Popov et al. (2011) were able to induce very high levels of TTS (45 dB), likely close to the level required to induce PTS, by presenting octaveband noise centred on 45 kHz at a received SEL of 183 dB re. 1 μPa^2s. This signal was of much higher frequency than the main energy of explosions and rock placement noise, however, and of longer duration (3 min) than a blast pulse (milliseconds). Furthermore, the experiment was performed on another species (although closely related). It is thus questionable whether this result can be transferred to impulsive sounds or rock placement noise. In line with Southall et al. (2007) the PTS threshold was here instead extrapolated from TTS thresholds by adding 15 dB, equal to 179 dB re. 1 μPa^2s for explosions and 203 dB re. 1 μPa^2s for rock placement noise.

The densities of porpoises in the waters relevant for this assessment, are very low (in the Gulf of Finland (Finnish and Estonian waters) densitites are <0.0004 individuals per km^2 (see footnote[2]).

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[2] This density should only be considered a rough estimate and it may only be correct to within several orders of magnitude, since it is based on extrapolation of a model derived mainly from data from the central part of the Baltic, i.e. without any positive porpoise observations from the Gulf of Finland. Even a single positive observation included in the dataset would likely change the density estimate considerably.

Thus, combined with the opportunistic sightings from recent years (2011-2015), it is concluded that porpoises may be present in the impact areas all year but in very low densities.

Based of the above information, the sensitivity of harbour porpoises to PTS and TTS is assessed to be **low**, both at individual level and population level, due to the very low density in the impact area.

7.1.4 TTS and PTS in seals

Southall et al. (2007) estimated TTS and PTS thresholds for seals in general, but these estimates were based on data from bottlenose dolphins, beluga and California sea lions. However, since 2007 actual measurements from harbour seals have become available and are used here instead to estimate thresholds for ring and grey seals.

PTS was induced due to an experimental error by Kastak et al. (2008), where a harbour seal was exposed to a 60 s tone at 4.1 kHz at a total SEL of 202 dB re. 1 $\mu Pa^2 s$. This means that an actual measurement is available. In fact, a second experiment (in a different facility and on a different animal) produced a very strong TTS (44 dB) by accident by exposure to 60 minutes of 4 kHz octave band noise at a SEL of 199 dB re. 1 $\mu Pa^2 s$ (Kastelein, Gransier, and Hoek 2013). The level of TTS is considered to have been very close to inducing PTS. By combining the two experiments a threshold for PTS in harbour seals for continuous noise (rock placement) is set to 200 dB re. 1 $\mu Pa^2 s$.

A number of experiments have determined TTS in harbour seals for various types of noise of shorter and longer duration, summarized by Finneran (2015) and producing an average threshold estimate of 188 dB re. 1 $\mu Pa^2 s$, which is considered as the appropriate threshold for rock placement noise.

No experiments have been performed on harbour seals with single noise impulses. The thresholds estimated for rock placement are very similar to the thresholds for porpoises, however. This leads to an adoption of the same TTS and PTS thresholds for single impulsive noises for seals as for porpoises, i.e. 164 dB re. 1 $\mu Pa^2 s$ and 179 dB re. 1 $\mu Pa^2 s$ for TTS and PTS, respectively.

There are no results available from grey or ringed seals, or any other phocine seal of similar size. Results from California sea lions (Finneran et al. 2003) are considered less likely to be representative for grey and ringed seals than the harbour seal data. Consequently the results from harbour seals should until actual data becomes available be considered valid for grey seals and ringed seals as well.

The sensitivity of both seal species to TTS is assessed to be **low** on both individual and population level due to the reversible and temporary nature of the impact.

The sensitivity of grey seals in the impact area to PTS is assessed to be **high** on individual level because of the potential detrimental effect and the high likelyhood that an individual will be present near a munition clearance. At a population level, sensitivity is assessed to be **low**, because, despite that the impact may be detrimental to several individuals, the population as a whole is increasing and the population is in good environmental status.

The sensitivity of ringed seals to PTS is assessed to be **high** on individual level in all areas because of the potential detrimental effect and the high likelyhood that an individual will be present, as ringed seals can be encountered in all parts of the Gulf of Finland. The sensitivity of ringed seals to PTS is assessed to be **high** on population level in all areas occupied by the Gulf of

Finland ringed seal population (i.e. all Russian impact areas as well as the M1-2 area in Finland). In the M4-area in Finland, the sensitivity at the population level is assessed to be **low** due to the higher abundance (relative to the Gulf of Finland area) of the ringed seal populaton in the Archipelagio Sea and the Gulf of Riga and the greater distance of the pipeline to the core area of these stocks. In the M3-area in Finland, the sensitivity on population level is assessed to be **medium** because although fewer animals may be present compared to the M4 and the M1-2 area, it is likely that ringed seal from the endangered Gulf of Finland population will be present.

7.1.5 Summary of TTS and PTS thresholds

The risk that marine mammals exposed to explosions develop hearing threshold shifts (TTS and PTS) is high, because of the comparatively low thresholds and hence high likelihood of inflicting TTS and PTS by exposure to high-intensity sounds Table 7-2 presents a summary of estimated thresholds for inducing TTS and PTS from single explosions and continuous noise from rock placement.

Table 7-2 *Estimated thresholds for inducing TTS and PTS from single explosions and continuous noise from rock placement. See text for justification and references to experiments underlying these thresholds.*

Species	Explosions		Rock placement	
	TTS	PTS	TTS	PTS
Harbour porpoise	164 dB SEL	179 dB SEL	188 dB SEL	203 dB SEL
Seals	164 dB SEL	179 dB SEL	188 dB SEL	200 dB SEL

7.1.6 Noise induced disturbance of behaviour

Permanent or temporary changes in marine mammal hearing may not necessarily be the most detrimental effect of noise. Noise levels below the TTS threshold may affect and alter the behaviour of animals, which can carry implications for the long-term survival and reproductive success of individual animals, and thereby ultimately on the population status if a sufficiently high proportion of the population is affected for a sufficiently long period (NRC 2003) see Figure 7-5. Effects can occur directly from severe reactions as for example panic or fleeing (negative phonotaxis), by which there is an increased risk of direct mortality due to for example bycatch in gill nets (as suggested for porpoises in response to military sonar excercises (Wright et al. 2013) or separation of dependent calves from mothers. More common, however, is probably less severe effects where animals may be displaced or their foraging or mating behaviour altered due to noise. Seals are generally considered less sensitive to displacement by noise (see e.g. Blackwell, Lawson, and Williams 2004), but this assertion is largely without experimental evidence.

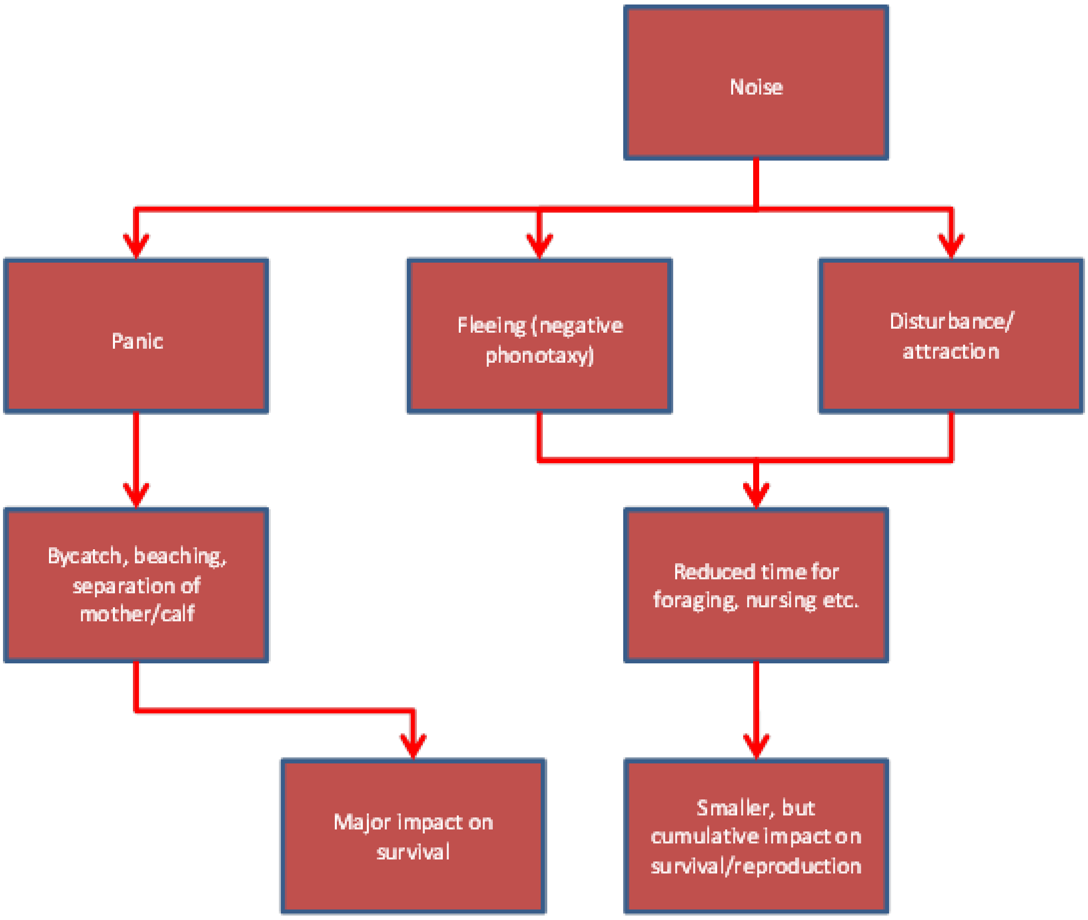

Figure 7-5 *Schematic illustration of mechanisms by which noise-induced changes to behaviour can lead to effects on short-term and long-term survival and reproduction (fitness) in marine mammals. From Skjellerup et al. (2015).*

Based on independent information about the conservation status of the focal population (for example population monitoring prior to impact) an acceptable limit of disturbance may be determined for a specific species and within agreed management objectives for the given population. Again based upon the status of the considered population additionally some small mortality may also be considered acceptable for the activity under evaluation. However, at present the knowledge about how immediate, short-term behavioural changes translate into population level effects is very incomplete for marine mammals, and to a degree where inference to population level is not possible (NRC 2003). At present it is therefore not possible to derive exposure limits based on management objectives for the conservation status of a population and assessment can only be based on the immediate disturbance from the noise.

Examples of sources of noise that may result in disturbance and behavioural changes such as avoidance in relation to the NSP2, are increased vessel traffic (construction and support vessel movement), rock placement and noise from vibratory sheet piling in Russia.

The sensitivity to noise induces behavioural changes or disturbances are assessed to be **medium** for seals and **low** for harbour porpoises due to the low density in the study area.

The noise caused by the operation of the gaspipe are very low and only potentially audible to marine mammals close to the compressor station in Russia and very close to the pipeline and their sensitivity is thus **low**.

7.1.7 Masking

Masking is the phenomenon that noise can negatively affect the ability to detect and identify other sounds. The masking noise must be audible, roughly coincide with (within tens of ms), and have energy in roughly the same frequency band, as the masked sound. Due to the singular nature of the noise from explosions they have essentially no ability to mask other sounds and this effect is thus not assessed. For sounds of longer duration, such as rock placement and ship noise the potential for masking of low frequency sounds is clearly present. However, as the current level of knowledge about conditions where masking occur outside strictly experimental settings and how masking affects short term and long term survival of individuals, it is not possible to assess masking, except noting that the zone of audibility can be used as a very precautionary indicator to the possible extent of the zone of masking. See Erbe et al. (2016) for a current review.

The sensitivity to masking caused by rock placement are assessed to be **medium** for seals and **low** for harbour porpoises due to the low density in the study area.

7.2 Sediment spill

7.2.1 Visual impairment

The harbour porpoise use echolocation for orientation in the environment as well as for prey localisation. Studies of porpoises tagged with acoustic/satellite transmitters have shown that they often hunt at night and move into depth of complete darkness with or without an accompanying calf (Wisniewska et al. 2016; Teilmann, Larsen, and Desportes 2007). Consequently, the sensitivity of harbour porpoises to the visual impairment caused by sediment plumes is assessed to be **low**.

Other studies have explored the effects of sediment plumes on seals, which do not use sonar for prey detection or orientation. If vision is used to locate prey, increased turbidity could affect their ability to hunt succesfully. In a captive environment,Weiffen et al. (2006) tested the visual acuity of harbour seals to increasing levels of turbidity, finding that it decreased substantially, as turbidity increased. However, they also reported the existence of blind but well nourished seals in the wild and the obvious poor image transmission at high levels of turbidity in natural conditions indicates that seals are able to forage even in conditions of poor light.

Similar assumptions were made by McConnell et al. (1999), who used satellite relay data loggers (SRDLs) to describe foraging areas and trip durations of grey seals in the North Sea. One blind seal was included in the study, but no significant difference in foraging behaviour was found. These results indicate that vision is not essential to seal survival, or ability to forage.

The sensitivity of seals to visual impairment from sediment spill is assessed to be **low**.

7.2.2 Behavioural impacts from sediment spill

Activities causing increased turbidity or sediment plumes and the presence of boat traffic, may affect the behaviour of the three Baltic marine mammal species inhabiting Finnish waters. Behavioural changes are, however, inherently difficult to evaluate due to the vast distances at which they may occur and due to the paucity of studies looking at effects at a population level (NRC 2003). Potential behavioual effects range from very strong reactions, such as panic or flight, to more moderate reactions where the animal may orient itself towards the disturbance; move slowly away or will cease an on-going behaviour. Additionally, the animals' reaction may vary greatly depending on season, behavioural state, age, sex, as well as in response to the intensity, frequency and time structure of impact causing behavioural changes.

At the population scale, the three marine mammal species in the Finnish, Estonian and Russian waters may thus be sensitive to permanent or long-term large scale changes or disturbances in their habitat if a large percentage of the population should be displaced into areas of poor quality or where they would have to compete with conspecifics or other marine mammal species. On the other hand, they may be relatively unaffected by short-term avoidance behavior, although some physiological impacts have been shown (see 7.1.6). The sensitivity of seals to changes in behaviour is assessed to be **medium.** For harbour porpoises it is **low** due to the low density.

7.2.3 Health effects caused by contaminants

Contaminant mobilization may have an impact if the level is severe enough for the contaminants to magnify through the food chain and end in marine mammals that are top-predators. Marine mammals make up the highest trophic levels and have large lipid stores. Environmental contaminants such as persistent organic pollutants (POPs) and heavy metals are therefore biomagnified in their tissues, leading to an increased risk of individual and population level toxicity (Vos et al. 2003). High contaminant levels have been linked to immune system depression, disease breakouts, reproductive alterations, developmental effects, and endocrine disruption (see Vos et al. 2003 for a review of toxins and marine mammals). The impact is determined by the level and type of contaminants and the length of the increased exposure (generations as well as in individuals).

To examine this impact will, however, be challenging, since marine mammals accumulate high levels of contaminants irrespective of whether sediment spills occur. Thus, linking remobilization of contaminants from sediment spills from the construction of a pipeline to effects in marine mammals will be impossible. Levels of toxins in blubber before, during, and after seabed disturbance are unknown because marine mammals are mobile and exposed to contaminants throughout their entire range, and effects are only likely to be discovered long after the sediment spill ceases (Todd et al. 2015).

The sensitivity of seals to contaminants in general (without including information on duration, type and level of contaminant exposure) is assessed to be **high**. For harbour poproises is it **low** due to the low density in the study area.

Unplanned events – Oil spill

The impact of oil spill on marine mammals have been measured and investigated in the past following large scale oil releases at sea e.g. the 'Deepwater Horizon' oil spill in the Northern Gulf of Mexico with a total spill of 690,000 tons and the 'Exxon Valdez' oil spill in Prince William Sound, Alaska with a total spill of between 36,000 and 124,000 tons. These examples are extreme and in general, the magnitude of the spill from colissions of ships is somewhat lower. For instance, in a review of oil spills from ships, Dalton and Jin (2010) concluded that the maximum oil spill from a tanker or freight ship in the US from 2002 to 2006 was 1 million tons.

Cetaceans appear to be able to detect oil but do not necessarily avoid it in the wild (Dalton and Jin 2010). Thus they may be exposured to oil through direct contact at the surface and in the water column, through incidental ingestion from water or sediments while feeding, and through ingestion of contaminated prey (Schwacke et al. 2014). Furthermore, they may inhale volatile petroleum-associated compounds. For seals, the same threats are relevant and furthermore, oil may smother their fur and thereby reduce their ability to maintain body temperatures.

The resultant health effects from oil via any of these exposure routes have been shown to cause significant decreases in cetacean reproductive success and high mortality rates (Lane et al. 2015), poor body condition, a high prevalence of lung disease, and abnormally low adrenal hormone levels; all consistent with previous studies of petroleum toxicity (Schwacke et al. 2014).

