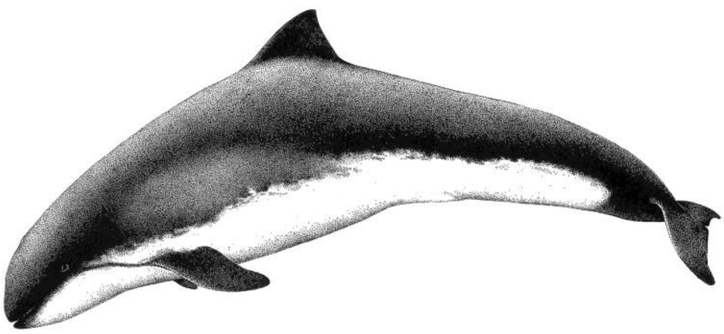
Monitoring of marine mammals in the area of offshore wind farm "Bałtyk Środkowy III"

Impact assessment for the variant chosen for realisation and rational alternative variant

Version 4



Bałtyk Środkowy III Sp.z o.o.

The expert in WATER ENVIRONMENTS

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Monitoring of marine mammals in the area of offshore wind farm “Bałtyk Środkowy III”

Final report with impact assessment for the variant chosen for realisation and rational alternative variant

Version 4

Prepared for Bałtyk Środkowy III Sp. z o.o.

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Abbreviations

CI	Confidence Interval
dB	Decibel
deg	Degrees
EMF	Electromagnetic field
GBF	Gravity based foundation
Hz	Hertz
ht	Hearing threshold
kHz	Kilohertz
km	Kilometre
Leq	Equivalent sound pressure level
Lpeak	Peak sound pressure level
m	Metre
MP	Monopile (part of a monopile foundation)
MW	Megawatt
MV	Millivolt
ms	Milliseconds
m/s	Metre per second
OWF	Offshore wind farm
PSZW	“Pozwolenie na wznoszenie i wykorzystanie sztucznych wysp, konstrukcji i urządzeń w polskich obszarach morskich”
PTS	Permanent threshold shift

rms	Root-mean-square
s	Seconds
SEL	Sound exposure level
SL	Source level
SPL	Sound pressure level
TL	Transmission loss
TP	Transition piece (part of a monopile foundation)
TTS	Temporary threshold shift
V	Volt
µPa	Micropascal

Glossary

Absorption.	Conversion of sound into heat.
Ambient noise.	Background noise in the environment without distinguishable sources.
Attenuation.	Decrease of sound pressure levels / acoustic energy.
Audiogram.	Graph showing the absolute auditory threshold versus frequency.
Auditory brainstem response.	A method of measuring hearing by placing electrodes on the head to record the electrical activity in the brain when sound occurs.
Auditory threshold (Hearing threshold)	Minimum sound level that can be perceived by an animal in the absence of background noise.
Bandwidth.	Range of frequencies of a given sound.
Critical band.	Frequency band within which ambient- / background noise has strong effects on detection of a sound at a particular frequency.
Cylindrical spreading.	Sound spreading for cylindrical waves. Given by 10 log (r), with r being range.
Decibel (dB).	The logarithmic measure of sound intensity / pressure. The decibel value for sound pressure is 20 log10 (P / P0) with P = actual pressure and P0 = reference pressure.
Duty cycle.	Percent of a time a given event occurs. A 1 s long tone with silent intervals of 1 s has a duty cycle of 50 %.
Hertz. (kHz)	The unit for frequency where 1 Hz = 1 cycle per second. One Kilohertz are 1,000 cycles per second.
Impulsive sound.	Transient signals emitted in brief sequences (pulses) with short duration and often high peak sound pressure levels.
Masking. cies. Micro Pascal (µPa).	Obscuring of sounds of interest by interfering sounds at similar frequen- Reference pressure for underwater sound. 1 µPa = 10-5 µbar.
Octave band. One-third-octave-band.	Interval between two discrete frequencies having a frequency ratio of two. Interval of 1/3 of an octave. Three adjacent 1/3 octave bands span one octave.

Pascal.	Unit of pressure equal to one Newton per square metre.
Permanent threshold shift.	A permanent elevation of the hearing threshold due to physical damage to the sensory hair cells of the ear.
Propagation loss (Transmission loss).	Loss of sound power with increasing distance.
Pulse.	A transient sound having a finite duration.
Rise time.	Time needed to go from zero to maximum sound pressure.
Source level.	Acoustic pressure at a standard reference distance of 1 m. Unit in dB re 1 µPa at 1 m (sometimes given as: @ 1m).
Sound pressure level.	Expression of the sound pressure in decibel (dB)
Spherical spreading.	Sound spreading for spherical waves. Given by 20 log (r), with r being range.
Temporary threshold shift (TTS).	Temporal and reversible elevation of the auditory threshold.
Waveform.	Graph showing the oscillations of a sound wave (in Pa or mV/V over time).
White noise.	Noise for which the spectrum density is independent of frequency over a specified range.
Ultrasonic.	Sound with frequencies too high to be audible to humans (~ > 20 kHz).

1 Non-technical summary

1 Polenergia plans to build the offshore wind farm "Bałtyk Środkowy III" in the Polish Exclusive Economic Zone of the Baltic Sea. In this document we assess the impact of the planned project on marine mammals (harbour porpoises, harbour seals and grey seals) for the variant chosen for realisation and rational alternative variant.

2 There is a variety of existing activities that affect marine mammals in the BŚ III area and surrounding seas: These existing pressures are by-catch of mammals in fishery, contaminants, eutrophication, shipping (collisions), tourism and recreation and underwater noise. Underwater noise levels will increase in Polish waters over the next decades due to the increase in shipping, and the other pressures would act as well on marine mammal populations. Under the assumption that wind energy will be developed in the Polish marine area but the BŚ III project will not be implemented, the construction noise levels of other wind farms would add significantly but temporarily to the existing noise levels. If we assume that wind energy will not be developed in the Polish Marine Area, but mining industry is developed, these activities will to some extent add locally to the overall increasing shipping noise. It is likely that despite the pressures, the grey seal population will continue to increase while no statements can be made on harbour seals (they are sporadic travellers through the area). For harbour porpoises no solid population trends are available.

3 There is a variety of activities that relate to offshore wind farms that can affect sea mammals: Construction-related impacts can be caused by the hammering of turbine foundation piles into the sea bottom (=impact pile driving), by dredging for site preparation, construction shipping, suspension of sediments, release of pollutants and changes in the sea area that is used by the mammals for their life functions (=habitat). Impacts during operation can be caused by noise from turbines and service and maintenance traffic, electromagnetic fields that are emitted from the electric cables to land, reef effects due to increase of hard material around the piles and visual effects. Dismantling activities will mainly involve drilling and shipping similar to the situation during construction, although, most likely, pile driving will not be used. Although all of these impacts can lead to effects on marine mammals, the effects of noise during the construction of the wind farm are by far potentially the most severe ones due to the very high noise levels on the one hand and the relatively high sensitivity of marine life to underwater sound on the other.

4 Harbour porpoises are protected in Polish waters under various mechanisms, for example the EU Habitats Directive. The exact amount of porpoises inhabiting the Polish waters is unknown but it is probably an area of low to very low density. Porpoises are very sensitive to underwater sound and are potentially vulnerable to the high noise levels that go along with the construction of the planned wind farm. Their sensitivity to the operating wind farm is lower compared to the situation during construction. Amongst others grey seals are protected under the EU Habitats Directive Appendix II. Studies indicate that grey seal numbers are relatively low in Polish waters but that counts have been increasing over the last years. Grey seals are sensitive to underwater sound although the range of frequencies which they can hear is smaller compared to harbour porpoises. Their sensitivity to offshore wind farm construction is probably high as well. Harbour seals enjoy the same protection status in Polish wasters as the grey seals. Their status in Polish waters is not clear but numbers at the BŚ III site are very low. Their sensitivity to sound and wind farm construction is identical to that of grey seals. Both species are probably not very sensitive to wind farms in operation.

5 We found that for the variant chosen for realisation (10 m diameter monopile) and for the rational alternative variant (7.5 m diameter monopile), the unmitigated sound generated by impact pile driving will be the same and will have a large effective range (= range over existing background noise) of between > 10 and at least 150 km, depending on the distance to land and the sea bottom profile. Thus, pile driving will add significantly to the existing noise, although the activity will be temporary. Impacts of construction noise will be moderate for single sound emissions (=single strikes) for both harbour porpoise and seals, but for multiple strikes from one pile (= cumulative strikes) the impacts are likely to be high for porpoises and moderate for seals (due to their sporadic appearance in the BŚ III area). The operational phase will have low impact although marine mammals will be able to detect operational sound at a distance of several km. Seals are not expected to react to the operation noise, but a small proportion of harbour porpoises that are exposed to operational sound could react at several km distance under very low background noise conditions. However, it is extremely unlikely that this reaction will go on for any long time. There is a potential for positive effects due to the creation of artificial reefs and the accompanied increase in fish which in turn will increase the food base for marine mammals. The dismantling of the wind farm will have low significance for marine mammals. Cumulative impacts are possible during the construction activity both resulting from more than one pile driving activity at any given time and the simultaneous construction of another wind farm. In this case the impacted area will increase to a maximum of twice the one calculated for the single activity. The exact impact ranges are difficult to define due to the complexities of the interactions of the acoustic fields emitted from the two parallel activities.