Thus the sensitivity of seals in the study area to oil spill is assessed as **high** while the sensitivity of harbour porpoises in the study area is assessed as low due to the **low** density of porpoises.

Changes in the habitat

The physical presense of the pipeline alter the existing habitat. In the construction phase most sessile benthic flora and fauna will be disturbed and likely destroyed in the immediate vicinity of the pipeline and non-sessile animals displaced. Once in operation, however, the solid substrate of the pipeline and the overlaying rocks may introduce the possibility of increased bentic diversity and consequently fish diversity and abundance, in particular in areas with soft bottom substrate without possibility for settlement of sessile animals. Furthermore, the new reef structures are likely to attract fish, that will use the hard structures as shelter or hide-outs. This may locally increase the abundance of fish. The main prey of the Baltic marine mammals are fish and consequently if the suggested changes in the fish community are significant this may positively impact the prey availability for marine mammals. Thus, the sensitivity of seals to changes in the habitat is assessed to be **medium**. While the sensitivity of harbour porpoises to changes in the habitat is assessed to be **low**, due to the low density of porpoises.

Unplanned events – Gas release

During the assessment of NSP the risk of gas release during operation was calculated to be on average once every 293,500 years. However, in the unlikely event of gas release it is judged that all marine mammals within the gas plume or the subsequent gas cloud will die or flee from the influenced area (Nord Stream 2008). However, since a potential gas release will likely be associated with some noise, it is likely that marine mammals will have time to avoid the plume. Thus the sensitivity to gas release are assessed to be **medium** for seals and **low** for harbour porpoise, due to the low density of porpoises in the study area.

7.3 Seasonal sensitivity

The most vulnerable periods for seals in the Baltic Sea are primarily during their moulting, breeding and lactation periods. Harbour porpoises are also vulnerable in the breeding period, but the calves are dependent on their mother for at least 10 months and may be vulnerable throughout the first year and especially in the first period after leaving their mother. Table 7-3 below summarises these vulnerable periods over a year per species on the basis of the low, medium, high sensitivity matrix used for this assessment. For more details see baseline report (Teilmann, Galatius, and Sveegaard 2017). **The actual sensitivity for a given activity is found as the combination of the sensitivity to the activity itself and the sensitivity related to the period**.

Table 7-3 *Sensitivities of marine mammals in Finnish, Russian and Estonian waters during the year. Sensitivities are judged without consideration of actual abundance of animals and thus represents the sensitivity of individuals that might be present in the relevant areas at the different times of the year, even if they are encountered only rarely.*

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise	High	High	High	High	High	High	High	High	High	High	High	High
Grey seal	Med	High	High	High	High	High	Med	Med	Med	Med	Med	Med
Ringed seal	Med	High	High	High	High	Med	Med	Med	Med	Med	Med	Med

8. Magnitude of impact

Determining the magnitude of each potential impact is important in order to assess the overall significance of the impact on marine mammals. Some impacts such as the extent of noise from munition clearance and rock placement and the extent of sediment spill may be estimated through models, while others require field studies or expert judgement. This chapter reviews the results of models predicting underwater noise and sediment spill in relation to the Baltic marine mammals and assesses the impact magnitude.

8.1 Underwater noise

Transmission of underwater noise were modelled in order to estimate impact ranges for the noise. Details are given in the report "Underwater noise modelling, Finland", document number W-PE-EIA-PFI-REP-805-030600EN (Rambøll 2016d) and "Underwater noise modelling, Russia" document number W-PE-EIA-OFR-REP-805-0706UNEN-02 (Rambøll 2016a).

8.1.1 Munition clearance - TTS/PTS, Finland

The extent of noise propagation from explosions at the four locations M1 through M4 is given in the document "Underwater noise modelling, Finland", document number W-PE-EIA-PFI-REP-805-030600EN (Rambøll 2016d). All results are provided here. Plotted on maps (Figure 8-1 - Figure 8-6) is the extent of the zones wherein animals can be expected to experience TTS and PTS, respectively. These zones were generated by modelling propagation of noise based on actual source levels measured during munition clearance in connection to construction of the Nord Stream pipeline and applying the threshold criterias from section 7.1 (Underwater noise) above. Two scenarios were used for each site: a maximum source level encountered during Nord Stream construction in each of the four areas (denoted "Max" in Figure 8-1 - Figure 8-6) and the mean of actual sound pressure levels measured for unexploded munition typical for each of the four areas (denoted "Ave" in Figure 8-1 - Figure 8-6). As hydrographical conditions differ greatly in the Baltic between summer and winter affecting the noise propagation conditions, two separate models (summer and winter) were made and plottet for each of the three species. The contour curves represent the worst case situation, as they indicate the maximal extent of a zone where sound exposure level *anywhere* in the water column exceeds therelevant threshold (TTS or PTS).

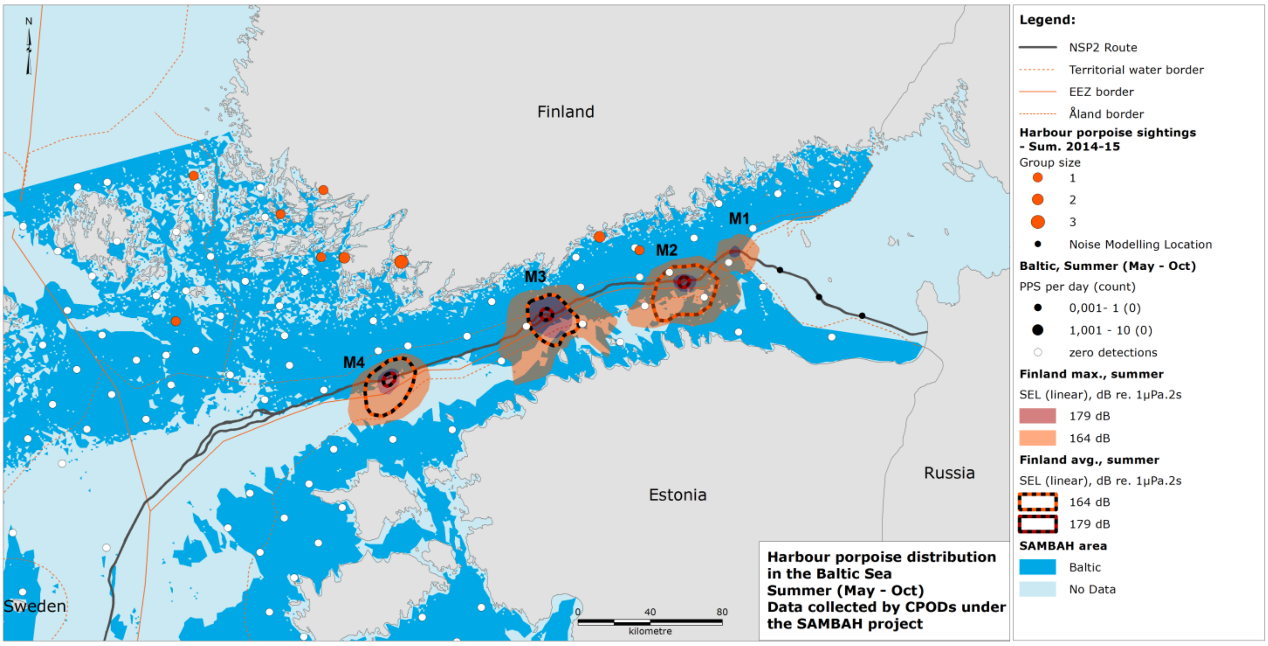

Figure 8-1 *Harbour porpoise detections (Porpoise positive seconds per day) during summer (May – Oct) as detected during the SAMBAH project 2011-2013, opportunistic sightings in Finnish waters in 2014-2015 and the modelled extent of munitions clearance during winter in Finnish waters.*

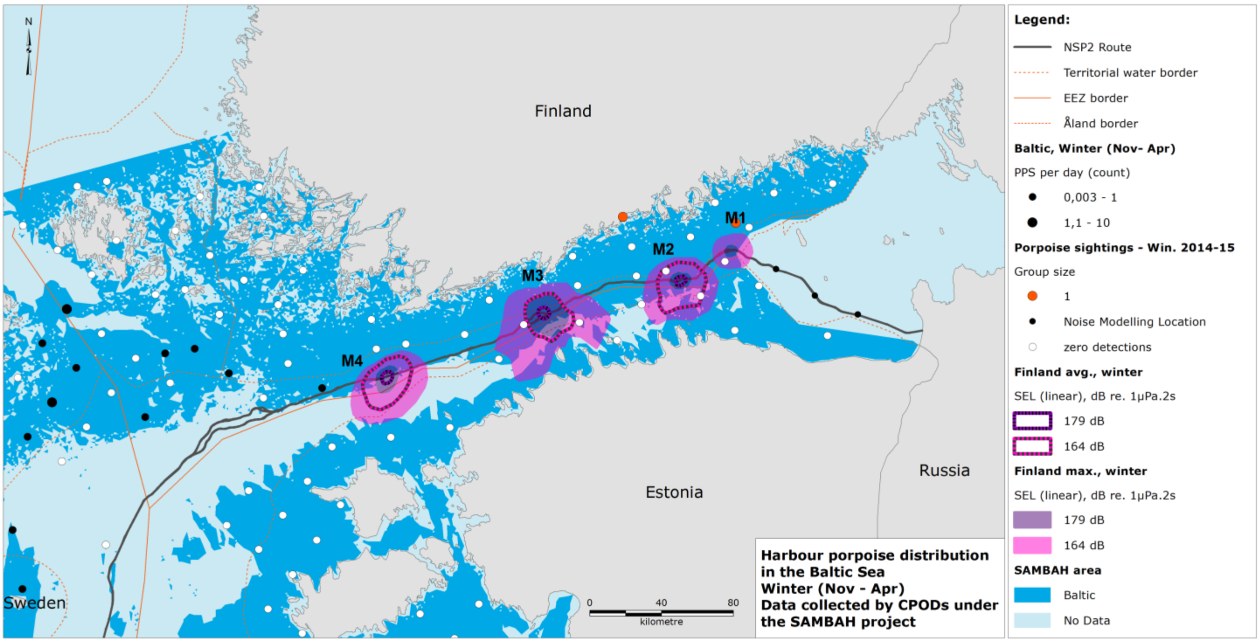

Figure 8-2 *Harbour porpoise detections (Porpoise positive seconds per day) during winter (Nov - Apr) as detected during the SAMBAH project 2011-2013, opportunistic sightings in Finnish waters in winter 2014-2015 and the modelled extent of munitions clearance during winter in Finnish waters.*

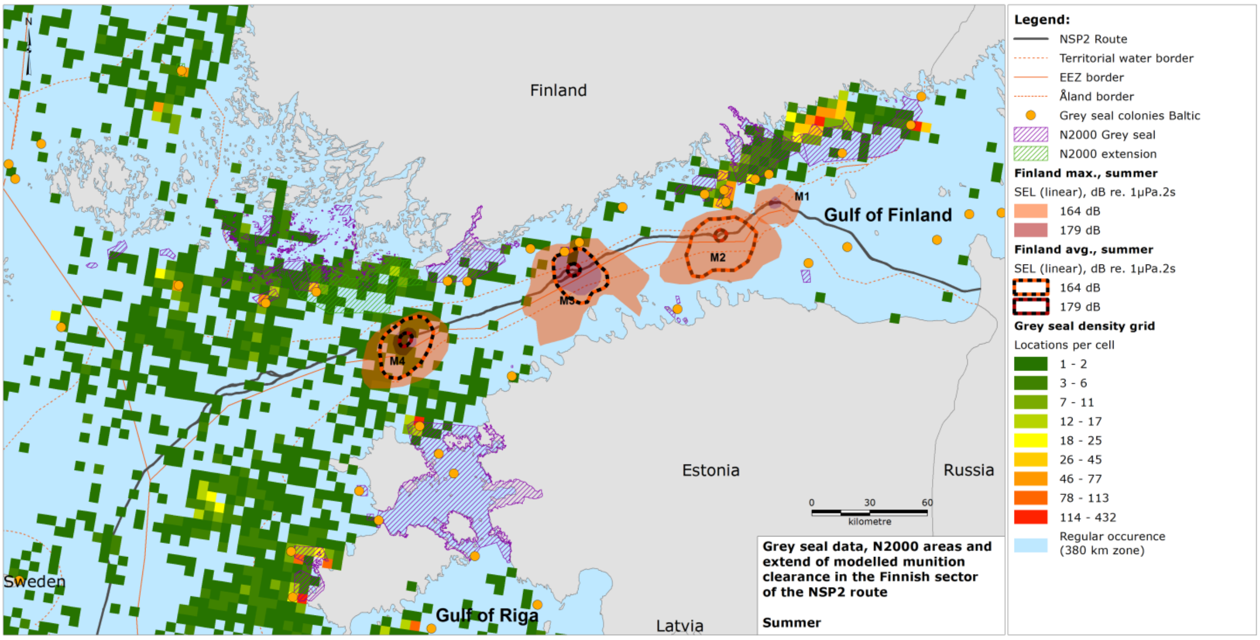

Figure 8-3 *Grey seal density grid based on telemetry data (displayed as number of locations from 38 GPS tracked grey seals per grid cell. Data source: HELCOM BALSAM Seal), locations of colonies, N2000 for grey seals and the modelled extent of munitions clearance during summer (May-Oct). Only Finnish and Estonian Natura 2000 areas within 100 km of the NSP2 route are displayed. Note that the distribution grid does not show the distribution of the whole population and is biased by the sites where seals have been tagged. Thus, it can be used only as an informative overview of seals in Baltic.*

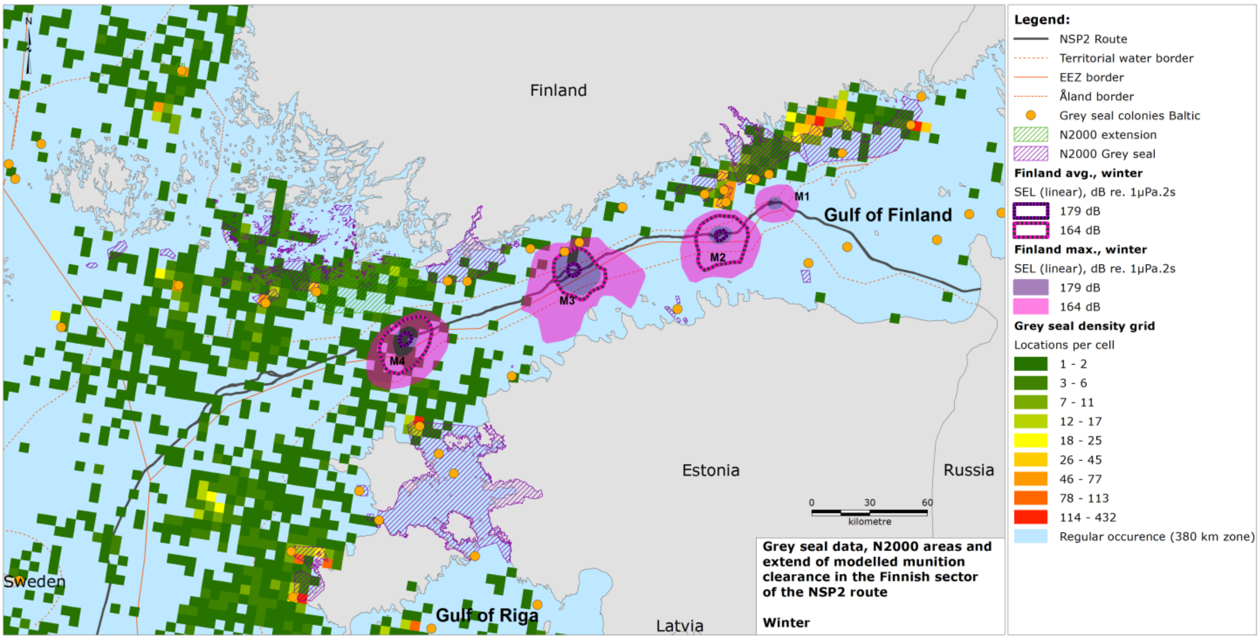

Figure 8-4 *Grey seal density grid based on telemetry data (displayed as number of locations from 38 GPS tracked grey seal per grid cell. Data source: HELCOM BALSAM Seal), locations of colonies, N2000 for grey seals and the modelled extent of munitions clearance during winter (Nov-Apr). Only Finnish and Estonian Natura 2000 areas within 100 km of the NSP2 route are displayed. Note that the distribution grid does not show the distribution of the whole population and is biased by the sites where seals have been tagged. Thus, it can be used only as an informative overview of seals in Baltic.*