Impacts on Natura 2000 sites are possible with regard to Ostoja Słowińska (PLH220023). Here, likely effects are behavioural disturbance and temporary loss of hearing in both grey seals and harbour porpoises. However, since the area is close to the coast, sound will be attenuated and effects will not occur with the same intensity in the whole area. After application of a noise mitigation measure in the form of a bubble curtain, PTS, TTS and behavioural impacts will be insignificant for porpoises and seals both during piling at BSIII site and during simultaneous piling at BŚ III and BŚ III and Baltica 3 site.

The described impacts can be mitigated effectively suing sound reduction measures, such as cofferdams (an air-filled steel pipe around the pile driver) and bubble curtains (= a curtain of air bubbles around the pile driver).

6 There is a variety of other impacts that should be considered in combination. Marine mammals produce a wide variety of sounds and can thus affect the acoustic environment. However, since the baseline studies at BŚ III clearly indicate that all three species (harbour porpoise, grey seal and harbour seal) appear only in very low numbers in the planning area, their contribution to background noise at BŚ III will be minimal, and any changes in their distribution due to the construction or operation of the planned farm will not affect background noise levels. The same can be said for their effect on fish and tourism. There is a variety of other components affecting marine mammals. Non-biological components such as current flows and sediments will undergo changes due to the construction and operation of the wind farms, but knock-on effects on marine mammals will most likely be insignificant. Many other receptors - comprising a variety of human activities such as fishing and shipping - will be reduced and this will most likely have positive effects on marine mammals.

7 It is clear from the assessment that behavioural disturbance range due to multiple strikes in harbour porpoise and TTS range for seals could lead to transboundary effects. Yet, it has to be pointed out that using the suggested mitigation measures will result in a sufficient alleviation of the impact so that transboundary issues can be ruled out. Effects of construction noise, although relatively far ranging with regard to behavioural avoidance – will not lead to any barrier effects on subpopulations.

8 The predictions made here should be tested using a monitoring programme. The monitoring should investigate the impacts of the construction noise on harbour porpoises. Post-construction monitoring shall be undertaken to verify the return of the usage of the area by porpoises to baseline levels. The monitoring should be undertaken using automated porpoise click detectors (CPODs).

2 Introduction

Here we present the assessment of the impacts of the planned wind farm Bałtyk Środkowy III on marine mammals. Three species of marine mammals can occur in the Bałtyk Środkowy III area: the harbour porpoise (*Phocoena phocoena*), the harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*). There is also the rare possibility to encounter ringed seals (*Phoca hispida*), but due to the scarceness of the species in the area around the planned project, the assessment will concentrate on the three species mentioned above.

The assessment is necessary since the construction, operation and ultimate dismantling of an offshore wind farm are associated with a number of different activities, such as pile-driving, seabed preparation, sediment removal, cable laying and maintenance which could affect marine mammals. The impacts can be direct through disturbances, or indirect through impacts on prey species availability. For constructing the OWF Bałtyk Środkowy III - near Słupsk Bank, four foundation options are being considered: monopiles, tripod, jacket foundations, and gravity base foundations. The impact assessment will be based on the variant chosen for realisation and rational alternative variant which has the same sound footprint.

This report builds on four other investigations. First, baseline data on abundance and distribution of the three species in the project area and adjacent waters has been investigated through an extensive and tailor-made marine mammal monitoring programme as part of a complex programme of pre-investment studies of the local marine environment. The results of this 13-month baseline assessment are being referred to at various places in the report. Secondly, we have undertaken a background noise monitoring campaign in parallel to the biological investigations that aimed to describe the zero-state with regards to background noise at BŚ III. Then, the changes to this zero-state due to the construction of the wind farm have been investigated using numerical modelling and they are presented in a separate background report (acoustic modelling).

The collected results of the previous investigations are used here to assess the potential impact of the construction, operation and dismantling of the Bałtyk Środkowy III offshore wind farm on harbour porpoises, harbour seals and grey seals.

3 Description of the planned project

Polenergia plans to build the offshore wind farm "Bałtyk Środkowy III" in the Polish Exclusive Economic Zone of the Baltic Sea. DHI was involved as a consulting company during the EIA process and assigned to conduct environmental research on marine mammals, background noise and migrating birds, as well as to revise and consult research of other components and include the results in the dedicated model.

The project "Bałtyk Środkowy III" is situated outside the borders of Polish territorial waters, approximately 23 km from the shore (Figure 1).

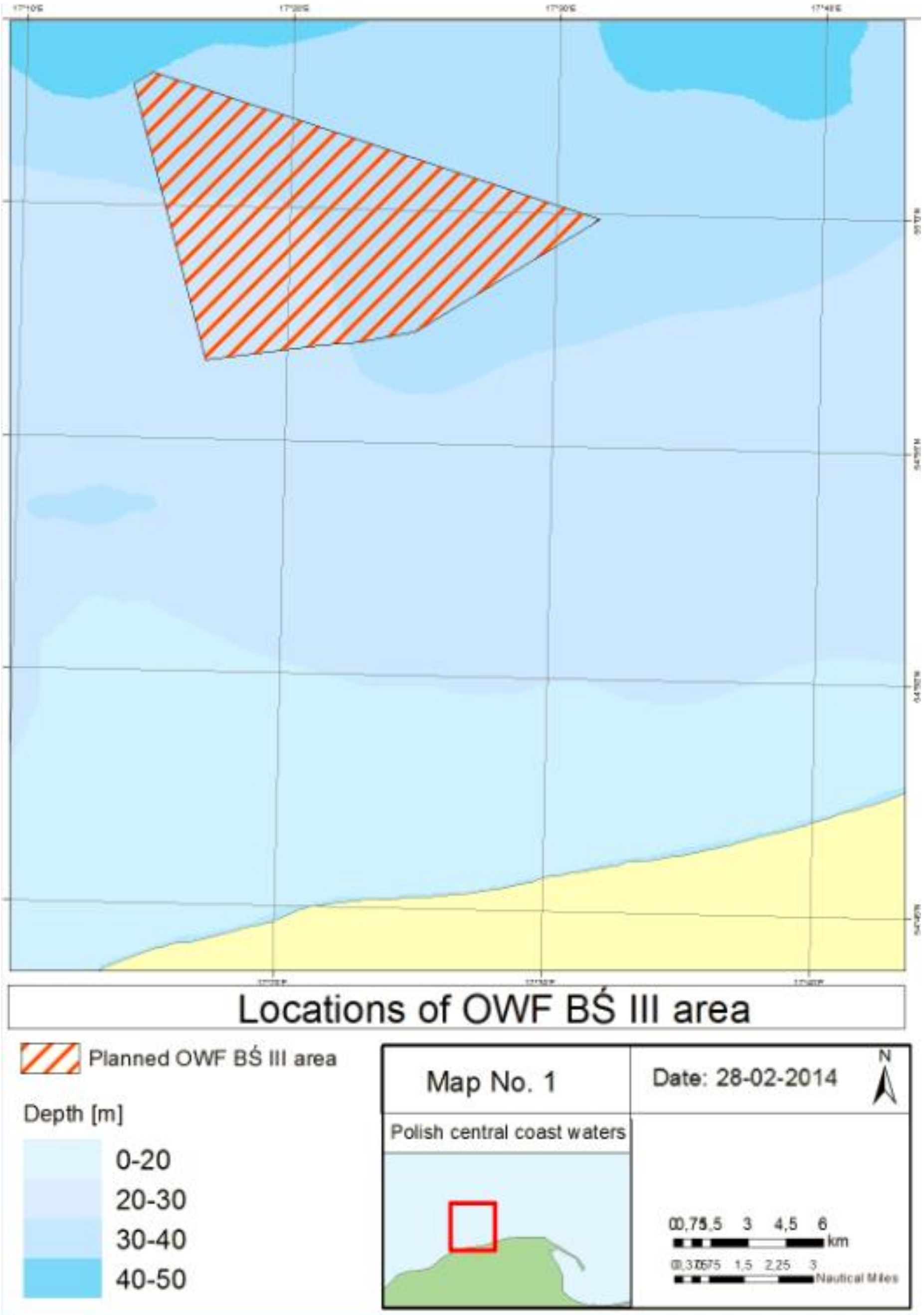

Figure 1 Location of the planned OWF "Bałtyk Środkowy III" area.

The total area of the farm is approximately 119.52 km^2 according to PSZW (license for construction and use of the artificial islands, installations and devices in the Polish maritime areas, obtained on 30 March 2012).

This area, as defined in PSZW, is reduced by the 500 m buffer from the inner boundary of the project implementation area excluded from the location of any structural elements of the farm. The size of the buffer 1 (500 m) is approximately 23 km^2. The size of buffer 2 (determined by the size of the rotor) is approximately 28 km^2.

Therefore, the maritime area available for implementation of the project is the area defined by PSZW, reduced by the area of the buffers and comprises 89 km^2.

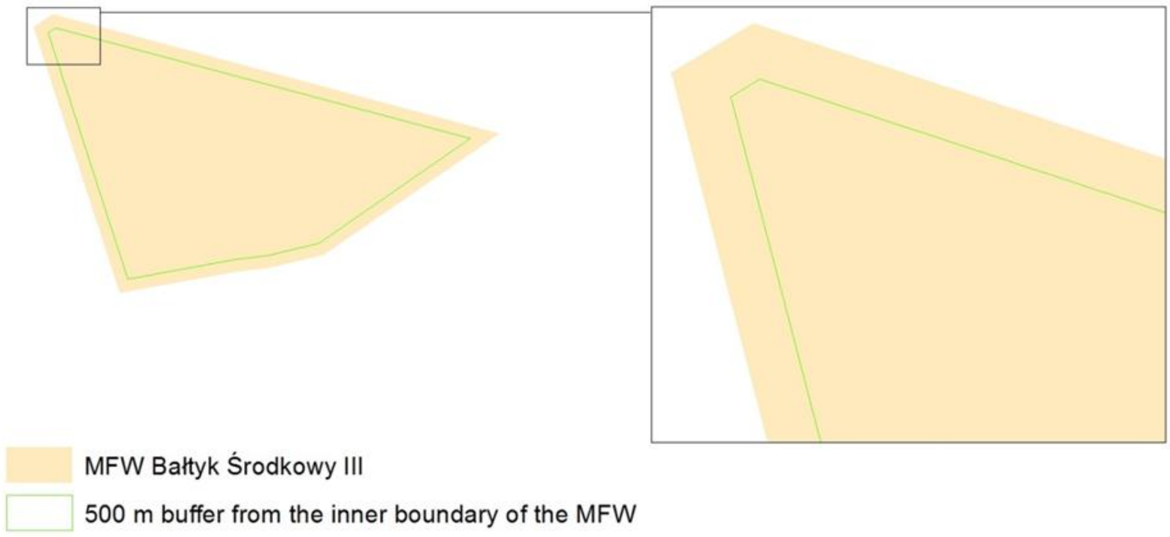

Figure 2 Boundaries of OWF BŚ III area and lines of buffers (MWF Bałtyk Środkowy III Sp. z o.o.).

3.1 Analysed variants of the project

3.1.1 Rational alternative variant

The rational alternative variant was prepared by the investor and combines maximum effectiveness of energy production with respect to formal and technical conditions of the project implementation. In this variant the whole OWF area is used for development taking into account limitations resulting from:

- The license for construction and use of the artificial islands, installations and devices in maritime areas for the OWF project Bałtyk Środkowy III (PSZW),
- “Conditions of connecting the OWF Bałtyk Środkowy III to the transmission network”,

Boundary conditions for technical parameters of the wind farm resulting from PSZW and “Conditions of connection…” enable a maximum connection of 1 200 MW and a maximum number of power plants (PSZW) - 200. Maximum technical parameters of the project in this variant are presented in Table 1.

Table 1 Basic technical parameters of OWF BŚ III (rational alternative variant).

Parameter	Maximum value
Total height of the power plant above the sea surface	212.5 m
Minimum distance from the lowest position of the blade and sea surface	20 m
The diameter of the rotor	192.5 m
Maximum quantity of power plants	200
Maximum zone of a single rotor	29 104 m^2
Maximum total rotor zone	5 820 800 m^2
Maximum quantity of foundations of associ-ated infrastructure	8
Maximum area of sea bottom occupied by 1 foundation (GBS, diameter 40 m)	1 257 m^2
Maximum area of sea bottom occupied by foundations (208)	261 456 km^2
Maximum density of power plants (89 km^2 for development)	2.25 power plant/km^2
Maximum length of cables of the wind farm inner connection infrastructure	200 km

Source: MFW Bałtyk Środkowy III Sp. z o.o. „Morska farma wiatrowa Bałtyk Środkowy III – opis metodyki wariantowania", Investor's data.

3.1.2 Variant chosen for implementation

The variant chosen for implementation is at the same time the favourable variant for nature, fulfilling the investment objective, and thereby the energy production effectiveness. This variant results from applying boundary environmental conditions on technologies used in the rational alternative variant. Those limitations enable the development of 120 power plants of a maximum unit power of 10 MW and a maximum rotor diameter of 200 m. The power plant would be located within the area of 89 km^2. The maximum technical parameters of the project in this variant are presented in Table 2.

Table 2 Basic technical parameters of OWF BŚ III (variant chosen for realisation).

Parameter	Maximum value
Total height of the power plant above the sea surface	275 m
Minimum distance from the lowest position of the blade and sea surface	20 m
Maximum distance from the lowest position of the blade and the sea surface	75 m
The diameter of the rotor	200 m

Parameter	Maximum value
Maximum quantity of power plants	120
Maximum zone of a single rotor	31 400 m^2
Maximum total rotors zone	3 768 000 m^2
Maximum quantity of foundations of associated infrastructure	6
Maximum area of sea bottom occupied by 1 foundation (GBS, diameter 40 m)	1 257 m^2
Maximum area of sea bottom occupied by foundations (126)	158 382 km^2
Maximum density of power plants (89 km^2 for development)	1.35 power plant/km^2
Maximum length of cables of the wind farm inner connection infrastructure	200 km

Source: MFW Bałtyk Środkowy III Sp. z o.o. „Morska farma wiatrowa Bałtyk Środkowy III – opis metodyki wariantowania", Investor's data

3.1.3 Comparison of variants

In the variant chosen for implementation, the number of power plants has been reduced by 40%. Together with this change, the area of sea bottom occupied by foundations decreased by 39%. At the same time the impact on sediment spill, benthos destruction, birds and bat mortality caused by collisions and noise generated during the construction phase decreases which means that the variant chosen for implementation is more favourable for the environment.

Table 3 Comparison of technical parameters of both variants.

Parameter	Variant chosen for realisation	Rational alternative variant
Total height of the power plant above the sea surface	275 m	212.5 m
Minimum distance from the lower position of the blade and sea surface	20 m	20 m
The diameter of the rotor	200 m	192.5 m
Maximum quantity of power plants	120	200
Maximum zone of a single rotor	31 400 m^2	29 104 m^2
Maximum total rotor zone	3 768 000 m^2	5 820 800 m^2
Maximum quantity of foundations of associated infrastructure	6	8
Maximum area of sea bottom occupied by 1 foundation (GBS, diameter 40 m)	1 257 m^2	1 257 m^2
Maximum area of sea bottom occupied by foundations (126/208)	150 382 m^2	261 456 m^2

Parameter	Variant chosen for realisation	Rational alternative variant
Maximum density of power plants (89 km^2 for development)	1.35 pc./km^2	2.25 pc./km^2
Maximum length of cables of the wind farm inner connection infra-structure	200 km	200 km

3.2 Parameters used in the impact assessment

Here we will list the main technical parameters of the project with relevance to the noise impact assessment for the variant chosen for realisation (Table 4) and rational alternative variant (Table 5). The information is directly derived from the High Level Technical Design Study (Haskoning 2014) and associated data supplied in the form of excel files (=matrix of environmental impact RH 2014). For the acoustic assessment, only a limited amount of parameters needs to be known, which relate mainly to the type of turbine (monopile, tripod, jacket), its size and diameter (here with the lower end at 3 MW and 5 m and the higher end at 10 MW and 10 m). In addition, the piling time, number of strikes and number of turbines are listed here.

Table 4 Input parameters for the impact assessment for the variant chosen for realisation (see also Haskoning 2014; n.i. = no information).

	Monopile 3 MW	Monopile 10 MW	Tripod 3 MW	Tripod 10 MW	Jacket 3 MW	Jacket 10 MW
Pile diameter (m)	5	10	1.5	2.5	1	1.8
Number of strikes per pile	8400	8400	8400	8400	8400	8400
Number of strikes per hour	2800	2800	2800	2800	2800	2800
Number of strikes per foundation	8400	8400	25200	25200	50400	50400
Piling time (h)	3	5	Indicative active piling time per foundation (excluding soft start): 18 hr	Indicative active piling time per foundation (excluding soft start): 18 hr	Indicative active piling time per foundation (excluding soft start): 18 hr	Indicative active piling time per foundation (excluding soft start): 18 hr (for piles with 3.5 m diameter, maximum 6 piles per foundation)
Hammer Energy (kJ)	2300	3000	1900	2300	1900	2300
Number of turbines	120	120	120	120	120	120

Table 5 Input parameters for the impact assessment for the rational alternative variant (see also Haskoning 2014; n.i. = no information).