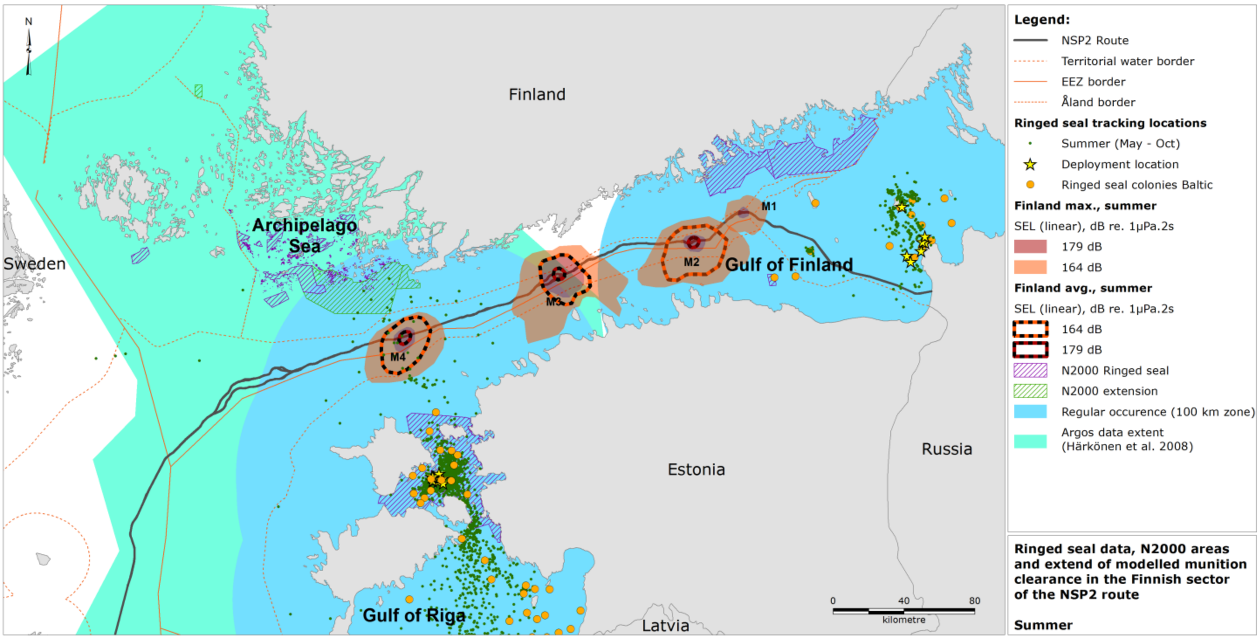

Figure 8-5 *Ringed seal telemetry data (37 tracked individuals, source: Estonian Fund for Nature, Pro Mare), locations of colonies, N2000 for ringed seals and the modelled extent of munitions clearance during summer (May-Oct). Only Finnish and Estonian Natura 2000 areas within 100 km of the NSP2 reference route are displayed. Note that the distribution grid does not show the distribution of the whole population and is biased by the sites where seals have been tagged. Thus, it can be used only as an informative overview of seals in Baltic.*

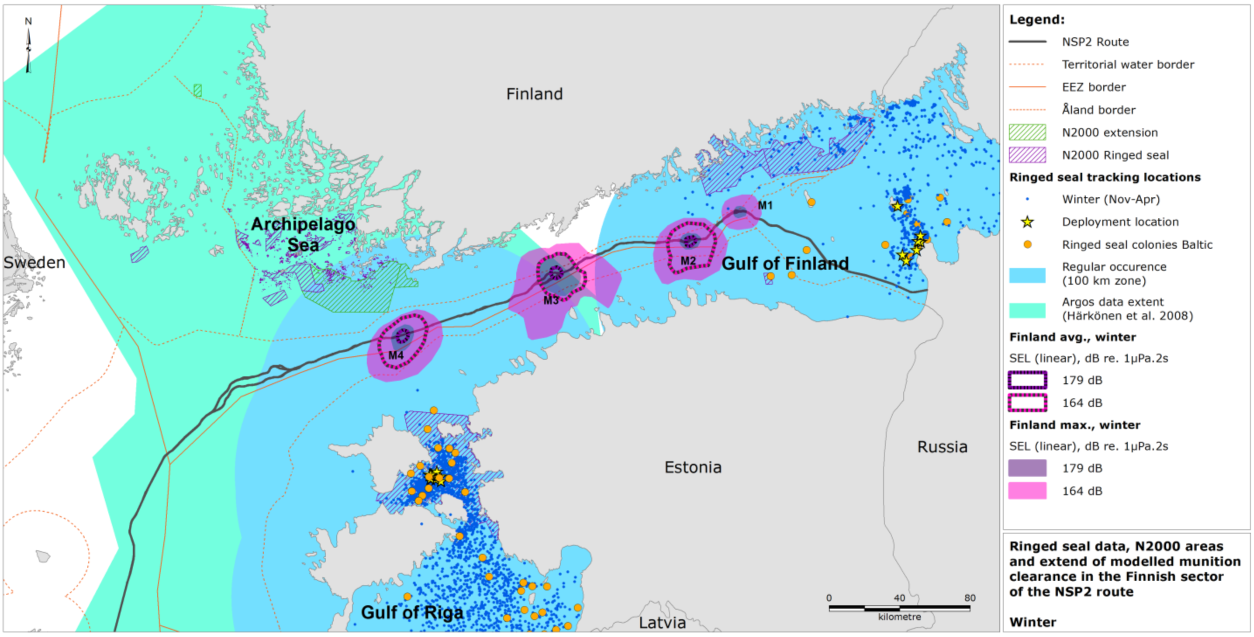

Figure 8-6 *Ringed seal telemetry data (37 tracked individuals, source: Estonian Fund for Nature, Pro Mare), locations of colonies, N2000 for ringed seals and the modelled extent of munitions clearance during winter (Nov-Apr). Only Finnish and Estonian Natura 2000 areas within 100 km of the NSP2 reference route are displayed. Note that the distribution grid does not show the distribution of the whole population and is biased by the sites where seals have been tagged. Thus, it can be used only as an informative overview of seals in Baltic.*

The extent of the TTS and PTS zones are similar across the species, because of the identical PTS and TTS thresholds established (Table 7-2) for explosions. There are only minor differences between summer and winter and they are thus not differentiated in the assessment. Estimated maximum impact ranges and mean expected impact ranges are given in Table 8-1. It is evident that the extent of the TTS and PTS impact zones are considerable for both seals and porpoises and extend into both Estonian and Russian waters. The extent of the impact (when assessed by the buffer zones in Chapter 6 (Figure 6-2) covers large parts of the Gulf of Finland and at several locations it is transboundary.

Effects of the munitions cleareance are either temporary and reversible (TTS) or permanent and irreversible (PTS, by definition). Permanent and irreversible applies only to the individual animal inflicted with PTS and the effect will thus disappear from the population whenever the affected animals eventually die. For the population the effect is thus long-term, but reversible.

For all species in the TTS/avoidance zone (164 dB) the duration is short-term and the impact magnitude is **low**.

Within the PTS zone (179 dB), impact of munition clearance is irreversible and covers a relatively large area (up to 15 km from the NSP2 route). It is also transboundary (i.e. not confined to Finnish waters**)** and the duration is long-term, as PTS by definition is permanent. As described above (7.1.2) it is unknown to what degree a smaller or larger permanent hearing loss will effect individual animals in terms of impact on their fitness, reproduction and communication, but it is considered unlikely that animals will be subject to hearing losses sufficiently large to affect their survival.

The impact magnitude of PTS is **medium** in all areas and for all marine mammal species on both the individual and the population level, due to the large geographical extent, the irreversible and cumulative nature and high intensity of the impact.

Table 8-1 *Maximum and mean extent of the TTS and PTS zones for explosions at the four Finnish positions M1 through M4 (Rambøll 2016d). Indicated are both maximum and mean values (based on maximum and mean sound pressure, respectively, encountered during construction of Nord Stream).*

Animal group	Effect	Threshold distances (km)							
		M1 (max)	M1 (mean)	M2 (max)	M2 (mean)	M3 (max)	M3 (mean)	M4 (max)	M4 (mean)
Seals	PTS	3.5	3.5	8	3.5	15	3.5	9	3.5
	TTS	15	15	38	26	44	19	32	22
Porpoises	PTS	3.5	3.5	8	3.5	15	3.5	9	3.5
	TTS	15	15	38	26	44	19	32	22

8.1.2 Munition clearance – Blast injury, Finland

Blast injuries from munition clearance may cause fatal injuries (most notably rupture of lungs and intestines) in the vicinity of the explosion. Depending on the size of the detonation and which threshold is considered most relevant for marine mammals, thie fatal injuries may occur within some hundred meters from the explosion. Applying the thresholds of Yelverton et al. (1973) to the large explosion in Figure 7-2 provides an estimate of impact range for moderately severe (but survivable) injuries up to 900 m from the explosion at the surface and up to 2.8 km at the bottom and evidently a smaller range for fatal injuries (no threshold given by Yelverton et al. 1973). If, instead, the thresholds for fatal injury in human divers derived by Lance et al. (2015) is applied to the large explosion in Figure 7-2, lethal injuries can be expected out to ranges about 1 km from the blast in the surface and 3 km at the bottom.

The impact magnitude of blast injury is **high** in all areas and for all marine mammal species on both the individual and the population level, due to the irreversible and high intensity of the impact.

8.1.3 Munition clearance - TTS/PTS, Russia

The extent of noise propagation from explosions at the four locations $M1_{Rus}$ through $M3_{Rus}$ is given in the document “Underwater noise modelling, Russia”, document number W-PE-EIA-OFR-REP-805-0706UNEN-02 (Rambøll 2016d). All results are provided here. Plotted on maps (Figure 8-7 - Figure 8-12) is the extent of the zones wherein animals can be expected to experience TTS and PTS, respectively. These zones were generated by modelling propagation of noise based on actual source levels measured during munition clearance in connection to construction of the Nord Stream pipeline and applying the threshold criterias from section 7.1 (Table 7-2) above. Two scenarios were used for each site: a maximum source level encountered during Nord Stream construction in each of the four areas (denoted “Max” in Figure 8-7 - Figure 8-12Figure 8-1) and the mean of actual sound pressure levels measured for typical unexploded munition in each of the four areas (denoted “Ave” in Figure 8-7 - Figure 8-12). As hydrographical conditions differ greatly in the Baltic between summer and winter affecting the noise propagation conditions, two separate models (Summer and winter) were made and plottet for each of the three species. The contour curves represent the worst case situation, as they indicate the maximal extent of a zone where sound exposure level *anywhere* in the water column exceeds the threshold.

Table 8-2 *Maximum and mean extent of the TTS and PTS zones for explosions at the three Russian positions $M1_{Rus}$ through $M3_{Rus}$ (Rambøll 2016a). Indicated are both maximum and mean values (based on maximum and mean sound pressure level, respectively, encountered during construction of Nord Stream).*

Animal group	Effect	Threshold distances (km)					
		$M1_{Rus}$ (max)	$M1_{Rus}$ (mean)	$M2_{Rus}$ (max)	$M2_{Rus}$ (mean)	$M3_{Rus}$ (max)	$M3_{Rus}$ (mean)
Seals	PTS	23	5	11	3	18	5
	TTS	56	26	55	13	60	20
Porpoises	PTS	23	5	11	3	18	5
	TTS	56	26	55	13	60	20

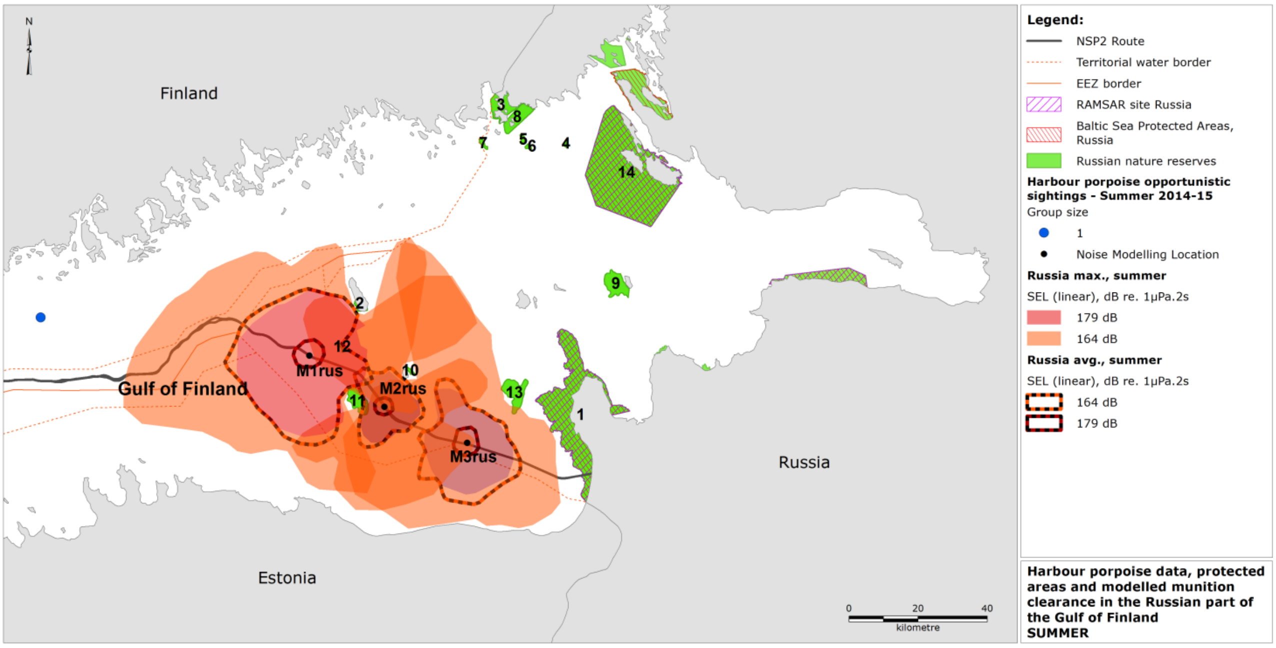

Figure 8-7 *Harbour porpoise opportunistic sightings 2014-2015 during summer (May – Oct), protected areas in Russian waters, and the modelled extent of munitions clearance during summer in Russian waters. Numbers refer to names of nature reserves: 1) Kurgalskyi, 2) Suursaari, 3) Prigranichnyi, 4) Hally Cliff, 5) Bolshoy Fiskar, 6) Bolshoy Fiskar, 7) Kopytin, 8) Long Rock, 9) Seskar, 10) Bolshoy Tyuters, 11) Malyi Tyuters, 12) Virginy islands, 13) Virgund cliff, 14) Berezovye islands.*

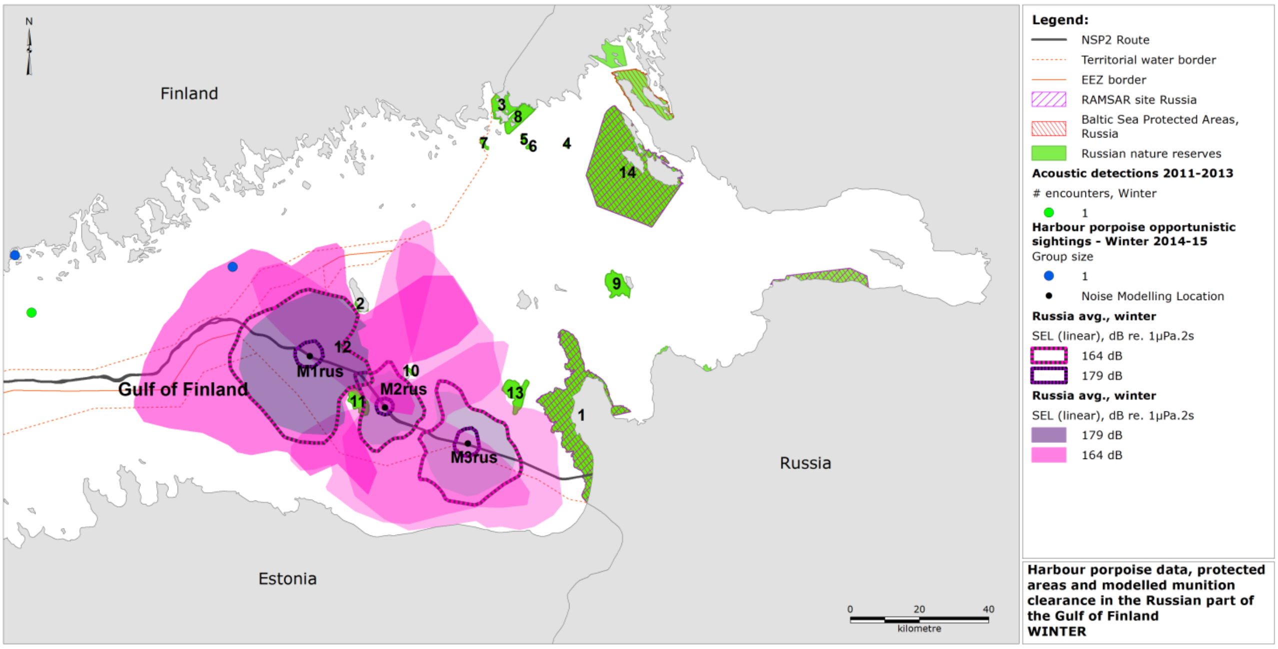

Figure 8-8 *Harbour porpoise opportunistic sightings in Finnish waters 2014-2015 and acoustic detections (SAMBAH) during winter (Nov – Apr), marine protected areas in Russian waters, and the modelled extent of munitions clearance during winter in Russian waters. Numbers refer to names of nature reserves: 1) Kurgalskyi, 2) Suursaari, 3) Prigranichnyi, 4) Hally Cliff, 5) Bolshoy Fiskar, 6) Bolshoy Fiskar, 7) Kopytin, 8) Long Rock, 9) Seskar, 10) Bolshoy Tyuters, 11) Malyi Tyuters, 12) Virginy islands, 13) Virgund cliff, 14) Berezovye islands.*