	Monopile 3 MW	Monopile 8 MW	Tripod 3 MW	Tripod 8 MW	Jacket 3 MW	Jacket 8 MW
Pile diameter (m)	5	7.5	1.5	2.5	1	1.5
Number of strikes per pile	8400	8400	8400	8400	8400	8400
Number of strikes per hour	2800	2800	2800	2800	2800	2800
Number of strikes per foundation	8400	8400	25200	25200	50400	50400

	Monopile 3 MW	Monopile 8 MW	Tripod 3 MW	Tripod 8 MW	Jacket 3 MW	Jacket 8 MW
Piling time (h)	3	3	Indicative active piling time per foun-dation (exclud-ing soft start): 18 hr	Indicative active piling time per foun-dation (exclud-ing soft start): 18 hr	Indicative active piling time per foun-dation (exclud-ing soft start): 18 hr	Indicative active piling time per foundation (excluding soft start): 18 hr (for piles with 3.5 m diameter, maxi-mum 6 piles per foundation)
Hammer Energy (kJ)	2300	3000	1900	2300	1900	2300
Number of tur-bines	200	200	200	200	200	200

4 Existing anthropogenic pressures

4.1 By-catch

Large numbers of by-catches in the Baltic are thought to be the primary threat to harbour porpoises in this region (Koschinski 2002). Recommendations from the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) state that populations should be restored to 80% of their carrying capacity and kept there for the population to remain viable. The carrying capacity could be achieved if the by-catch rate does not exceed two individuals per year. But the by-catch rates in the Baltic supersede this number – on average seven individuals are by-caught per year. (Berggren *et al.* 2002; ASCOBANS 2002). Even if the individuals are saved from the fishing gear and released alive, they may suffer long term effects on growth and reproduction, which could potentially affect the population by further reducing population recovery rates (Wilson *et al.* 2014). Skóra & Kuklik 2003 investigated by-catch of harbour porpoises in Polish waters and found that 40% of the by-caught animals were caught in salmon semi-drift nets, and further 33.3% died in bottom set gillnets used for cod.

Both harbour seals and grey seals actively seek out fishing gear to forage. This behaviour leads to accidental by-catch. By-catch of harbour seals along the Swedish west-coast has been documented for the period 2001-2006 through voluntary log-books, and an estimated total of 150 animals were caught in gillnets, fyke nets and static fishing gear, with gillnets being the predominant cause of by-catch (Lundström K. *et al.* 2010). By-catch of harbour seals has also been documented in trawling fisheries off the west coast of Sweden (Lunneryd 2001). Grey seal by-catch in the Baltic has been documented along the Swedish east-coast. In 2001 the estimated number of grey seals by-caught in the central Baltic was 305 individuals, with turbot nets accounting for 128 individuals, cod nets for 98 individuals, salmon drift-nets for 27 individuals, and 46 individuals were caught in eel traps (Lunneryd 2001). In Poland, seal by-catch events are reported by the fishermen to the Hel Marine Station on a volunteer basis. In the years 1980-2010, 75 events of seals by-catch were recorded, within which most concerned gill nets (programme of the green seal protection – project). Moreover, some of the observations of dead seals made by WWF Polska in the years 2010 – 2012 on the Polish shore indicated that the animals were by-caught. It concerned 17 individuals, however, in each case the cause of death could not be determined with certainty (Polska 2013).

All studies of harbour porpoise by-catch in the Baltic clearly show levels above the criteria required to maintain a viable population. By-catch is therefore a significant threat to porpoises in the Baltic (ASCOBANS 2009). For seals the rates of by-catch are not nearly as extensive and the threat to the population from by-catch is not considered a cause of concern (Westerberg *et al.* 2008).

4.2 Contaminants

Marine pollutants such as organochlorine compounds, and trace metals have been linked to a number of deleterious conditions in marine mammals, such as depression of the immune response, thereby increasing the risk of infectious diseases (Beineke A. *et al.* 2005; Das *et al.* 2008). They have also been linked to reproductive impairment, bone lesions, incorrect thyroid hormone production, limited vitamin A uptake, and increased vitamin E uptake as a response to the oxidative stress associated with high contamination loads (Jenssen 1996; Routti *et al.* 2005). The levels of contaminants in marine mammals in the Baltic Sea are generally significantly higher than the loads found in marine mammals from the Kattegat-Skagerrak Seas, the west coast of Norway and in Icelandic and Greenlandic waters (Berggrena *et al.* 1999; Routti *et al.* 2005; Huber *et al.* 2012). DDT levels in Baltic marine mammals have been measured to be between 5-12 mg/kg and PCB concentrations more than 20 mg/kg (Aguilar *et al.* 2002). Siebert *et al.* 1999 found higher levels of mercury in harbour porpoises in the Baltic Sea (max 449 µg/gdw, mean 39 µg/gdw) compared to the Greenland waters (max 67 µg/gdw, mean 20 µg/gdw). (Ciesielski *et al.* 2006) studied concentrations of trace metals

(Al, B, Ba, Cd, Co, Cr, Cu, Fe, Ga, Hg, Li, Mn, Mo, Ni, Pb, Se, Si, Sr, Tl, V, Zn, Ca, K, Mg, Na and P) in the livers of marine mammals obtained from by-catches or stranded animals on beaches on the Polish Baltic coast . The concentration levels of metals were relatively high, however, depending on the element, on a similar or a lower level than in other areas (comparing to e.g. Greenland, Danish, German and North Sea waters).

Overall contaminant levels in previously highly contaminated areas such as the Baltic have been decreasing in recent years (Aguilar *et al.* 2002). This trend has also been measured in both grey seals and harbour porpoises in the Baltic, where especially the levels of DDT found have been decreasing (Nyman *et al.* 2002; Huber *et al.* 2012). However, the levels of some contaminants in the Baltic Sea remain unchanged or may even be increasing (Nyman *et al.* 2002; Huber *et al.* 2012). Marine pollution by contaminants and trace metals does therefore still constitute a significant pressure with management implications for harbour porpoises, harbour seals and grey seals in the area, as the high concentration of contaminants affects population growth (Aguilar *et al.* 2002).

4.3 Eutrophication

Eutrophication is one of the biggest threats to the Baltic Sea ecosystem (HELCOM 2009). Eutrophication of the Baltic can lead to an increase in biomass production which may result in oxygen depletion in some areas. It also has the potential to change the structure of fish communities as species that were previously of low importance and abundance could replace species of higher value to marine predators (HELCOM 2006). Harbour porpoises, harbour seals, and grey seals are known to predate on herring, cod, whitefish, sprat and gobies (Härkönen & Heide-Jørgensen 1991; Lundström K. *et al.* 2007; Sveegaard *et al.* 2012). Changes to the fish communities that are unfavourable for these fish species could therefore impact the marine mammals preying on them. Harbour porpoises, harbour seals and grey seals are, however, all relatively opportunistic feeders (Härkönen & Heide-Jørgensen 1991; Hall & Thompson 2009; Sveegaard *et al.* 2012), and the effects on fish populations will most likely not constitute the most severe pressure for marine mammals.

4.4 Shipping

The high levels of ship traffic in the Baltic (AIS data from Søfartsstyrelsen 2013, Denmark) can potentially cause an increase in the risk of ship strikes for seals and porpoises. Though ship strikes are commonly associated with large baleen whales, there is data to suggest that this may also be a significant source of mortality in small cetaceans in areas with a high density of ship traffic (Van Waerebeek *et al.* 2007). If fast vessels are operating in the area, such as high speed ferries, this further increases the animals' risk of being struck by a vessel (Carrillo & Ritter 2010). Ship strikes in seals are not well documented. However, although there is a risk of ship strikes, it is not considered a major issue, as porpoises and seals will most likely have sufficient time to move out of the way given that traffic is commenced at speeds of commercial ships in shipping lanes (see Evans *et al.* 2011). The most relevant issue for marine mammals in connection with shipping is the generated noise. This will be described in more detail below.

4.5 Tourism and recreation

There may be some disturbance to marine mammals due to tourism and recreation. For seals this is mainly through disturbance at haul-out sites, but activities such as the use of jet skis and small speed boats have the potential to cause the greatest disturbance. These small vessels move with high speed, and with no direct path that could be predictable for a marine mammal trying to avoid collision. This increases the risk of ship-strikes in an area greatly. They may also produce noise of higher frequencies that could be problematic for marine mammals (Richardson *et al.* 1995). There may be some local problems, and though this is not considered a threat in line with by-catch and contaminants, it is not an insignificant threat to marine mammal populations in the Baltic. Prochnow

& Kock 2000 investigated the impact of tourism on harbour porpoises off Sylt (German North Sea) and found that even high amounts of activities did not lead to any significant impacts.

4.6 Underwater noise

Figure 3 shows an overview of frequencies (x-axis) and sound levels (in decibel or dB; Y-axis) of anthropogenic and naturally occurring sound sources in the marine environment. This graphic is very generic (details can be found in Boyd *et al.* 2008 and OSPAR 2009) but provides a good starting point for understanding anthropogenic pressures due to sound. Typical human sources of noise are distant and undefined shipping, drilling, dredging, larger nearby ships as tankers, frigates, seismic airguns for geophysical exploration (= investigations of the seafloor with the use of sound). It can be seen that each of the sources has its own level of sound (normalised to 1 m distance) with seismic survey having relatively high sound levels at 1 m. It is also visible that in general anthropogenic sound has most energy at the lower frequencies (= below 1 kHz).

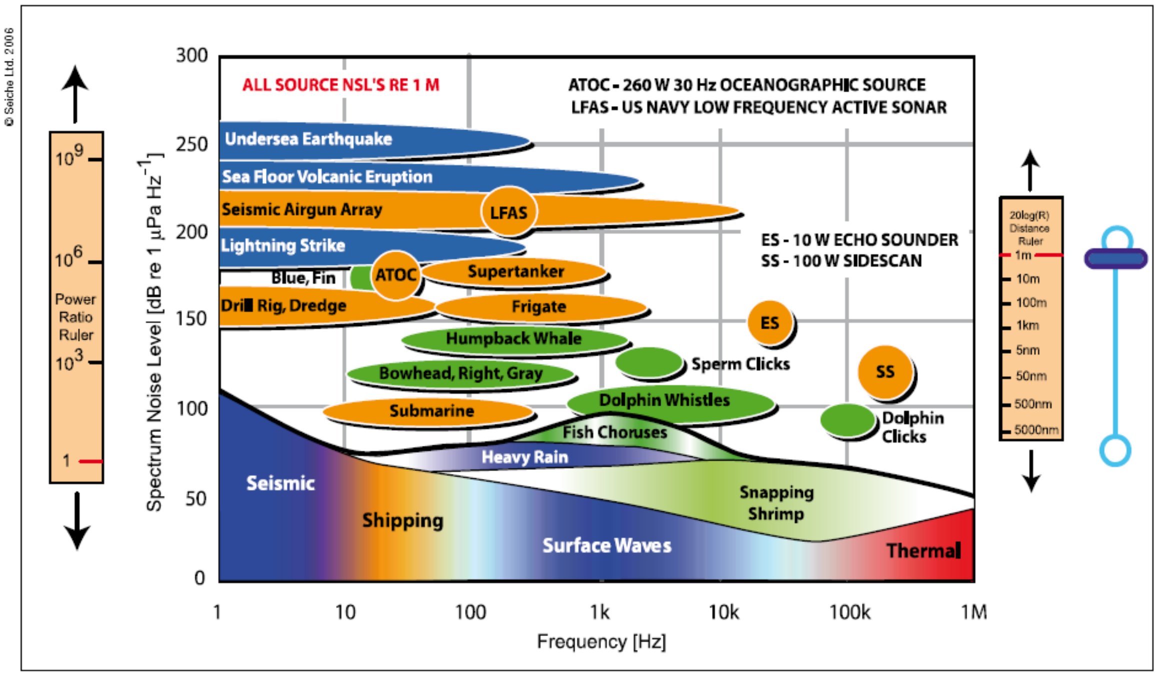

Figure 4. Noise levels and frequencies of anthropogenic and naturally occurring sound sources in the marine environment

Figure 3 Noise levels and frequencies of anthropogenic and naturally occurring sound sources in the marine environment (from Seiche Ltd and Boyd *et al.* 2008).

It is clear from the cumulative assessment (please refer to chapter 9.2) that potential noise sources at BŚ III are shipping (distant and low frequency, potentially drilling and dredging). Furthermore, there is the potential for seismic survey sounds, as geophysical explorations have been used for site specific investigations at BŚ III (Maritime Institute Gdansk, personal communication). Looking at the different activities, however, it can be deducted that shipping will be by far the most important contributor to underwater noise at the BŚ III site.

4.6.1 Shipping noise

The intensity and frequency of noise produced by ships depend largely on the size and speed of the vessel, with large slow-moving vessels producing lower frequency noise, and the small fast vessels producing noise with more energy at higher frequencies. OSPAR 2009 makes the following distinction:

- Small leisure crafts and boats < 50 m; Variable output: 160-175 dB re 1µPa at 1 m; <1kHz - > 10 kHz
- Medium sized ships 50 -100 m; 165 – 180 dB re 1µPa a 1 m; < 1 kHz
- Large vessels > 100 m; 180 - > 190 dB re 1µPa a 1 m; < 200 Hz

It can be concluded that the main energy of shipping noise is generally below 1 kHz (see also Richardson *et al.* 1995). However, it is also important to note that there is still also considerable energy at frequencies above 1 kHz. This could potentially pose a problem for harbour porpoises with more acute hearing at higher frequencies. Yet, sound production shall not be affected by shipping sound, as frequencies of used sounds and shipping sounds do not overlap much with sounds used by toothed whales in general and with harbour porpoises in particular (their emissions are at the right end of the scale in Figure 4). Seal hearing is relatively sensitive at these lower frequencies and their sound emissions overlap with shipping (see Figure 4).

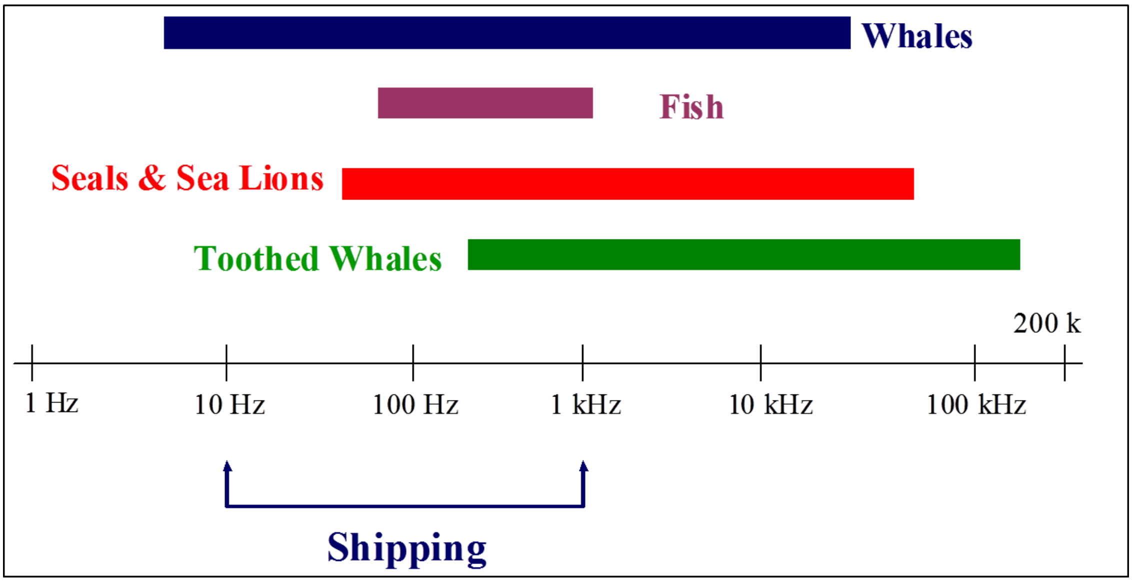

Figure 4   Typical frequency bands of sounds produced by marine mammals and fish compared with the nominal low-frequency sounds associated with commercial shipping (porpoises belong to toothed whales; from OSPAR 2009).

Ambient noise levels were recorded in the OFW area in the frequency range of 20 Hz to 20 kHz. This covers all of the frequencies identified as characteristic for shipping by OSPAR 2009. Noise at the different frequency levels can be seen in Figure 5.

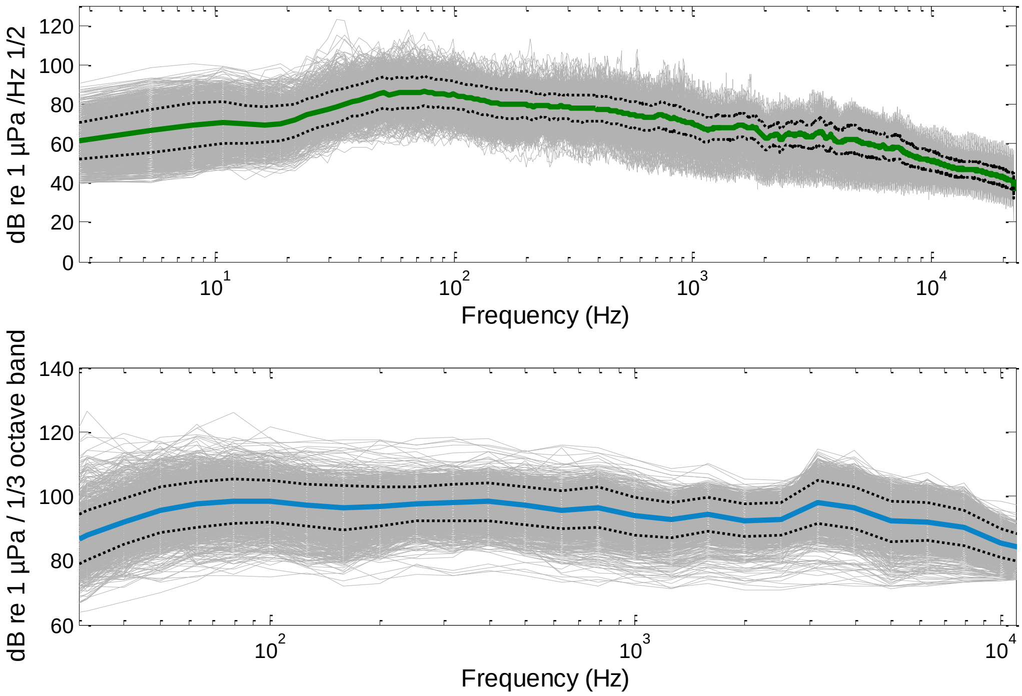

Figure 5 Top panel: Power spectral density in 1Hz bands of the sample subset covering all four seasons from December 1^{st} 2012 to November 30^{th} 2013 (n = 1401). Grey lines are the power spectral densities of individual samples. The green line is the mean power spectral density, and the dashed lines are one standard deviation from the mean. Bottom panel: Power spectral density in third octave bands of sample subset from the whole year. Grey lines are the power spectral densities of individual samples. The blue line is the mean power spectral density, and the dashed lines are one standard deviation from the mean.