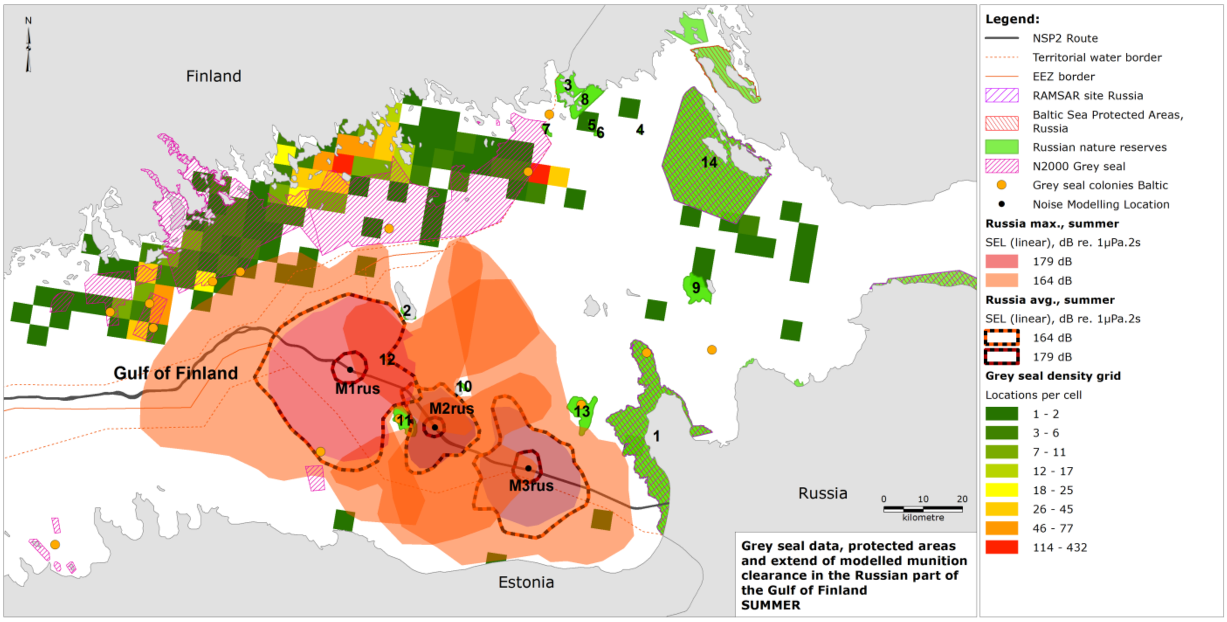

Figure 8-9 *Grey seal density grid based on telemetry data (displayed as number of locations from 38 GPS tracked grey seal per grid cell. Data source: HELCOM BALSAM Seal), locations of colonies, N2000 for grey seals, marine protected areas in Russian waters and the modelled extent of munitions clearance during summer (May-Oct). Note that the distribution grid does not show the distribution of the whole population and is biased by the sites where seals were tagged. Thus, it can be used only as an informative overview of seals in Baltic. Finnish and Estonian Natura 2000 areas as well as Russian MPAs within 100 km of the NSP2 route are displayed. Numbers refer to names of nature reserves: 1) Kurgalskyi, 2) Suursaari, 3) Prigranichnyi, 4) Hally Cliff, 5) Bolshoy Fiskar, 6) Bolshoy Fiskar, 7) Kopytin, 8) Long Rock, 9) Seskar, 10) Bolshoy Tyuters, 11) Malyi Tyuters, 12) Virginy islands, 13) Virgund cliff, 14) Berezovye islands.*

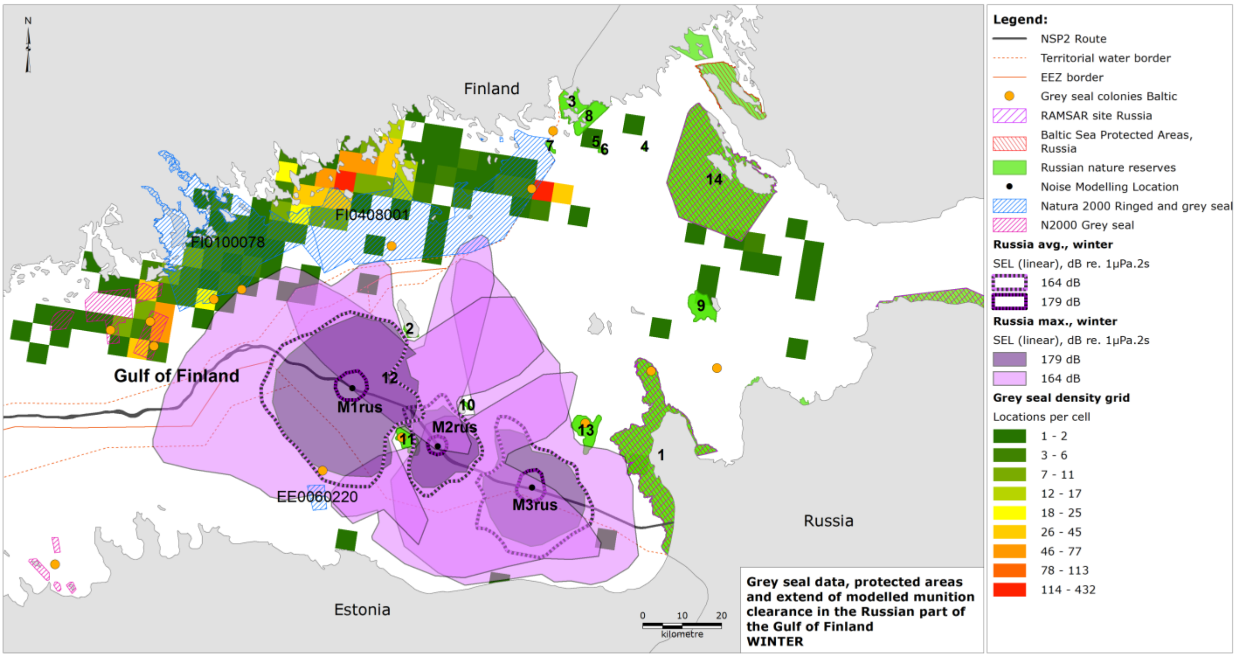

Figure 8-10 *Grey seal density grid based on telemetry data (displayed as number of locations from 38 GPS tracked grey seal per grid cell. Data source: HELCOM BALSAM Seal), locations of colonies, N2000 for grey seals, marine protected areas in Russian waters and the modelled extent of munitions clearance during Winter (Nov-Apr). Note that the distribution grid does not show the distribution of the whole population and is biased by the sites where seals have been tagged. Thus, it can be used only as an informative*

overview of seals in Baltic. Finnish and Estonian Natura 2000 areas as well as MPAs in Russian waters within 100 km of the NSP2 route are displayed. Numbers refer to names of nature reserves: 1) Kurgalskyi, 2) Suursaari, 3) Prigranichnyi, 4) Hally Cliff, 5) Bolshoy Fiskar, 6) Bolshoy Fiskar, 7) Kopytin, 8) Long Rock, 9) Seskar, 10) Bolshoy Tyuters, 11) Malyi Tyuters, 12) Virginy islands, 13) Virgund cliff, 14) Berezovye islands.

The extent of the TTS and PTS zones Table 8-2 are similar across the species, because of the identical PTS and TTS thresholds established (Table 7-2) for explosions. There are only minor differences between summer and winter and they are thus not differentiated in the assessment. It is evident that the extent of the TTS and PTS impact zones is considerable and extend into both Estonian and Finnish waters. The extent of the zones covers large parts of the Gulf of Finland and at several locations it is transboundary (For PTS only into Estonian waters).

Effects are either temporary and reversible (TTS) or permanent and irreversible (PTS, by definition). Permanent and irreversible effects apply only to the individual animal inflicted with PTS and the effect will thus disappear from the population whenever the affected animals eventually die. Thus for the population the effect is long-term, but reversible.

For all species in the TTS/avoidance zone (164 dB) the duration is short-term and the impact magnitude is **low**.

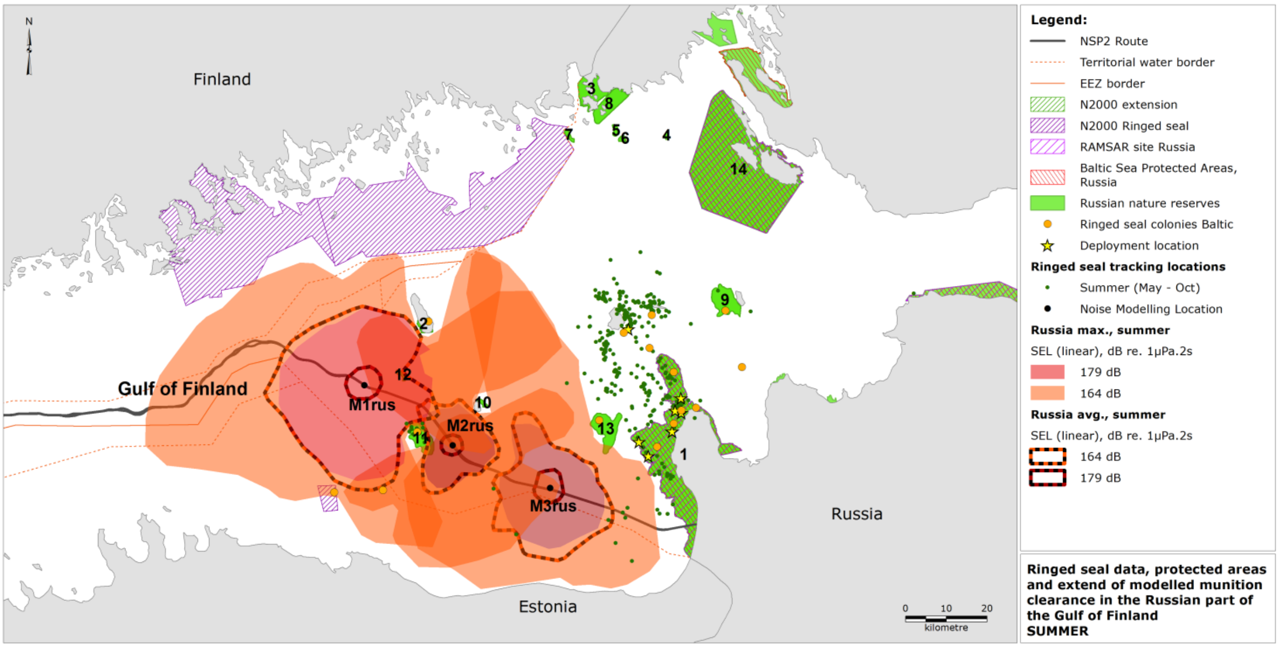

Figure 8-11 *Ringed seal telemetry data during summer (May – Oct, source: Estonian Fund for Nature, Pro Mare), locations of colonies, N2000 and other protected areas for ringed seals and the modelled extent of munitions clearance during summer in Russian waters. Only Finnish and Estonian Natura 2000 areas within 100 km of the NSP2 reference route are displayed. Numbers refer to names of nature reserves: 1) Kurgalskyi, 2) Suursaari, 3) Prigranichnyi, 4) Hally Cliff, 5) Bolshoy Fiskar, 6) Bolshoy Fiskar, 7) Kopytin, 8) Long Rock, 9) Seskar, 10) Bolshoy Tyuters, 11) Malyi Tyuters, 12) Virginy islands, 13) Virgund cliff, 14) Berezovye islands.*

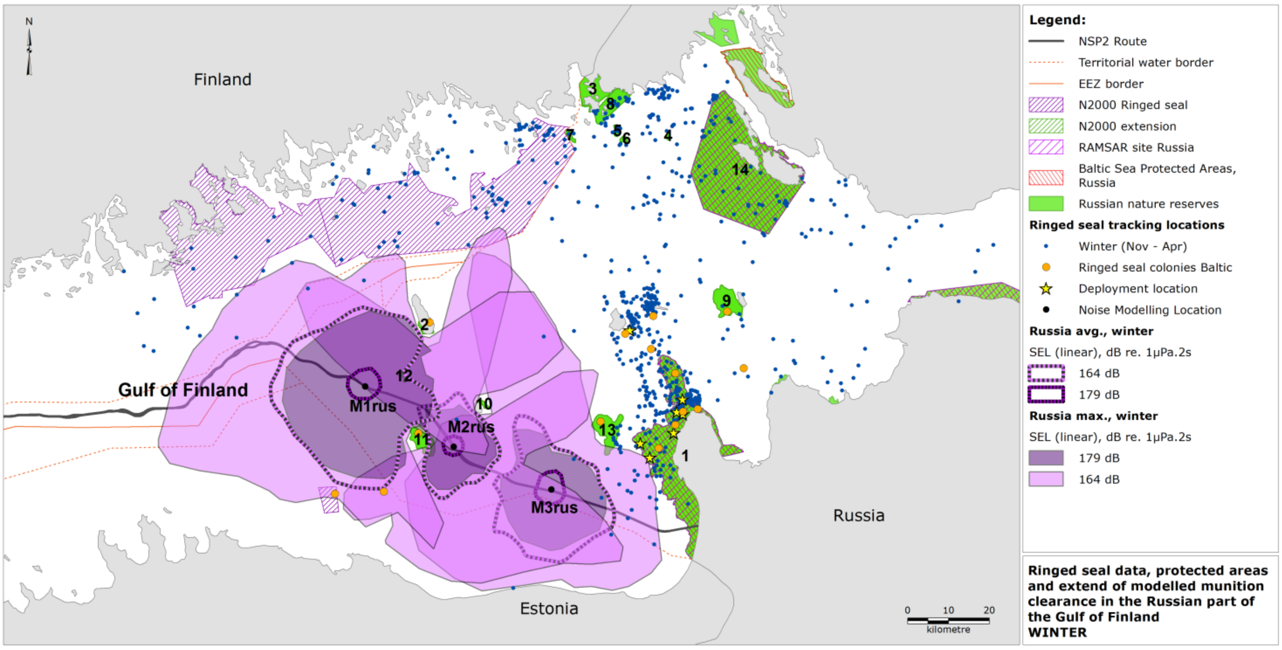

Figure 8-12 *Ringed seal telemetry data during winter (Nov – Apr, source: Estonian Fund for Nature, Pro Mare), locations of colonies, N2000 and other protected areas for ringed seals and the modelled extent of munitions clearance during winter in Russian waters. Only Finnish and Estonian Natura 2000 areas within 100 km of the NSP2 reference route are displayed. Numbers refer to names of nature reserves: 1) Kurgalskyi, 2) Suursaari, 3) Prigranichnyi, 4) Hally Cliff, 5) Bolshoy Fiskar, 6) Bolshoy Fiskar, 7) Kopytin, 8) Long Rock, 9) Seskar, 10) Bolshoy Tyuters, 11) Malyi Tyuters, 12) Virginy islands, 13) Virgund cliff, 14) Berezovye islands.*

For the PTS zone (179 dB), impact of munition clearance is irreversible and covers a relatively large area (up to 23 km from the NSP2 route). It is also transboundary (i.e. not confined to Russian waters**)** and the duration is long-term, as PTS by definition is permanent. As described above (7.1.2) it is unknown to what degree a smaller or larger permanent hearing loss will effect individual animals in terms of impact on their fitness, reproduction and communication, but it is considered unlikely that animals will be subject to hearing losses sufficiently large to affect their survival.

The impact magnitude of PTS is **medium** for all marine mammal species and all areas in Russia on both the individual and the population level, due to the large geographical extent, the irreversible and cumulative nature and high intensity of the impact.

8.1.4 Munition clearance – blast injury, Russia

Blast injuries from munition clearance may cause fatal injuries (most notably rupture of lungs and intestines) in the vicinity of the explosion. Depending on the size of the detonation and which threshold is considered most relevant for marine mammals, the fatal injuries may occur within some hundred meters from the explosion. Applying the thresholds of Yelverton et al. (1973) to the large explosion in Figure 7-2 provides an estimate of impact range for moderately severe (but survivable) injuries up to 900 m from the explosion at the surface and up to 2.8 km at the bottom and evidently a smaller range for fata injuries (no threshold given by Yelverton et al. 1973). If, instead, the thresholds for fatal injury in human divers derived by Lance et al. (2015) is applied to the large explosion in Figure 7-2, lethal injuries can be expected out to ranges about 1 km from the blast in the surface and 3 km at the bottom.

The impact magnitude of blast injury is **high** in all areas and for all marine mammal species on both the individual and the population level, due to the irreversible and high intensity of the impact.

8.1.5 Rock placement – TTS/PTS

Modelled noise levels from rock placement were low. Cumulated SEL was estimated at two different positions along the Nord Stream 2 corridor: one at the eastern border of the Finnish EEZ (RP1) and one at the opening of the Gulf of Finland (RP2). See (Rambøll 2016d), figure 3-1 for precise location). Estimated extent of TTS and PTS zones under a very conservative assumption that animals would remain stationary at the same distance from the rock placement for 2 hours, are given in Table 8-3. Modelled noise levels were not sufficiently high to induce PTS, even if the receiving animal is right next to the rock placement, whereas TTS could hypothetically be induced if a seal or a porpoises lingered within a distance of 80 m from the rock placement ship for a period of 2 hours or more.

Table 8-3 *Maximum extent of the TTS and PTS zones for rock placement at the two Finnish positions RP1 and RP2 (Rambøll 2016d) and one Russian position, R1$_{Rus}$ (Rambøll 2016a).*

Marine group	Effect	RP1	RP2	RP1$_{Rus}$
		Threshold distances, max	Threshold distances, max	Threshold distances, max
Seals	PTS	0 m	0 m	0 m
	TTS	80 m	80 m	80 m
Porpoises	PTS	0 m	0 m	0 m
	TTS	80 m	80 m	80 m

Impact extent from rock placement and other vessel-based activity are very small. Effects are temporary and reversible, as PTS is considered unlikely to occur. The impact magnitude is assessed to be **low** for all marine mammal species.

8.1.6 Dredging, vibro-piling and pipeline noise PTS/TTS – Russia

As for noise from rock placement, even with precautionary assumptions regarding impact of noise from vibratory sheet piling, the impact is strictly local (Table 8-4), temporary and of low intensity (PTS unlikely). The magnitude of impact is thus **low**.

Table 8-4 *Maximum extent of the TTS and PTS zones for dredging, vibro-piling and pipeline noise at three different Russian positions (Rambøll 2016a).*

Marine group	Effect	DR1 Dredging[1]	CD1 Vibro-piling[1]	PO1 Pipeline noise[2]
		Threshold distances	Threshold distances	Threshold distances
Seals	PTS	0 m	0 m	0 m
	TTS	50 m	20 m	0 m
Porpoises	PTS	0 m	0 m	0 m
	TTS	50 m	20 m	0 m

1) Based on 2h cumulated sound exposure (SEL)
2) Based on 24 h cumulated sound exposure (SEL)

8.2 Sediment spill

The magnitude of the sediment spill for Finnish waters is given in the document "Modelling of sediment spill in Finland" document number W-PE-EIA-PFI-REP-805-030400EN (Rambøll 2016c) and "Modelling of sediment spill in Russia", document number W-PE-EIA-PRU-REP-805-070500EN (Rambøll 2016a). A short summary of each report is given below.

Finland

The widest spreading of suspended sediments in the water mass will occur during munition clearance and more so in the in the lowest 10 m above the seabed, where concentrations may exceed 15 mg/l in an area of up to 27.8 km^2 for a maximum of 10 hours and up to 10 mg/l in an area of up to 46 km^2 for a maximum of 13 hours. The concentration will never exceed 107 mg/l. Sedimentation following munitions clearance will not exceed 179 g/m^2 at any location.

For the rock placement scenarios, the area with concentrations of suspended sediment exceeding 10 mg/l, is limited to an area of approximately 6 km^2 for a maximum of 18 hours. The concentrations never exceed 61 mg/l during winter conditions and 22 mg/l during summer conditions. Sedimentation does not exceed 400 g/m^2 at any location after rock placement and it is limited to the area at the vicinity of the pipeline route.

The plume can cover long distances from the pipeline and the scale of sediment spill is thus quite large. The duration is however temporary and the impact is reversible, and the impact magnitude is thus **low**.

Russia

The widest spreading of suspended sediments in the water mass will occur during dredging (micro-tunneling) near the Russian coast where up to 55,360 tonnes of suspended sediment will be released into the water column and result in up to 371 km^2 having a concentration of >10 mg/l for up to 374 hours (~20 days) and an area of 328 km^2 having concentrations of >5 mg/l for 407 hours hours (~17 days). This is significantly greater than the sediment spill for munition clerance (19 km^2 with concentration > 10 mg/l for 9 hours) and the area affected is a protected important breeding area for ringed seal (Kurgalskyi).

The sediment plume cover long distances from the pipeline and the scale of sediment spill is thus quite large. The duration is however temporary although significantly longer than for sediment spill further away from the coast. The impact is reversible, and the impact magnitude is thus **low**.

8.3 Changes in the habitat

The physical presense of the pipeline alter the existing habitat and consequently the flora and fauna inhabiting the area.

In the construction phase, all benthic flora and fauna will be eliminated in the corridor of the NSP2 route and in areas of rock placement, but in the operation phase the solid material of the pipeline may introduce the possibility of increased bentic diversity depending on depth. The monitoring of fish and epifauna along the NSP pipeline was conducted from one year before the construction and four years after in Swedish waters (Nord Stream 2014). Here it was concluded that the colonisation of sessile epifauna gradually increased over time and showed a more pronounced establishment within the shallowest areas (23-27m) compared to the deeper areas (35-64 m, comparable to the NSP2 route in Finnish waters). The monitoring further indicated that the demersal fish community in all of the deeper areas studied were strongly dominated by cod (<38 cm) and that the pipeline may function as nursery grounds for cod during the autumn season. Cod at this size are potential prey for marine mammals, but it was also concluded that the effects on demersal fish species from the pipeline were small and of local character. The impact of habitat change in relation to the NSP2 route in Finnish and Russian waters will be different from the Swedish waters since depth and species differ. The impact is long-term and irreversible, but covers a small spatial scale and area of low intensity. The impact magnitude is thus assessed to be **negligible** for all marine mammal species in Finnish waters and also for harbour porpoises in Russian waters. For seals in Russian waters, however, the impact magnitude is **low** due to the shallower waters near the shore enabling more flora and fauna to be affected.

8.4 Health effects caused by contaminants

Over time, sediments accumulate toxins and pollutants such as hydrocarbons and heavy metals. Disturbance of sediments can release contaminants into the water column, which has the potential to change chemical properties of the sediment, and reduce water quality. Once suspended, contaminants can become available to marine organisms, and potentially accumulate up the food chain and end in marine mammals (Todd et al. 2015). The suspension of sediment caused by rock placement or munition clearance is restricted in both time and space (Rambøll 2016b). The prime concern for marine mammals in this regard would be biomagnification of the suspended contaminants. However, given the estimated concentrations and the temporal and spatial extents of the suspension (Rambøll 2016c), and as long as highly contaminated sediments are managed strictly, concentrations are not high enough to have detrimental effects on the environment or food webs (Roberts 2012).

The spatial scale of contaminant remobilization is national and the duration is temporary (from hours to few days). The impact magnitude is thus **negligible**.

8.5 Oil spill

Major oil spill accidents such as the 'Amoco Cadiz' oil spill in Brittany, France and the 'Exxon Valdez' oil spill in Prince William Sound, Alaska will have a major impact on marine mammals. In general, however, the amount of oil spilled in ship accidents is much smaller (typically involving only bunker oil). Thus, although the spatial scale may potentially be transboundary and the duration long-term, the impact magnitude is assesed as **low** since the actual risk of the NSP2 service ships contribution to a collision involving oil spill is basically negligible.

8.6 Gas release

During the assessment of NSP, the risk of gas release during operation was calculated to be on average once every 293,500 years. However, in the unlikely event of gas release it is judged that all marine mammals within the gas plume or the subsequent gas cloud will die or flee from the influenced area (Nord Stream 2008). Since a potential gas release will likely be associated with some noise, it is likely that marine mammals will have time to avoid the plume. The impact will be temporary and local. The magnitude of the impact is **low.**

9. Assessment of impact in the construction period without mitigation measures

The overall significance of an impact is a combination of sensitivity and impact magnitude. These were assessed for each impact in the Chapters 7 and 8. The overall significance of impact in the construction period is assessed below for each impact and species. The assessment of “munition clearance” is assessed separately for Finnish and Russian waters. For all other impacts, the assessment is combined for all national waters. In this chapter, we assess the maximum impact due to muniton clearance without considering mitigation measures. Assessment of residual impacts that may occour when NSP2 mitigation measures are implemented are described in Chapter 12.

9.1 Underwater Noise

9.1.1 Munition Clearance, Finland

As described in Chapter 6, we have opted to assess the impacts of munition clearance for all marine mammal species on two scales:

1. Significance at the population level and by extension, the environment related to seal distribution and abundance.
2. Significance at the individual level: although injury to or death of individual seals may not impact populations and the environment significantly, individual injuries to or deaths of large mammals may have profound ethical implications.

In the assessment, we have focused on the PTS (179 dB SEL threshold) and TTS (164 dB SEL threshold) zones for maximum detonations and not the average detonation zones. It will not make any difference whether we look at the average or the max, since we do not have sufficient data on population sizes and spatial distribution to quantify the impact in terms of number of affected individuals. Thus the conclusions will be based on the expert assessment of the likelihood of one or more animals being inside the impacted area, and that will not differ much regardless of the size of the zone.

The impact of blast injury, PTS (179 dB SEL iso-contours) and TTS/avoidance (164 dB SEL iso-contours) are assessed separately for each species below.

Harbour Porpoise

The waters adjacent to the NSP2 pipeline in Finnish waters holds a very low density of harbour porpoises all year. Sensitivity to PTS, TTS and avoidance is therefore assessed to be low on both individual and population level.

The impact magnitude of TTS and avoidance is low and the overall significance is thus **minor**.

The impact magnitude of blast injury is assessed to be high and since the sensitivity of porpoises are low, the overall significance *should* be **moderate**. However, since the density of porpoises are expected to be extremely low and the likelyhood of a porpoise being present during the explosions is therefore also very low, the overall significance are assessed to be **minor** on both population and individual level when disregarding cumulative impacts.

The impact magnitude of PTS is medium, the sensitivity is low and the significanse is thus **minor**.

However, cumulative impact on porpoises from several explosions can occur if the same individuals happens to be exposed several times from different detonations. Given the low number of mines expected to be cleared in the M4 and M1-2-area and the very few porpoises likely to be present, it is estimated that the likelihood that the same individual will be exposed several times is very small. Cumulative effects hence do not change the assessments for individual porpoises.

The same applies to cumulative effects at the population level in area M1-2 and M4. As the likelihood that single individuals are exposed to levels causing injury and the expected number of explosions is low, the cumulative impact is not significantly affected and remains **minor**.

The potential cumulative impact for the M3-area is larger, since a larger number of mines are likely to be encountered (42 detonations during the previous NSP construction). The significance of a single explosion is assessed to be minor. Hovewer, the risk of increased impact due to cumulative effects will increase with number of explosions and at some level (critical number of explosions) warrant an increase in the impact from minor to moderate. Without detailed knowledge about the movement of the porpoises and thus the likelihood that they are present in M3-area, it is not possible to quantify this critical number of explosions. Estimation of such a number is further complicated by the fact that the sound exposure from each explosion is not known beforehand (as charges likely detonate only partially). However, it is assessed that the number of explosions in the M3-area is critical and consequently, the overall significance in the M3-area is assessed to be **moderate** for both blast injury and PTS due to the increased cumulative risk**.**

Grey seal

Grey seals can be found everywhere in Finnish waters. With the available data it is not possible to estimate the number of individuals affected along the NSP2 pipeline. However, based on the distribution of grey seal haul outs and the available telemetry data, it is likely that grey seals will be present in all Finnish waters relevant to the construction of NSP2 including the PTS and blast injury zones at M1-M4 areas.

The sensitivity to TTS is assessed as low and the impact magnitude is also low. Thus, the overall significance are assessed to be **minor** on both individual as well as population levels since the impacts will be temporary and most likely only affect a small proportion of the population.

The sensitivity to avoidance and masking caused by munition clearance is assessed as low and the impact magnitude is medium. The overall significance is assessed to be **minor** due to the temporary nature of the impact.

Individual level: The sensitivity to blast injuries is considered high on the individual level, since seals will be injured and possibly die. The impact magnitude is also high and the overall significance is thus assessed to be **major**.

The sensitivity to PTS is high on the individual level and the impact magnitude is medium. The overall significance is thus assessed to be **moderate**.

Population level: Blast injuries can be lethal and thus reduce the number of grey seals. The Baltic population of grey seals is, however, abundant and has been increasing over the last decades. The sensitivity to blast injuries is therefore considered low at the population level and the overall significance is thus **moderate**.

The sensitivity to PTS is low on population level and the impact magnitude is medium. The overall significance is thus assessed to be **minor**.

Cumulative impact from several explosions can occur if the same individuals happens to be exposed several times from different detonations. This is likely to occur for some grey seals, as they are numerous, especially in the **M3 area**, where the largest number of detonations is likely to take place. However, as the overall significance of blast injuries for individual grey seals is already assessed as major, the cumulative effects cannot change this assessments further.

In the same way as for blast injury, PTS can be cumulative for individual seals, if they are exposed multiple times. As discussed above (0), this means that after some number of multiple exposures to the individual animal the significance shifts from moderate to major. Where this transition occurs cannot be assessed, but is considered not to be within the realistic limits of the activities of Nord Stream 2 and the cumulative significance thus remains moderate.

Cumulative impact at the population level is relevant in all areas but most likely in area M3, where the highest number of mines is likely to be encountered (42 detonations during construction of Nordstream). As the sensitivity is assessed to be low on population level (due to the favourable population status), and the impact magnitude is high for blast injuries, the repeated exposure does not affect the overall significance, which remains **moderate.**

As for individual seals, the impact on the population is cumulative, as more and more animals are likely to suffer PTS, as the number of explosions is increased. Given the favourable population status of the grey seals, however, this cumulative impact is not considered to raise the impact above minor.

Ringed seal

Ringed seals can potentially be found everywhere in Finnish waters, but densities are generally higher near the haul outs and at foraging sites. These foraging sites may change seasonally and annually and with the current knowledge, we cannot assess whether or not significant foraging sites exist in areas relevant to the NSP2 pipeline.

The sensitivity of ringed seals to TTS as well as the impact magnitude of TTS is assessed to be low, and the overall significance is thus **minor** on individual as well as population levels since the impact is temporary.

The sensitivity of ringed seals to avoidance and masking caused by munition clearance is assessed as low and the impact magnitude is medium. The overall significance is assessed to be **minor** due to the temporary nature of the impact.

Individual level: Sensitivity to blast injury on the individual level as well as the impact magnitude is assessed as high. Thus, the overall significance for the affected individuals will be **major.**

The sensitivity to PTS is high on the individual level and the impact magnitude is medium. The overall significance is thus assessed to be **moderate**.

Population level: In the assessment of blast injury and PTS on the population level, we have adopted a precautionary approach, meaning that we consider the three breeding areas (Gulf of Finland, Archipelago Sea and Gulf of Riga) to be reproductively isolated. This means that impacts need to be assessed relative to the estimated abundances of each area.

Munitions clearance at the M1-2 area will potentially affect ringed seals from the inner Gulf of Finland. As the ringed seal abundance in this area is very low (probably between 100-300 individuals), every individual is demographically important. Although we have no telemetry data from animals tagged at the most proximate haul-outs to the M1/M2 area, it is unlikely that more than a few individuals will be present within the blast injury zone at the time of each munition clearance. However, if these e.g. are 2-3 mature females, the impact on the populaton may be high, while male individuals are less important. The sensitivity to blast injuries and the impact magnitude at the M1-2 area on population level is thus assessed as high and overall significance as **major**.

The sensitivity of ringed seals to PTS on population level in the M1-2 area is high and the impact magnitude is medium. The significance of the impact is thus **moderate**.

The M3 area is relatively distant to ringed seal haul outs (= colonies/breeding sites) and locations from telemetry data. Nevertheless, low numbers of transient individuals from all 3 breeding areas, including the threatened Gulf of Finland population may potentially be present within the PTS or blast injury zone at the time of munition clearance. We therefore assess the sensitivity at the M3 area as medium for both blast injuries and PTS. The impact magnitude is high for blast injuries and medium for PTS. The overall significance is thus **major** for blast injuries and **moderate** for PTS.