The results of the study on ambient noise are detailed in part 1 (final report with research results). We also provide a detailed comparison to noise levels at other sites in the Baltic and North Sea which indicates that the recorded levels present a medium pressure due to noise from shipping.

For a better understanding of the acoustic environment of the harbour porpoises at BŚ III, the hearing sensitivity of the harbour porpoise (Kastelein *et al.* 2002) in relation to the ambient noise levels at BŚ III in spring (both presented in 1/3 octave bands and thus directly comparable); see Figure 6. The audiogram of the porpoise extends well into the ultrasonic range (above 20 kHz) with best sensitivities at around 100 kHz. It is thus possible that higher frequency sounds, such as those from echo sounders, affect porpoises at higher frequencies as well.

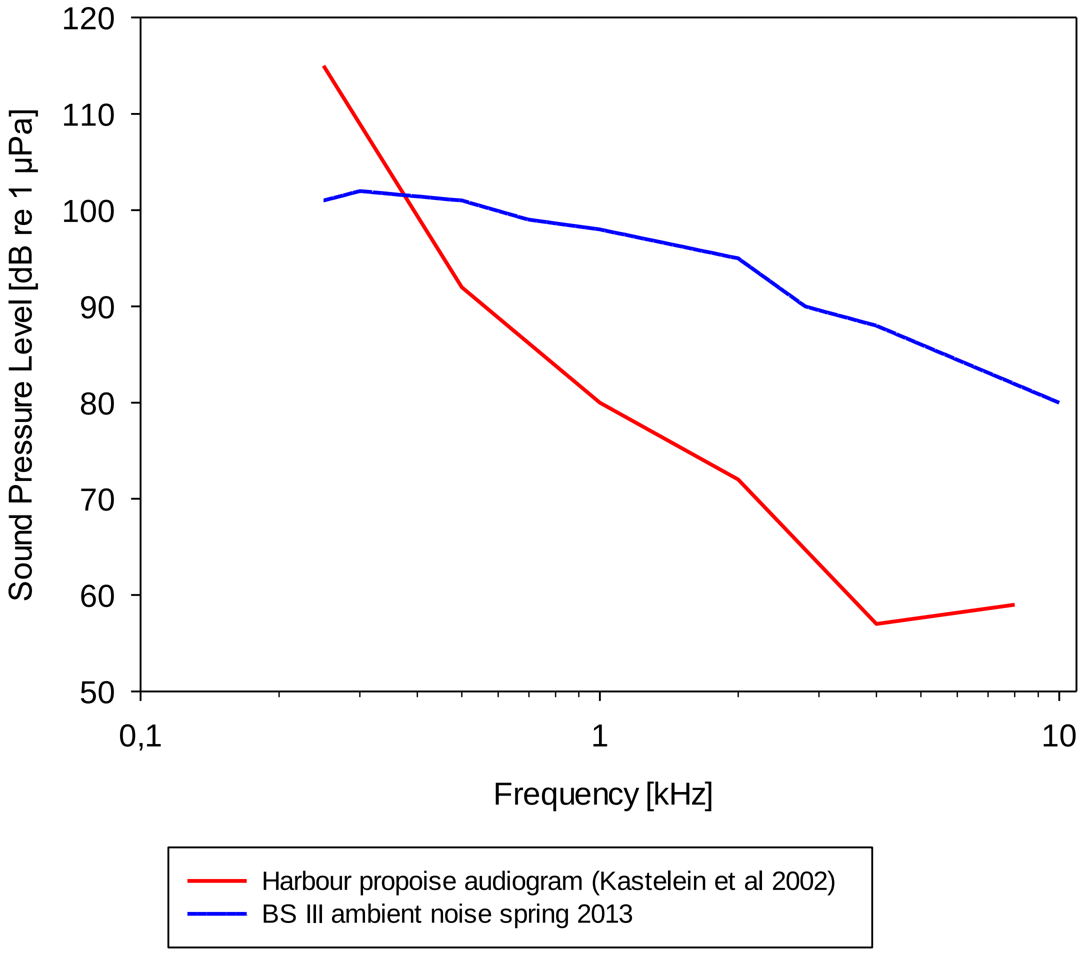

Figure 6 Ambient noise levels in 1/3 octave bands at BŚ III in spring 2013 in relation to the hearing sensitivity of the harbour porpoise in 1/3 octave bands.

It is evident from Figure 6 that ambient noise below app. 400 Hz is below the hearing sensitivity of harbour porpoises. As a consequence, low frequency ambient noise is not detectable by porpoises. At frequencies > 400 Hz the ambient noise level is decreasing only slightly and hearing is getting better. At around 4 kHz, the ambient noise levels are about 30 dB higher than the audiogram values. We can deduct from Figure 6 that porpoises at BŚ III live at a constant noise level where the potential impact increases with frequencies. However, looking at the overall levels, these are most likely not high enough to lead to any impact on hearing (Kastelein *et al.* 2012b). Therefore, ambient noise levels are high enough to be detected by porpoises but it is unlikely that they lead to any impact on hearing under normal circumstances.

The presence of ships in the Baltic could potentially result in displacement of porpoises. The ambient noise levels at BŚ III are, however, lower or comparable to some of the areas with the heaviest shipping activities in Danish waters, and in these areas a very high abundance of harbour porpoises is common (Sveegaard *et al.* 2011). Impacts may therefore at least not cause permanent displacement or significant behavioural changes in harbour porpoises. Seals in general also seem to habituate fairly quickly to underwater noise (Harris *et al.* 2001; review by Southall *et al.* 2007).

4.6.2 Seismic surveys

Seismic surveys are used by the oil and gas industry amongst others to explore different properties of the seabed before drilling. Seismic surveys are also in many cases carried out before construction of offshore wind farms to determine the substrate quality before deciding on the placement of the individual turbines and have been used in pre-construction work for BŚ III (Maritime Institute Gdansk, personal communication). Seismic surveys typically use arrays of airguns that can cause high sound pressure source levels of 220 to 255 dB re 1µPa with most energy in the low frequency range below 100 Hz (review by Genesis 2011). Most of the energy is directed downwards, but some of the sound energy may still propagate horizontally. Lucke *et al.* 2009 induced a 6 dB temporary threshold shift in harbour porpoises at received sound exposure levels of 164 dB re $1uPa^2 \cdot s$. TTS in seals from airguns have not been investigated, but seismic surveys can potentially have negative effects on both porpoises and seals at considerable distances. It is possible that the extent of seismic surveys in the Baltic is increasing with the numbers of construction sites for oil and gas and the planned wind farms, and thus underwater noise from geophysical explorations can be an increasing problem for marine mammals in the Baltic. Noise which likely came from a seismic survey was recorded in the ambient noise recording scheme for Bałtyk Środkowy III OFW, and some examples can be seen in Figure 7. The seismic surveys started at the beginning of October (5 October 2013) and lasted 2 weeks.