Munitions clearance at M4 or adjacent areas will potentially affect individuals from the Archipelago Sea and Gulf of Riga breeding areas. We have no telemetry data from animals tagged at the most proximate haul-outs for either of the three breeding areas (Inner Gulf of Finland, the Archiopelago and the Gulf of Riga) available, but it is likely that some individuals will be present within the PTS or blast injury zone at the time of munition clearance. However since these populations are not treathened, we assess sensitivity to blast injuries and PTS at the M4 area as low on population level. The impact magnitude is high for blast injuries and medium for PTS. The overall significance for ringed seals on population level in the M4 area is thus **moderate** for blast injuries and **minor** for PTS.

Cumulative impact from several explosions can occur if the same individuals happens to be exposed several times from different detonations. This is most likely to be the case in the M3 area, where the largest number of detonations is likely to take place, but as this is also the area with fewest ringed seals, the likelihood that the same individuals are exposed multiple times is considered low and without effect on the overall assessment of impact.

Cumulative impact may also take place at the population level, as each additional explosion will increase the risk that individuals are injured or gains PTS, adding up in the cumulative impact on the population. This is of particular importance in the M1-2 area (where six detonations were performed during construction of Nordstream), but for this area the assessment for a single explosion is already considered to be of **major** significance for blast injuries, indicating that any number of explosions, down to a single one, is considered problematic. For PTS the predicted low number of munition clerances will not alter the significance assessment of **moderate.**

The potential cumulative impact of PTS for area M3 is larger, as a larger number of mines are likely to be encountered (42 detonations during Nordstream construction). As the sensitivity is assessed to be medium and significance of a single explosion is moderate, the cumulative risk of impact with increasing number of explosions will also increase and at some level (number of explosions) warrant an increase of the impact significance from moderate to major. Without detailed knowledge about the movement of the seals and thus the likelihood that ringed seals from the Gulf of Finland population are present in area M3 it is not possible to quantify this critical number of explosions. Estimation of such a number is further complicated by the fact that the sound exposure from each explosion isn’t known beforehand (as charges likely detonate only partially). It is, however, judged that the impact significance is not significantly affected by cumulative impact and remains **moderate**.

The potential cumulative impact of PTS in the M4 area is low, as the expected number of explosions is lower (seven detonations during construction of Nordstream) and the population status of the affected ringed seal population (Gulf of Riga) is better than for the Gulf of Finland population. The cumulative impact from a small number of explosions will thus not change the assessed impact from **minor**.

9.1.2 Munition Clearance, Russia

As for Finland, the impacts of munition clearance are assessed both at the level of individuals and populations and in general the assessment follows the Finnish closely.

Harbour Porpoise

The abundance of porpoises in the Russian part of the Gulf of Finland is expected to be very low all year, at the same level in as the Finnish part of the Gulf, or lower. Sensitivity to PTS, TTS and avoidance is thus assessed to be low on both individual and population level.

The impact magnitude of TTS and avoidance is low and the overall significance is thus **minor**.

The impact magnitude of blast injury is assessed to be high and with low sensitivity the overall significance should be moderate. However, since the density of porpoises is expected to be extremely low, the overall significance is assessed to be **minor** on both population and individual level.

The impact magnitude of PTS is medium and the significance is **minor**.

As for the Finnish waters, there is potential for a cumulative impact on porpoises from multiple explosions. Given the very low probability that porpoises will be present, it is estimated that the likelihood that the same individual will be exposed several times is very small. Cumulative effects hence do not change the assessments for individual porpoises.

The same applies to cumulative effects at the population level. Since the likelihood that single individuals are exposed to levels causing injury is very low, the cumulative impact is not significantly affected and remains minor.

Grey seal

Grey seals can be found everywhere in the Russian part of the Gulf of Finland, although predominantly along the northern shores. These individuals are believed to be part of a larger, common population of the entire Baltic. With the available data it is not possible to estimate the number of individuals affected along the NSP2 pipeline.

The sensitivity to TTS is assessed as low and the impact magnitude is also low. Thus, the overall significance is assessed to be **minor** on both individual as well as population levels since the impacts will be temporary and most likely only affect a small proportion of the population.

The sensitivity to avoidance and masking caused by munition clearance is assessed as low and the impact magnitude is medium. The overall significance is assessed to be **minor** due to the temporary nature of the impact.

Individual level: The sensitivity to blast injuries is considered high on the individual level, since seals will be injured and possibly die, the impact magnitude is also high and the overall significance is thus assessed to be **major**.

The sensitivity to PTS is high on the individual level and the impact magnitude is medium. The overall significance is thus assessed to be **moderate**.

Population level: Blast injuries may be lethal and thus reduce the number of grey seals. The Baltic population of grey seals is, however, abundant and has been increasing over the last decades. The sensitivity to blast injuries is therefore considered low at the population level and the overall significance is thus **moderate**.

The sensitivity to PTS is low on the population level and the impact magnitude is medium. The overall significance is thus assessed to be **minor**.

Cumulative impact from several explosions can occur if the same individuals happen to be exposed several times from different detonations. This is likely to occur for some grey seals, as they are numerous. However, as the overall significance of blast injuries for individual grey seals is already assessed as major, the cumulative effects do not change this assessment further. As for the grey seals in Finnish waters, PTS can be cumulative for individual seals, if they are exposed multiple times, but it is considered not to be within the realistic limits of the activities of Nord Stream 2 to reach a level where significance is affected and the cumulative significance thus remains moderate.

Cumulative impact at the population level is relevant in Russian waters, due to an expectation of a high number of munitions encountered. However, as the sensitivity is assessed to be low (due to the favourable population status), the repeated exposure does not affect the overall cumulative impact, which remains **moderate** for blast injuries and **minor** for PTS.

Ringed seal

Ringed seals can be found everywhere in the Russian part of Gulf of Finland, but densities are generally higher near the haul outs and at foraging sites. These foraging sites may change seasonally and annually and with the current knowledge, we cannot assess whether or not significant foraging sites exist in areas relevant to the NSP2 pipeline.

The sensitivity of ringed seals to TTS as well as the impact magnitude of TTS is assessed to be low, and the overall significance is thus **minor** on individual as well as population levels since the impact is temporary.

The sensitivity of ringed seals to avoidance and masking caused by munition clearance is assessed as low and the impact magnitude is medium. The overall significance is assessed to be **minor** due to the temporary nature of the impact.

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Individual level: Sensitivity to blast injury and PTS on the individual level is considered high and the impact magnitude is high for blast injury and medium for PTS. The overall significance for the affected individuals will thus be **major** for blast injuries and **moderate** for PTS.

Population level: Munitions clearance in Russian waters will likely exclusively affect ringed seals from the inner Gulf of Finland population. As the ringed seal abundance in this area is very low (probably between 100-300 individuals), every individual is demographically important. Sensitivity to blast injury and PTS on the population level is considered high and the impact magnitude is high for blast injuries and medium for PTS. Consequently, the overall significance is **major** for blast injury and **moderate** for PTS.

Cumulative impact from several explosions can occur if the same individuals happen to be exposed several times from different detonations and may also incur at the population level, as each additional explosion will increase the risk that individuals are injured, adding up in the cumulative impact on the population. However, as the assessment for a single explosion is already considered to be of major significance for blast injuries, indicating that any number of explosions, down to a single one, is considered problematic, the cumulative impact does not further increase the significance.

Regarding cumulative impact of PTS, the cumulative risk of impact with increasing number of explosions will increase and at some level (number of explosions) warrant an increase of the impact significance from moderate to major. Without detailed knowledge about the movement of the seals and thus the likelihood that ringed seals from the Gulf of Finland population are present in area M3 it is not possible to quantify this critical number of explosions. Estimation of such a number is further complicated by the fact that the sound exposure from each explosion is not known beforehand (as charges likely detonate only partially). It is, however, judged that the impact significance of PTS is not significantly affected by cumulative impact and remains **moderate**.

9.1.3TTS/PTS from rock placement

Even with precautionary assumptions regarding impact of noise from rock placement, the impact is strictly local, temporary and of low intensity (PTS unlikely). The magnitude of impact is thus low. The sensitvity for seals is medium, while is is low for porpoises. The significance of the impact is assessed as **minor** for all species, both for Finland and Russia.

9.1.4TTS/PTS from vibratory sheet piling in Russian waters

As for noise from rock placement, even with precautionary assumptions regarding impact of noise from vibratory sheet piling, the impact is strictly local, temporary and of low intensity (PTS unlikely). The magnitude of impact is thus low. The sensitvity for seals is medium, while it is low for porpoises. The significance of the impact is assessed as **minor** for all species.

9.1.5Behavioural reactions to noise

Noise from the rock placement was used as a proxy for construction related noise from vessels in general, as the rock placement is considered one of the noisiest activities arising from the project (except for munitions clearance). Behavioural reactions to underwater noise from rock placement and other vessel related activities around the pipeline are expected to occur only in the vicinity of the vessels and remain only for the time when the vessels are present. The duration is thus temporary and the scale is local. Disturbance from activities during construction, pre-commissioning and commissioning is considered of minor importance. Disturbances are likely to be of similar magnitude as disturbance from passing merchant vessels, which are very abundant along the pipeline corridor (see Figure 9-1). The intensity and impact magnitude from vessel noise and rock placement is therefore rated low and the overall significance **minor** for all marine mamal species.

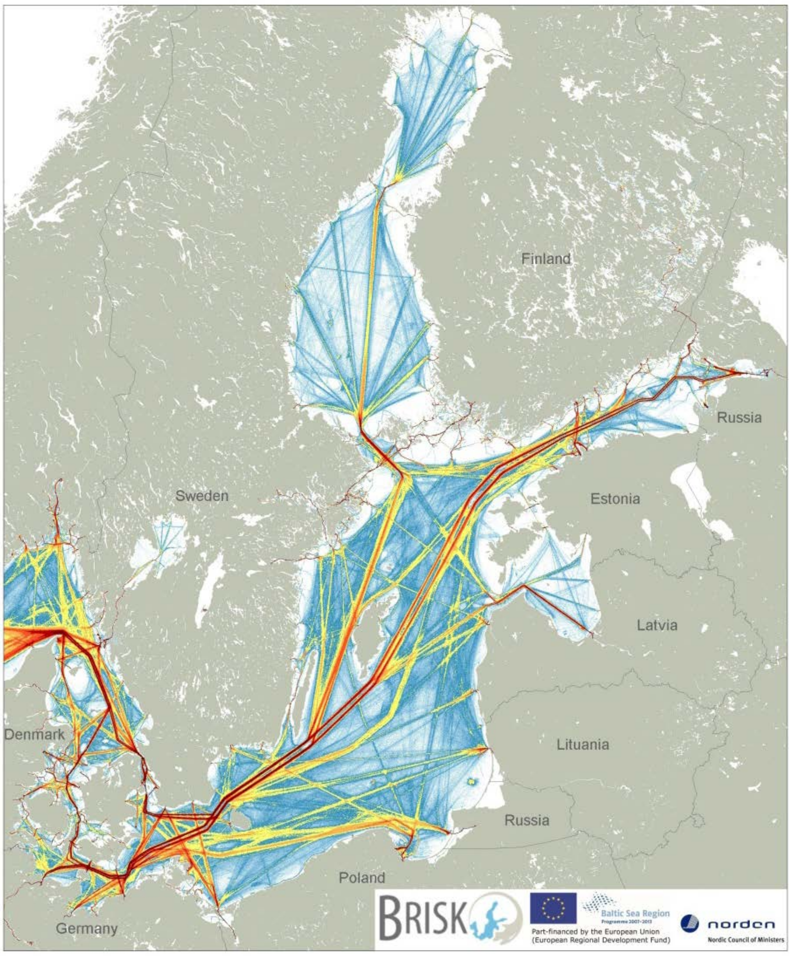

Figure 9-1 *Density of ship traffic based on AIS data in the Baltic in 2009. (Downloaded from* http://www.brisk.helcom.fi/risk_analysis/traffic/*). AIS includes all commercial vessels above 300 tons and some fishing vessels and pleasure boats that carry AIS on a voluntary basis.*

Seals and porpoises will be able to hear noise from munition clearance at very large distances from the blast sites and may be expected to react to the sounds, even if the levels are not high enough to cause PTS or TTS. At ranges where the rise time of the shock wave is sufficiently steep the noise is likely to induce a startle reflex, which is an involuntary contraction of the body muscles. This reflex is harmless, but repeated exposures may lead to fear conditioning (Götz and Janik 2011). At further distances from the blast site the animals are likely to react to the shock wave by a brief cessation of current activities. Behavioural effects of munition clearance are thus considered to be very short and without significant consequences for the animals.

9.2 Sediment spill

Suspended sediment may have a direct effect on marine mammals by either hindering their visual capacity or by affecting their vision since suspended sediment scatters light, degrades the image contrast, limits the visual range and also determines the spectral bandwidth and intensity of light available for vision at certain water depths (Weiffen et al. 2006).

Indirectly, suspended sediment and sedimentation can impact the benthic and pelagic prey of marine mammals by covering the sea bed with sediment, by increasing turbidity and releasing contaminants.

If the area exposed to sedimentation is relatively small, this impact is assessed to be of minor importance to marine mammals. In the case of NSP2 sedimentation will only occur in relative proximity to the pipeline and no detrimental impacts (especially not on measurable level) are expected on marine mammals.

9.2.1 Visual impairment

Since the harbour porpoise use echolocation for orientation in the environment as well as prey localisation, the visual impairment caused by sediment plumes, is not assessed to have a significant impact at an individual nor at a population level. Seals does not use echolocation, but like porpoises they are often found in darkness and in turbid waters where prey aggregate and as such, visual impairment are not believed to have a significant negative impact.

The spatial and temporal extent of a sediment spill and hence visual impairment is national and temporary, with low intensity and the impact magnitude is low. Consequently, the overall significance on seals and porpoises in Finnish, Russian and Estonian waters is **minor.**

9.2.2Behavioural impacts of sediment spill

The duration of behavioural responses caused by sediment spill are temporary and the scale national meaning that the animals will return or assume their normal behaviour once the activity has ceased. The behavioural impacts are all assessed to be reversible and the impact magnitude is low. The sensititivy is assessed to be medium for seals and low for porpoises, the overall significance is **minor** for all species.

9.2.3Health effects caused by contaminants

The impact magnitude of health effects caused by contaminants is negligible, which in combination with a low sensitivity gives an overall significance of **negligible**.

9.3 Unplanned events

9.3.1Oil spill

The sensitivity of marine mammals to oil spill is generally high (although here assessed as low for porpoises due to the very low density of animals), but due to the low risk of the impact occuring, the overall significance is **minor.**

10. Assessment of impact in the operation period

The overall significance of an impact is a combination of sensitivity and impact magnitude. These were assessed for each impact in the chapters 7 and 8. The overall significance of impact in the operation period is assessed below for each impact and species. The assessment of “underwater noise from the pipeline” and “changes in the habitat” is assessed separately for Finnish and Russia waters. For all other impacts, the assessment is combined for all national waters.

10.1 Underwater noise from pipeline

10.1.1 Finland

Sensitivity of seals and porpoises to underwater noise from the pipeline in the entire Finnish assessment area is low, but since the sound is practically inaudible, the impact magnitude is negligible. Thus, the overall significance of this impact in Finnish waters is considered **negligible.**

10.1.2 Russia

Underwater noise levels around the pipelilne in Russian waters is likely to be more audible to marine mammals, due to the proximity to the compressor station, the main noise source, and because ambient noise levels are expected to be lower than the central Gulf of Finland. Intensity and magnitude is low, and the impact strictly local. Thus, the overall significance of pipeline noise in Russian waters is considered **minor.**

10.1.3 Underwater noise from service vessels

The level of ship activity in relation to inspection and maintenance of the pipeline is considered to be insignificant in comparison with the general level of shipping activity in the Gulf of Finland (Figure 9-1) and any disturbance from these ships will be local and temporary. The intensity and magnitude is low and the sensitivity is also low. Thus the the overall significance in Finnish waters is assessed as **minor**.

The level of exsisting shipping along the NS2 corridor through Russian waters is considerably lower than in the central Gulf of Finland (Figure 9-1). Service ship activity along the pipeline is expected to be low, however, and disturbances from the ships to marine mammals will be local and temporary. Thus, although the level of disturbance is likely to be higher than in Finnish waters, due to the lower exsisting ship traffic, intensity and magnitude is expected to be low. As the sensitivity is also low, the overall significance of disturbance form service vessels in Russian waters is assessed as **minor**.

10.2 Changes in the habitat

10.2.1 Finland

The sensitivity of seals to changes in the habitat is assessed to be medium. While the sensitivity of harbour porpoises to changes in the habitat is assessed to be low, due to the low density of porpoises. The impact magnitude are assessed to be negligible. Consequently, the overall significance of habitat change are assessed to be negligible for all marine mammals in Finnish waters.

10.2.2 Russia

The sensitivity of seals to changes in the habitat is assessed to be medium. While the sensitivity of harbour porpoises to changes in the habitat is assessed to be low, due to the low density of porpoises. The impact magnitude are assessed to be low in Russia, due to the shallower water. Consequently, the overall significance of habitat change are assessed to be **minor** for all seals in Russian waters. For porpoises, however, the significance are assessed to be **negligible**.

10.3 Unplanned events

10.3.1 Gas release

The impact magnitude of gas release is low and the sensitivity of marine mammals is assessed to be high. The overall significance of gas release on marine mammals is, however, assessed to be **minor** due to the low likelyhood of gas release occuring.

11. General approach to mitigation

The only major source of potential impact on marine mammals in the Nord Stream 2 project is noise from munition clearance. This potential impact is considerable, however, especially on ringed seals, and mitigation measures to reduce impact may be appropriate.

In general, the impact from noise can be mitigated by three different approaches: reduction of generated noise, reduction of radiated noise and reduction of received noise.

Reduction of generated noise

The noise generated by the detonation of explosives cannot be modified, as the detonation is uncontrollable. The only way to reduce the generated noise is thus to move the explosives to a different location for detonation (very shallow water or dry land) or avoid detonation altogether by chemical degradation of the explosives, either in situ or after recovery. Such procedures involve extensive handling of the explosives and may thus be connected with considerable risks for equipment and personell.

Reduction of radiated noise

An attractive alternative to handling the explosives is to attenuate the transmitted noise from the explosion and into the surroundings. This may be achieved by mechanical shielding with gravel or other sediment or be achieved by means of a bubble curtain. The latter is attractive, as it has proved to be very effective in attenuation of impulsive noise, such as the noise from pile driving (Lucke et al. 2011), and has also been suggested as a mitigation measure for underwater explosions (Croci et al. 2014).

Reduce received noise

The last approach involves reducing the noise that reaches the animals (or the number of animals affected), by seaking to avoid explosions whenever animals are close to the detonation site. This can be achieved by several methods.

First of all munition clearance can be conducted during periods where fewer animals are in the area and at times of the year when they are less vulnerable (typically outside breeding and molting time). Ringed seals and grey seals breed mid-February to mid-March. Disturbances, such as displacement, which would at other times not have a significant impact, may be significant for breeding success at this time. Ringed seals moult from mid-April to early May and grey seals moult from early May to mid-June. During the moult, disturbances may increase the energy expenditure of the seals at a time when they have little time for foraging. The potential detrimental effects during these seasons are most serious during breeding, as survival of pups/calves may be affected directly.

Secondly, by means of deterrent devices, such as seal scarers or a series of pre-explosions with increasing amounts of explosives, a deterrence of animals from the dangerous zone can be achieved. This is likely to be efficient for deterring porpoises. Seals may not be deterred, but may seek to the surface and by keeping their head out of the water achieve protection. Visual observations prior to detonation cannot guarantee that no animals are affected by the detonation, as the impact areas are very large and seals and porpoises may remain submerged and undetected for long periods. Nevertheless, even if not very efficient, a visual survey prior to detonations will protect those animals that may be sighted, given that the detonation is postponed until the animals are believed to have cleared the area.

The mitigation measures are not ranked according to effectiveness and can be combined to achieve an increase in reduction of impact.

12. Assessment of impact with mitigation

The assessments conducted in the previous chapters has been carried out on the basis of the assumption that no measures were taken to mitigate impact of especially munition clearance. As stated in chapter 11, there are several options available, which individually or in combination, will reduce the impact on marine mammals. Some of these mitigation measures were used during munition clearance in connection to construction of the Nord Stream pipeline. This chapter describes how the mitigation measures used for NSP (primarily seal scarers) affect the assessment of impact magnitude and overall significance of munition clearance. This leads to a reduction in assessed impact, but does not neccesarily represent the maximum reduction possible, as several of the other suggested mitigation measures have not been included in the assessment.

12.1 Mitigation measures used for the Nord Stream pipeline, Finnish waters

During construction works for the Nord Stream pipeline numerous unexploded munitions were encountered and cleared by detonation. Mitigation measures were implemented to reduce impact on fish and marine mammals, as described in Rambøll (2017):

"*Several measures were implemented to mitigate and monitor impacts on marine mammals, diving seabirds and fish. Visual observations were performed by marine mammal observers from one hour before the detonation to one hour after the detonation. A sonar survey to identify any fish shoals in the area was carried out by the work boat and a passive acoustic monitor was deployed into the water column to record any vocalisation by marine mammals prior to detonation. In addition to observations, four acoustic deterrents (seal scrammers) were deployed and activated prior to detonation and a small fish scarer charge detonated was before firing the main donor charge to scare away any seals or fish from the area.*"

The typical layout is illustrated in Figure 12-1.

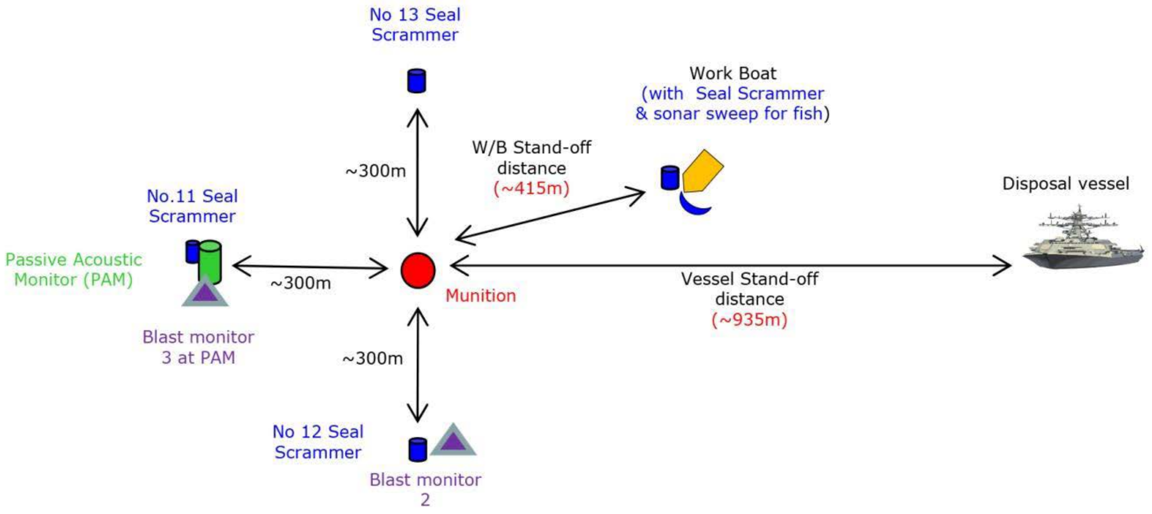

Figure 12-1 Layout of monitoring and mitigation equipment typically used during munitions clearance for the Nord Stream pipeline. From Rambøll (2017).

NSP2 plan to apply the same approach in Finland and, with minor differences, in Russia (Nord Stream 2 2017).

12.2 Effects of seal scarer

With respect to effects on marine mammals, the use of seal scarers (scrammers) is likely to have had the largest mitigating effect.

12.2.1 Harbour porpoises

Porpoises are known to react strongly to seal scarers by evasion (e.g. Johnston 2002; Olesiuk et al. 2002; Brandt et al. 2012). Deterrence ranges differ between studies, but appears to be at least 350 m for total deterrence and somewhere between 1 and 2 km for almost complete deterrence (See review by Hermannsen, Mikkelsen, and Tougaard 2015). Effects up to 8 km has been observed in a single study (Brandt et al. 2012). The most effective seal scarer appears to be the Lofitech; same model as used for Nord Stream (Nord Stream 2 2017). Using the NSP setup described above, porpoises would be scared away at least 1300-2300 m from the explosion site and possibly more.

12.2.2 Seals

Seals react differently to seal scarers than porpoises (Götz and Janik 2014). First of all the response is strongly context dependent. The primary use of seal scarers is to deter seals from aquaculture facilities and fishing gear. Seal scarers have been reported to have very variable ability for deterrence in these situations, ranging from some deterrence to active attraction (so-called "dinner-bell"-effect). See (Königson et al. 2007; Mikkelsen, Hermannsen, and Tougaard 2015) for reviews. When used as a mitigation device for loud underwater noise the context is different and the seals are not rewarded for ignoring the loud sound by a food source (the fishing gear or net pen). There is thus several studies supporting that seals are deterred from the vicinity of seals scarers when used without food reinforcement. The Lofitech device is considered effective in deterring harbour and grey seals out to a distance of at least some hundred meters (Mikkelsen, Hermannsen, and Tougaard 2015). At further distances, out to around 1 km, the seals may not be deterred, but will change their behaviour and spend more time in the surface (Gordon et al. 2015). Using the NSP setup described above, seals would be scared away from the nearest few hundred meters of the seal scarers (which corresponds to an area with a radius of at least 500 m from the blast site, as four seal scarers will be used, Figure 12-1) and alter their behaviour to be more surface active up to around 1300 m from the explosion site.

12.3 Consequences for assessment – blast injury

Mitigation measures, more specifically seal scarers, will greatly reduce the risk that marine mammals are very close when the explosion occurs and thus also reduce the risk that they suffer significant blast injury or death due to exposure to the shock wave from the explosion.

12.3.1 Harbour porpoises

In case of a large explosion, such as 300 kg TNT-equivalent at a depth of 40 m, the impact of the shock wave extends out to several kilometres (Figure 3-2). However, as the seal scarers, as described above, are very effective in deterring porpoises out to distances of at least 1-2 km and since the density of porpoises in these areas are very low, it is unlikely that any porpoises will be within this range at time of the explosion. For this large explosion the "*safe level*", where no blast injury is expected is about 2.5 km for animals in the surface and about 10 km for animals at the bottom. At the same time threshold distances for "*moderately severe blast injuries*" (terminology from Yelverton et al. 1973) is less than 1 km for animals in the surface and about 2.5 km for animals at the bottom (40 m). The category "*moderately severe blast injuries*" covers non-trivial, but survivable injuries, where animals are considered able to recover on their own.

Combining the above information about likely deterrence of porpoises and extend of injuries, it is concluded that using seals scares before detonations, as described above, will reduce the risk of fatal injuries to porpoises to negligible levels, and reduce, but not eliminate the risk that a porpoise present within some kilometres from the blast site could suffer non-lethal blast injuries. The impact magnitude of blast injuries is considered to be **low** at all modelled locations, both at individual and population level. Consequently the overall significance is **minor** at all sites.

12.3.2 Seals

As the same threshold distances described for porpoises apply equally well for seals, but since deterrence ranges are smaller, the effect of seal scarers as mitigation devices differ somewhat from porpoises. However, even though seals may only be displaced a few hundred meters from the seal scarer, the fact that several seal scarers are used, each about 300 m from the blast site, and that seals are likely to react to the seal scarer signals at distances up to 1 kilometre away by spending more time in the surface, will provide considerable protection for the seals for up to 1300 m from the explosion. Threshold distance for *moderately severe injuries* for the 300 kg explosion is about 1 km for animals in the surface and 2.8 km at the bottom (sensu Yelverton et al. 1973), which means that the likelihood that seals are killed by the explosion is reduced substantially especially at the surface. This is judged to reduce the assessment of impact magnitude to individual grey and ringed seals to **medium**, as the likelihood of killing or permanently disabling seals due to blast injuries is considered to be small. The overall significance of blast injuries to grey seals at all sites is thus moderate on the individual level and **minor** on the population level.

The overall significance of blast injuries to ringed seals at all sites is **moderate** on both population and individual level.

12.4 Consequence for assesment - PTS

Deterrence of seals and porpoises prior to munitions clearance will also have substantial effects on the number of animals likely to suffer permanent hearing loss (PTS) but only in a relative small area compared to both the average and maximum extend of the PTS zones. However, due to the exponential (on average) decrease in sound pressure level with distance from the blast site, the exclusion of seals from the innermost area around the blast site will significantly reduce the number of animals which would acquire severe PTS. On the other hand, as far more animals are likely to be exposed at larger distances, the overall number of animals acquiring PTS will not be reduced very much by the seal scarers. Consequently, the suggested mitigation measure of using seal scarers is considered not to change the assessed significance, which thus remains moderate.

Temporary threshold shift can occur at considerable distance from the blast site, i.e. well beyond the reach of the seal scarers. This means that the risk of inflicting TTS on marine mammals is largely unaffected by the use of seal scarers as mitigation measure.

12.5 Conclusion on mitigation

Summing up the above leads to a conclusion that the significance of the impact of blast injury and PTS on porpoises, ringed seals and grey seals in the Gulf of Finland can be reduced in several cases by use of seal scarers as mitigation measure, in a way comparable to what was done during construction of the Nord Stream Pipeline. The main reasons for this difference are that the likelihood of killing or permanently disabling animals due to blast injury is expected to be significantly reduced by deterrence of seals and porpoises by seal scarers, and also the elimination of the most severe permanent hearing loss likely to be inflicted on seals and porpoises.

13. Summary tables of assessment with and without mitigation

This chapter presents summary tables of activity, impact, sensitivity, assessment in the Finnish and Russian waters relevant for each activity for harbour porpoise, grey seal and ringed seal.The assessment values refer to the text in section 9, 10 and 12. The assessment for Natura 2000 sites is not included in tables but may be found in chapter 14.

13.1 Harbour porpoise

HARBOUR PORPOISE														
	Impact	Phase	Activity	Area	Level	Impact	Type	Reversibility	Value/ Sensitivity	Impact magnitude	Significance	Impact magnitude w. mitigation	Significance w. mitigation	Country of impact origin
Planned	Noise	Construction	Munition clearance	M1rus	Individual & Population	Blast injury	Direct / Transboundary	Irreversible	Low	High	Minor*	Medium	Minor	Russia
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	
				All	Individual & Population	TTS	Direct / Transboundary / Cummulative	Irreversible	Low	Low	Minor	Low	Minor	Finland/ Russia
				M1-2, M4	Individual	Blast injury	Direct / Transboundary	Irreversible	Low	High	Minor*	Medium	Minor	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	Finland
				M3	Individual	Blast injury	Direct / Transboundary	Irreversible	Low	High	Moderate	Medium	Minor	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	
				M1-M4	Population	Blast injury	Direct / Transboundary	Irreversible	Low	High	Minor*	Medium	Minor	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	
				All	Individual & Population	Avoidance, masking	Direct	Reversible	Low	Low	Minor	Low	Minor	Finland/ Russia
			Seabed intervention works (Rock placement)	All	Population	PTS/TTS, Avoidance, masking	Direct	Reversible	Low	Low	Minor	No effect of mitigation		Finland/ Russia
			Construction and support vessel movement	All	Population	Avoidance	Direct	Reversible	Low	Low	Minor			
		pre-commissioning and commissioning	Pipeline flooding, Pressure-test water discharge, Commissioning	All	Population	Avoidance	Direct	Reversible	Low	Low	Minor			
		Operation	Routine inspections, maintenance, support vessel movement	All	Population	Avoidance	Direct	Reversible	Low	Low	Minor			
			Pipeline presence	All	Population	Avoidance	Direct	Irreversible	Low	Negligible	Negligible			
	Sediment spill	Construction	Munition clearance, Rock placement	All	Population	Visual impairment	Direct	Reversible	Low	Low	Minor			
				All	Population	Avoidance, disturbance of natural behaviour	Direct	Reversible	Low	Low	Minor			
	Release of contaminants	Construction	Seabed intervention works, Pipe-laying, Anchor handling	All	Population	Health deterioration	Direct	Irreversible	Low	Negligible	Negligible			
	Habitat change	Operation	Pipeline presence	All	Population	Posible change in prey diversity/ abundance	Indirect	Irreversible	Low	Negligible	Negligible			
Unplanned	Release of contaminants	Operation	Gas release	All	Population	Death, avoidance	Direct	Reversible	Low	Low	Minor			
		Construction / Operation	Oil spill	All	Population	Death, health problems, avoidance	Direct	Irreversible	Low	Low	Minor			