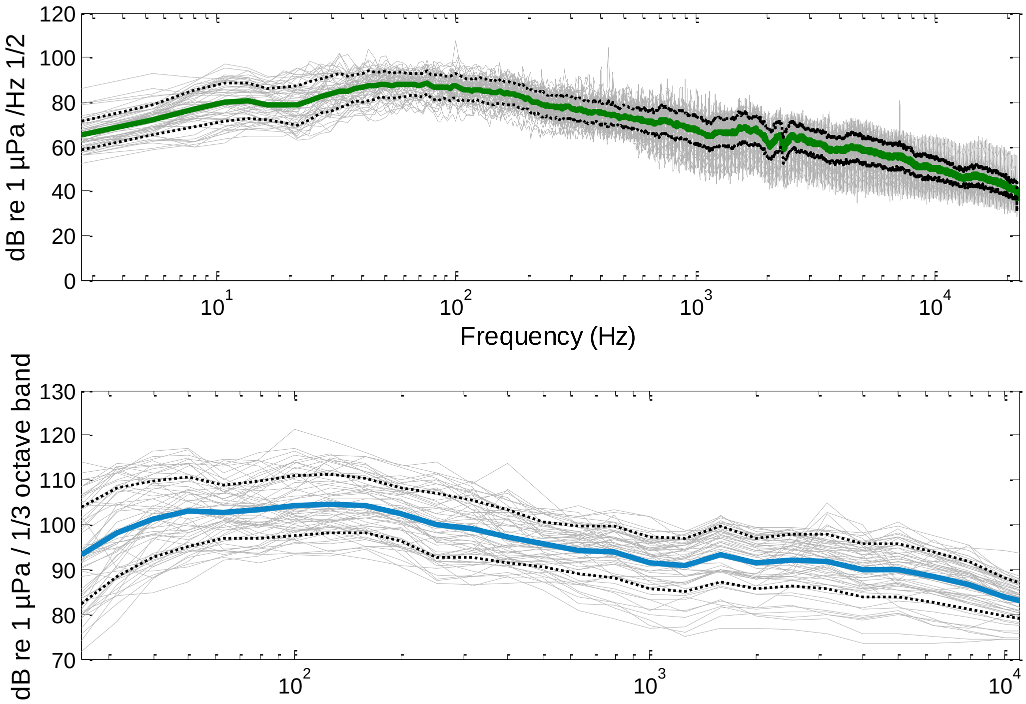

Figure 7 Top panel: Power spectral density in 1Hz bands of the sample subset from the autumn period containing a low frequency down-sweep (n = 62). Grey lines are the power spectral densities of individual samples. The green line is the mean power spectral density, and the dashed lines are the standard deviation. Bottom panel: Power spectral density in third octave bands of sample subset from the autumn period containing a low frequency down-sweep. Grey lines are the power spectral densities of individual samples. The blue line is the mean power spectral density, and the dashed lines are the standard deviation.

4.7 Diseases

Seal populations in the inner Danish waters have previously been subject to mass-deaths, due to epidemics of the phocine distemper virus (PDV). The first recorded epidemic was in 1988, when more than 23,000 harbour seals died. In 2002 an estimated death of more than 30,000 individuals was the result of a second outbreak (Härkönen *et al.* 2006) These epidemics are recurring events (Härkönen *et al.* 2006;Siebert *et al.* 2010). For a population already under pressure from contaminants, such events can be further deleterious, as a higher number of animals may be killed due to a lower immune response. Yet, the risk of infection for a population is highly dependent on contact with infected individuals from other populations, and for isolated populations of seals in the Baltic the risk may not be very big yet. However, as the population grows and single individuals migrate into the Belt Seas and Kattegat, the risk will increase. A risk of this kind of mass-death is difficult to assess, but it can constitute a substantial pressure.

The result of the review on baseline pressures are summarised in Table 6 in the form of a qualitative overview. For harbour porpoise, the highest pressure is bycatch with contaminants and eutrophication following but is decreasing. Noise has a medium pressure but is increasing (see also the next chapter). For seals contaminants and eutrophication are medium pressures and decreasing, noise is of similar concern but increasing. Diseases have the highest (potential) concern as population numbers are usually directly affected.

It is difficult to evaluate the overall pressure acting on porpoises and seals in the Baltic since the individual pressures are not equally contributing to the situation. ASCOBANS 2002 concludes that pressures on harbour porpoises are already high in the Baltic. Looking at the review, we would assess the pressure situation for seals as being slightly better (medium).

Table 6 Approximation of the existing pressures on marine mammals in the Baltic (+ = Low pressure, ++ = medium pressure, +++ = high pressure; * decreasing trend; ** = increasing trend).

Pressure	Harbour porpoise	Seals
Bycatch	+++	+
Contaminants	++*	++*
Eutrophication	++*	++*
Shipping (Collisions)	+	+
Tourism	+	+
Underwater noise	++**	++**
Diseases	+	+++

5 'Variant zero' analysis

Here we describe the proposed development of the marine mammal populations in Polish waters based on three scenarios:

1) It is assumed that wind energy will not be developed in the Polish marine area, nor BŚ III, nor other similar projects will be implemented, so these will have no impact on the environment.

   Both for harbour porpoises and seals, assessing clear future scenarios of the populations development is difficult, due to still scarce information on these animals in the Baltic (Olsen *et al.* 2014; Harding 2007).

   With no wind farms being developed in Polish water, the further development of populations of porpoises and seals at the BŚ III site and adjacent waters will be determined only by the pressures outlined in the previous chapter (see 0). Historical data indicates that porpoises were distributed widely throughout the Baltic, and the population numbers significantly declined in the middle of the 20th century, which was largely caused by the direct catches and by-catch in fisheries (Berggren *et al.* 2002). Nowadays, the numbers of porpoises in the Baltic remain low, and the factor considered as a major threat to their population is by-catch. As stated in ASCOBANS 2002 (see www.ascobans.org and various reports therein), the carrying capacity of the porpoise population can be kept only if the by-catch rates decrease. Another factor which could be considered are contaminants, which are still a significant pressure to the Baltic porpoises. Also the shipping noise might be disturbing, especially if the background noise is increasing further as predicted due to the increase in shipping. A negative impact could be expected, if the use of seismic surveys is on-going in the region. However, due to the extreme uncertainty about the number of porpoises in the Polish Baltic and their trends, it is not possible to predict future trends in abundance.

   Since the 1980s, the number of grey seals has been steadily increasing and the same is true for the grey seals in the Gdańsk Bay (i.e. in the reserve Mewia Łacha; 'Seagull Sandbank'; for detail, please refer to marine mammal research results). It is difficult to assess trends of harbour seals as their number in the Polish EEZ is very low with no breeding areas. With regard to seals, also by-catch could serve as an important factor disturbing the animals. It concerns mostly grey seals, which are known to migrate throughout the Baltic, including the BŚ III area, and they could use this site to forage. As for porpoises, however, the by-catch rates in the planned wind farm area are not known. Contaminants and the seismic surveys could also negatively impact seals present in the area. Yet, despite these pressures the grey seal population seems to increase and it is possible that this trend will continue under the first scenario.

2) It is assumed that wind energy will be developed in the Polish marine area, but the BŚ III project will not be implemented. However, projects assessed in cumulative impact assessment will be implemented. In this case we refer to the cumulative assessment undertaken in chapter 9.2. Under this scenario – and provided that several other offshore wind farms would go ahead – perhaps starting with Baltica 3 – the construction noise levels would add significantly but only temporarily to the existing noise levels. This would lead to a temporary displacement of harbour porpoises and seals from the construction site. It is possible that wind farms can reduce some of the environmental pressures if fishing activity is reduced. This could lead to a reduction in bycatch in the wind farm areas. This scenario has been discussed recently by Scheidat *et al.* 2011, who found an increase of harbour porpoises in a wind farm area post-construction compared to the situation before the wind farm was built. It has to be noted that the results of this study are difficult to assess as there is a trend of increasing abundance of porpoises in that part of the North Sea which could be solely responsible for the results found at the site (see bycatch by Thomsen *et al.* 2006a). Reduction of bycatch pressure is possible with seals as well.

3) It is assumed that wind energy will not be developed in the Polish Marine Area, but mining industry is developed. In this case noise would be introduced due to drilling and dredging, both low frequency emissions with medium intensity. Since noise is generated mainly by the drill and

dredge ship engine, the noise can be viewed as essentially stemming from shipping. Thus, the activities will to some extent add to the overall increasing shipping noise. This could lead to locally more disturbance to harbour porpoises, grey and harbour seals.

6 Methodology of the environmental impact assessment

This report derives its sources from three main elements for which detailed methodology descriptions are available:

- Methods for impact assessment used in the project. No deviations from the methodology were undertaken.
- The measurement of ambient noise from October 2012 to November 2013 (please refer to the DHI report *'Monitoring of acoustic background in the area of the offshore wind farm "Bałtyk Środkowy III" Bałtyk Środkowy III Offshore Wind Farm Monitoring of acoustic background, part 1 - Final report with research results'* for a detailed description of the methodology for data collection and analysis). The data has mainly been used for the impact assessment of background noise. But as noise is a pressure acting on marine mammals, the results are also used here.
- The numerical modelling of noise emitted during construction of BŚ III (please refer to the DHI report *'Environmental Impact Assessment of Bałtyk Środkowy III Offshore Wind Farm Numerical modelling of noise propagation from pile driving'* for a detailed description of the methodology of the modelling).
- A desk-based assessment using literature sources. The information in the different chapters was derived based on the most comprehensive information available. All scientific statements are supported by citations from the literature listed at the end of this report.

7 Potential impacts of the offshore wind farm

There is potential for a number of different impacts on marine mammals as a consequence of construction, operation and eventually dismantling of an offshore wind farm. These effects can be positive as well as negative. The potential effects can be measured both at the level of single individuals and at population level, where the local abundance and ultimately the population size could be affected based on the degree of disturbance.