*Assessed to be minor and not moderate due to very low density of porpoises

13.2 Grey Seal

GREY SEAL														
	Impact	Phase	Activity	Area	Level	Impact	Type	Reversibility	Value/ Sensitivity	Impact magnitude	Significance	Impact magnitude w. mitigation	Significance w. mitigation	Country of impact origin
Planned	Noise	Construction	Munition clearance	M1rus-M3rus	Individual	Blast injury	Direct / Transboundary	Irreversible	High	High	Major	Medium	Moderate	Russia
						PTS	Direct / Transboundary / Cummulative	Irreversible	High	Medium	Moderate	Medium	Moderate	
					Population	Blast injury	Direct / Transboundary	Irreversible	Low	High	Moderate	Medium	Minor	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	
				All	Individual & Population	TTS	Direct / Transboundary / Cummulative	Irreversible	Low	Low	Minor	Low	Minor	Finland/ Russia
				M1-M4	Individual	Blast injury	Direct / Transboundary	Irreversible	High	High	Major	Medium	Moderate	Finland
						PTS	Direct / Transboundary / Cummulative	Irreversible	High	Medium	Moderate	Medium	Moderate	
					Population	Blast injury	Direct / Transboundary	Irreversible	Low	High	Moderate	Medium	Minor	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	
				All	Individual & Population	Avoidance, masking	Direct	Reversible	Medium	Low	Minor	Low	Minor	Finland/ Russia
			Seabed intervention works (Rock placement)	All	Population	PTS/TTS, Avoidance	Direct	Reversible	Medium	Low	Minor	No effect of mitigation		
			Construction and support vessel movement	All	Population	Avoidance	Direct	Reversible	Medium	Low	Minor			
		pre-commissioning and commissioning	Pipeline flooding, Pressure-test water discharge, Commissioning	All	Population	Avoidance	Direct	Reversible	Medium	Low	Minor			
		Operation	Routine inspections, maintenance, support vessel movement	All	Population	Avoidance	Direct	Reversible	Medium	Low	Minor			
			Pipeline presence	M3Rus	Population (GoF)	Avoidance	Direct	Reversible	Medium	Low	Minor			Russia
			Pipeline presence	M1-M4, M1rus-M2rus	Population	Avoidance	Direct	Irreversible	Medium	Negligible	Negligible			Finland/ Russia
	Sediment spill	Construction	Munition clearance, Rock placement	All	Population	Visual impairment	Direct	Reversible	Low	Low	Minor			
				All	Population	Avoidance, disturbance of natural behaviour	Direct	Reversible	Medium	Low	Minor			
	Release of contaminants	Construction	Seabed intervention works, Pipe-laying, Anchor handling	All	Population	Health deterioration	Direct	Irreversible	High	Negligible	Negligible			
	Habitat change	Operation	Pipeline presence, near land	M1-M3Rus	Population (GoF)	Posible change in prey diversity/abundance	Indirect	Irreversible	Medium	Low	Minor			Russia
			Pipeline presence	M1-M4	Population	Posible change in prey diversity/abundance	Indirect	Irreversible	Medium	Negligible	Neglible			Finland
Unlanned	Release of contaminants	Operation	Gas release	All	Population	Death, avoidance	Direct	Reversible	Medium	Low	Minor			Finland/ Russia
		Construction / Operation	Oil spill	All	Population	Death, health problems, avoidance	Direct	Irreversible	High	Low	Minor			

13.3 Ringed seal

RINGED SEAL														
	Impact	Phase	Activity	Area	Level	Impact	Type	Reversibility	Value/Sensitivity	Impact magnitude	Significance	Impact magnitude w. mitigation	Significance w. mitigation	Country of impact origin
Planned	Noise	Construction	Munition clearance	M1rus-M3rus	Individual	Blast injury	Direct / Transboundary	Irreversible	High	High	Major	Medium	Moderate	Russia
						PTS	Direct / Transboundary / Cummulative	Irreversible	High	Medium	Moderate	Medium	Moderate	
					Population	Blast injury	Direct / Transboundary	Irreversible	High	High	Major	Medium	Moderate	
						PTS	Direct / Transboundary / Cummulative	Irreversible	High	Medium	Moderate	Medium	Moderate	
				All	Individual & Population	TTS	Direct / Transboundary / Cummulative	Irreversible	Low	Low	Minor	Low	Minor	Russia/ Finland
				M1-M4	Individual	Blast injury	Direct / Transboundary	Irreversible	High	High	Major	Medium	Moderate	Finland
						PTS	Direct / Transboundary / Cummulative	Irreversible	High	Medium	Moderate	Medium	Moderate	
				M1-M2	Population (GoF)	Blast injury	Direct / Transboundary	Irreversible	High	High	Major	Medium	Moderate	
						PTS	Direct / Transboundary / Cummulative	Irreversible	High	Medium	Moderate	Medium	Moderate	
				M3	Population (GoF, GoR, ArS transient individuals)	Blast injury	Direct / Transboundary	Irreversible	Medium	High	Major	Medium	Moderate	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Medium	Medium	Moderate	Medium	Moderate	
				M4	Population (GoR, ArS)	Blast injury	Direct / Transboundary	Irreversible	Low	High	Moderate	Medium	Minor	
						PTS	Direct / Transboundary / Cummulative	Irreversible	Low	Medium	Minor	Medium	Minor	
				All	Individual & Population	Avoidance	Direct	Reversible	Medium	Low	Minor	Low	Minor	Finland/ Russia
			Seabed intervention works (Rock placement)	All	Population	PTS/TTS, Avoidance, masking	Direct	Reversible	Medium	Low	Minor	No effect of mitigation		Finland/ Russia
			Construction and support vessel movement	All	Population	Avoidance	Direct	Reversible	Medium	Low	Minor			
		pre-commissioning and commissioning	Pipeline flooding, Pressure-test water discharge, Commissioning	All	Population	Avoidance	Direct	Reversible	Medium	Low	Minor			
		Operation	Routine inspections, maintenance, support vessel movement	All	Population	Avoidance	Direct	Reversible	Medium	Low	Minor			
			Pipeline presence	M3Rus	Population (GoF)	Avoidance	Direct	Irreversible	Medium	Low	Minor			
				M1-M4, M1rus-M2rus	Population	Avoidance	Direct	Irreversible	Medium	Negligible	Negligible			
	Sediment spill	Construction	Munition clearance, Rock placement	All	Population	Visual impairment	Direct	Reversible	Low	Low	Minor			
				All	Population	Avoidance, disturbance of natural behaviour	Direct	Reversible	Medium	Low	Minor			
	Release of contaminants	Construction	Seabed intervention works, Pipe-laying, Anchor handling	All	Population	Health deterioration	Direct	Irreversible	High	Negligible	Negligible			
	Habitat change	Operation	Pipeline presence, near land	M1-M3Rus	Population (GoF)	Posible change in prey diversity/abundance	Indirect	Irreversible	Medium	Low	Minor			Russia
			Pipeline presence	M1-M4	Population	Posible change in prey diversity/abundance	Indirect	Irreversible	Medium	Negligible	Negligible			Finland
Unplanned	Release of contaminants	Operation	Gas release	All	Population	Death, avoidance	Direct	Reversible	Medium	Low	Minor			Finland/ Russia
		Construction / Operation	Oil spill	All	Population	Death, health problems, avoidance	Direct	Irreversible	High	Low	Minor			

14. Assessment of impact in Natura 2000 areas in EU waters

14.1 Natura 2000 sites

14.1.1 Construction phase

Grey seals are listed as part of the selection criteria in 13 Finnish and 9 Estonian Natura 2000 sites that are located within 100 km of the NSP2 pipeline. Of these 3 Finnish and 2 Estonian Natura 2000 sites also have ringed seal as part of the selection criteria. None of the Natura 2000 sites are crossed by the NSP2 corridor. However, all of these sites are within a distance of the NSP2 pipeline corridor that makes it highly likely that seals inhabiting the sites will cross the NSP2 corridor at some point and thereby could be affected by the construction and operation of the pipeline.

Munition clearance is the only activity assessed to have a major impact on seals.

Individual seals will be injured and possibly die if they are within the blast injury zone (which on average is approx. 5 km from the explosion, see chapter 3.1.1) or the PTS zone during munition clearance. Three Finnish Natura 2000 sites for grey seals, namely Kallbådan islet and water area (FI0100089), Tammisaari and Hanko Archipelago and Pohjanpitäjänlahti marine protected area (FI0100005) and Söderskär and Långören archipelago (FI0100077) are located within the TTS zone (164 dB) related to the munition clearance noise models in Finnish waters (Chapter 6). Seals within this zone may get TTS and will likely display some avoidance behaviour such as fleeing or lifting their head out of the water. This impact is assessed to be not significant due to the short duration and the reversibility of the impact. Kallbådan islet and water area (FI0100089), located within the PTS (179 dB) zone (for maximum detonation at M3 area in Finland). Here, grey seals in the water within the Natura 2000 site may get PTS and/or other injuries and all seals using the area will very likely be temporary dislocated. The impact on grey seals within the Natura 2000 site due to the NSP2 construction activities are thus assessed to be **significant**. No other areas will be directly affected by the NSP2 construction.

The TTS zone of the munition clearance in the M1_{rus}-area in Russian waters reaches a Natura 2000 site in Estonian waters, called Uhtju (EE0060220). This site is designated for both ringed and grey seal. The seals within this zone may get TTS and will likely display some avoidance behaviour such as fleeing or lifting their head out of the water. This impact is assessed to be not significant due to the short duration and the reversibility of the impact.

There are no Natura 2000 sites with harbour porpoise as part of the selection criteria in Finnish or Estonian waters. Thus, an impact assessment is irrelevant.

14.1.2 Operation phase

It is not expected that any of the potential activities in the operation phase will have a significant impact on marine mammals within the Natura 2000 sites in Finland or Estonia listed in the baseline report (Teilmann, Galatius, and Sveegaard 2017). As outlined above in Chapter 10 the additional noise and potential disturbances from vessels and pipeline are likely to be strictly local and mainly temporary. The impacts on grey seals inside the Natura 2000 areas is thus considered

not significant, as effects are unlikely to have any consequences for the long term survival of the population.

14.1.3 Annex IV species

Harbour porpoise is on the Annex IV of the Habitat Directive and thus, the impact assessment of the Nord Stream 2 Pipeline needs to determine whether any of the pressures identified may lead to a violation of the prohibitions listed in the Habitats Directive, namely

- all forms of deliberate capture or killing of specimens of these species in the wild;
- deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;
- deterioration or destruction of breeding sites or resting places.

There are no known important breeding, rearing or migration sites for harbour porpoises in the impacted waters in Finland, Estonia and Russia.

Only underwater noise from munition clearance during the construction phase is assessed to be relevant here, since the high noise levels may leed to blast injury and PTS in porpoises (see section 8.1.1). Porpoises may be present in very low densities in all impacted areas along the NSP2 route. All impacts are assessed as minor except for munition clearance in the Finnish M3-area, which is assessed as moderate impact due to the cumulative impact of the expected number of munition clearances, which will heighten the likelyhood that a porpoise is present in the blast injury or PTS zone. This will however be reduced to minor thanks to the application of the mitigations measures to which NSP2 has committed to. Consequently, the construction of NSP2 will not leed to a violation of the Habitats Directive since no animals are injured (blast injury or PTS) during munition clearance. It is assessed that the likelyhood of this happening is low.

15. Conclusion

This report assesses the potential impacts on marine mammals in relation to the Finnish and Russian sections of the proposed gas pipeline Nord Stream 2. The construction and operation may have impacts on marine mammals in Finnish, Estonian and Russian waters and in these waters, the relevant marine mammal species are grey seal, ringed seal and harbour porpoises.

This chapter describes the total impact of NSP2 from construction to operation, including transboundary and cumulative impacts on each of the relevant species. Impact assessment describes how the use of mitigation measures to which NSP2 has committed to will reduce the potential impacts during construction.

The main impacts on marine mammals during construction of the gas pipeline are assessed to be hearing damage and blast injury from munition clearances, and avoidance behaviour caused by underwater noise from construction activities and sediment spill from seabed intervention activities. Modelled scenarios of these impacts show that they are often large scale and transboundary. Impacts from munition clearance may also be cumulative.

The main potential impacts during the pre-commissioning and commissioning phases are disturbances from ship traffic and other activities, while the main pressures on marine mammals during operation of the pipeline are noise from the pipeline itself (due to flowing gas) as well as from service vessels.

The only activity assessed to have minor to moderate impact on the marine mammals is munitions clearance. A summary of the overall impacts to harbour porpoises, grey seals and ringed seals in Finnish, Russian and Estonian waters due to munition clearance related to the NSP2 construction is presented below.

Harbour porpoise

The harbour porpoise population in the Baltic is very low in numbers and considered endangered. Thus, all individuals are of demographic importance and although the number of porpoises in the Finnish, Estonian and Russian waters are very low, it is still likely that some individuals will be present during the different phases of the NSP2.

The only activity assessed to have other than minor impacts on harbour porpoises is munition clearance in the central part of the Gulf of Finland (the M3 area) which is assessed to have a moderate significance if no mitigation measures are considered. The impacted area of munition clearance would be transboundary and the impacts from explosions in Finnish waters would also apply to porpoises in northern Estonian (such as the moderate significance of the M3 area) and western Russian waters, while the impacts from munition clearance in Russian waters would apply to eastern Finnish and Estonian waters.

However, the mitigation measures that NSP2 has committed to use, will reduce this impact. By using seal scarers in a way comparable to what was done during construction of the Nord Stream Pipeline, the impact will be reduced to minor significance in all areas.

Grey seal

The grey seals in the Baltic are considered to belong to one population. The population is abundant, has been increasing in numbers and is not considered threathened. Since grey seals are considered to be equally present along the Finnish and Russian portion of the pipeline, the assessment is the same for all modelled locations.

The only activity assessed to have other than minor impacts on grey seals is munition clearance in both Finnish and Russian waters. The impacts are assesed at both population and individual level. Due to the high number of grey seals in all areas affected by munition clearance, it is highly likely that, without any mitigation measures in place, some inviduals will be present and thus suffer death, blast injuries or permanent hearing damage. Therefore, in this case, munition clearance at the individual level is assessed to be of major significance. However, since the population is increasing in numbers, the likely number of affected individuals will not have severe impacts on the population status and thus the significance on population level is assessed to be moderate.

The use of mitigation measures is assessed to reduce the significance of the impacts from blast injury to moderate at the individual level and to minor at the population level. However, mitigation measures are not likely to change the significance of hearing loss impacts (PTS and TTS) because of the large distances up to which those are assessed to occur. Impacts to grey seals due to PTS are assessed to be moderate at individual and minor at population level, while impacts due to TTS are assessed to be minor at both population and individual levels. Additional reduction of impact may possibly be achieved by use of additional mitigation measures, but estimation of the level of reduction would require additional assessment.

The impacted area of munition clearance is transboundary and the impacts from explosions in Finnish waters will also apply to grey seals in northern Estonian and western Russian waters, while the impacts of munition clearance in Russian waters will apply to eastern Finnish and Estonian waters. However, when implementing the NSP mitigations measures, impacts at the population level are not assessed to be higher than minor and the transboundary impacts to grey seals on population level are thus also not expected to be larger than minor. For the individual seals, however, the impact of munition clearance are moderate and the significance of the transboundary impacts on the individual level is thus moderate.

Ringed seal

Ringed seals in the Baltic have suffered dramatic declines during the 20th century and are fragmented into four breeding areas; the Bothnian Bay, the Archipelago Sea, the Gulf of Riga and the Gulf of Finland. Seals from the latter three areas are relevant to this assessment, and these are also the areas where there has not been consistent recovery of the ringed seals after pressures from hunting and contaminants have been alleviated. The Gulf of Finland ringed seals are of particular concern, as the planned pipeline route intersects their range. These seals are severely threatened and there may be as few as 100 remaining.

The only activity assessed to have other than minor impacts on ringed seals is munition clearance in both Finnish and Russian waters. The impacts are assesed on both population level and individual level. Considering the moderate density of ringed seals in the areas affected by munition clearance, it is possible that some inviduals will be present and thus suffer death, blast injuries or permanent hearing damage. Therefore munition clearance at the individual level is assessed as of major significance if no mitigation measures are considered. Since the ringed seals in all the affected breeding areas are stagnating or declining in numbers and the particularly threatened Gulf of Finland ringed seals are located where the pipeline will pass through, even small numbers of affected individuals may have impact on the population status. Thus the significance on population level is assessed to be major in the Gulf of Finland and moderate in the Gulf of Riga and Archipelago Sea.

For ringed seals, mitigation measures will reduce this impact. More specifically, the use of seal scarers in a way comparable to what was done during construction of the Nord Stream Pipeline, can reduce the assessed impact to moderate, for ringed seals in the Gulf of Finland, and minor for ringed seals in the Gulf of Riga and Archipelago sea. Additional reduction of impact may possibly be achieved by use of additional mitigation measures, but estimation of the level of reduction would require additional assessment.

Several additional mitigation measures are available, which alone or combined could reduce the expected impact. The impact from these underwater explosions can be reduced to low levels, if alternatives to on-site detonation are used (local re-routing, removal, mechanical disintegration or other) and possibly also by shielding the explosion with air bubble curtains or otherwise.

The impacted area from munition clearance is transboundary and the impacts of explosions in Finnish waters will also apply to ringed seals in northern Estonian and western Russian waters, while the impacts of munition clearance in Russian waters will apply to eastern Finnish and Estonian waters.

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