Pile-driving during construction is considered to be the single activity capable of causing the highest degree of disturbance, as pile-driving activities generate impact noise with very high sound source levels (Nedwell *et al.* 2007, Tougaard *et al.* 2009, Thomsen 2010). Four types of foundations are considered for the construction: monopiles, tripod and jacket foundations, and gravity base foundations (GBF). The monopile, tripod and jacket foundations will require the use of impact pile-driving. Generally, GBFs do not require pile-driving, though it may be required in a few situations such as the preparation of the construction site (see Carstensen *et al.* 2006). However, before the foundation can be put in place, the bottom needs to be prepared, and after placement of the foundation scour protection may also need to be put in place to secure the foundation. These activities can cause significant suspension of sediments in the water column, as well as noise from dredging (Reach *et al.* 2012).

7.1 Construction

7.1.1 Pile driving noise

The monopile, jacket and tripod foundations considered for this project, will most likely require the use of impact pile-driving. This is a method where concrete or steel piles are driven into the seabed substrate using a hydraulic hammer, a process that generates very high sound pressures (reviewed by Nedwell & Howell 2004;Thomsen 2010). Measurements of pile-driving noise from the installation of a 3.9 m diameter steel pile at the Horns Rev II offshore wind farm showed that peak to peak sound pressure levels from a single strike were more than 190 dB re 1 µPa even 720 meters form the construction site (Brandt *et al.* 2011). Though most of the sound energy from pile driving is at low frequencies (<1 kHz), where especially porpoises have poor hearing, there is still sufficient energy in the sounds at frequencies where porpoises and seals are highly sensitive. Due to both intensity and frequency content of the impact sounds, they are thus capable of causing considerable disturbance to the marine mammals in the area.

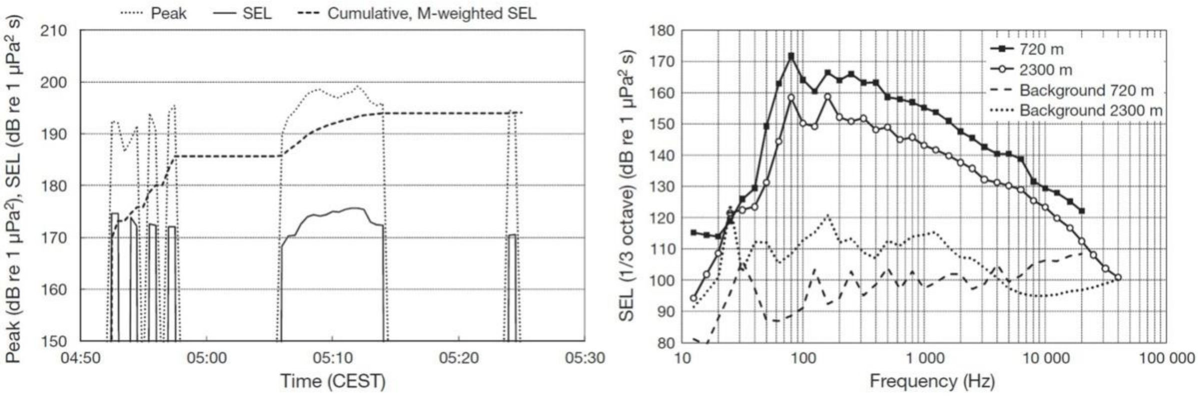

Figure 8 Left: Peak level and single-stroke sound exposure level (SEL) for the pile driving operation measured at 720 m distance. The M-weighted cumulative SEL (‘HF cetaceans’ M weighting, from Southall *et al.* 2007). Right: Power spectral density of pile driving noise at the 2 measurement locations. Brandt *et al.* 2011).

The intensity of the impact noise is correlated to the pile diameter (Betke 2008).The installation of tripod and jacket foundations with smaller pile-diameters will therefore not generate as intense sound pressure levels (See chapter 9). This is evident from measurements of the impact noise from the installation of two wind turbines off the North Eastern coast of Scotland (Bailey *et al.* 2010).

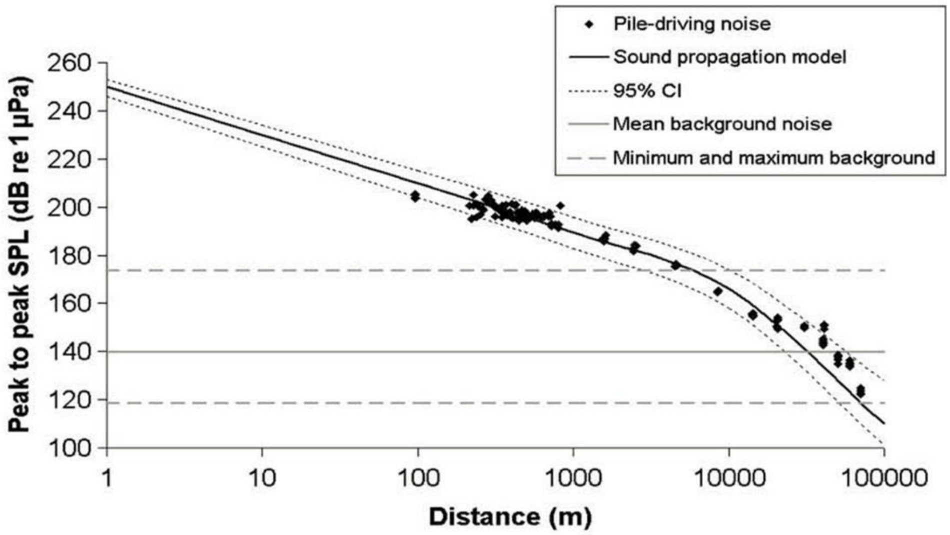

Figure 9 Broadband peak-to-peak sound pressure levels of pile-driving in relation to distance from the noise source and the best-fit sound propagation model. (From Bailey et al. 2010).

In a study in the Danish North (Sea Brandt *et al.* 2011) measured porpoise activity using click detectors (CPODs) and found a negative response to the pile driving until a distance of 18 km. Porpoise activity decreased significantly during the construction period compared to the baseline period. The duration of the effect of pile driving lasted up to 72 hours. They found no negative affect at the POD station 21.2 km away from the pile driving. This might indicate that porpoises exhibit no behavioural response at this distance or that porpoises from the nearer locations were displaced to this position. (Tougaard *et al.* 2006), found an effect at least 20 km from the source with return to baseline levels 4-5 hours after the cessation of the pile driving. (Dähne *et al.* 2014) could confirm the 20 km behavioural impact range at a recent study at the German research platform *alpha ventus* (German North Sea). The effect was short term too (median duration = 16.8 h;); (Dähne *et al.* 2014). Only in one case were the effects of the construction activity measurable beyond the cessation of the activity and that was for a wind farm where pile driving was only used for a limited period in support of the construction but not for ramming in piles (gravity base foundation; Carstensen *et al.* 2006). It is difficult to assess the results from this particular investigation as numbers of recorded porpoises were low form the start.

7.1.2 Dredging noise

In many cases dredging activities are needed before wind farm installations for side preparation (gravity based foundations but also other types). There is a variety of dredger types for various purposes but in many cases Trailing Suction Hopper Dredgers (TSHD) are used. Noise from TSHDs stems from a variety of sources with the main contributors being the noise generated by the dredging vessel itself and the drag head (CEDA 2011; Figure 10).

Most of the sound generated by the TSHD dredger is at frequencies below 1 kHz. However, depending on the composition of the substrate removed by dredging, sound energy may also be generated at higher frequencies. This is thought to be caused by larger sand grains and gravel, when they move through the pipe and pump (Robinson *et al.* 2011). However, even if the substrate dredged is sand, there is still acoustic energy above 1 kHz that could potentially affect porpoises and seals. The reported source levels are between 186 dB-188 dB re 1µPa rms at 1 m (Thomsen *et al.* 2009, Robinson *et al.* 2011). These levels are much lower than reported from pile driving (see above), but since dredging sound is more or less continuous and pile driving impulsive (pulse length

= 50 ms); the sounds cannot be compared. It is clear though that unless porpoises spend an extended time in the vicinity of the dredger, no physical damage can occur (see WODA 2013).

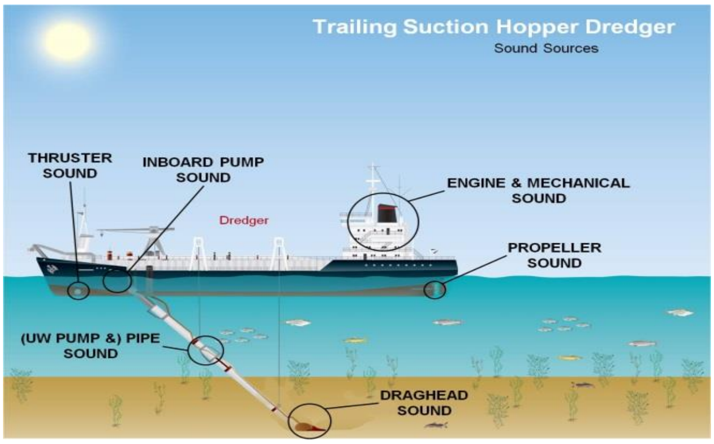

Figure 10 Sound sources of a Trailing Suction Hopper Dredger ((see WODA 2013).

CEDA 2011 noted the scarcity of studies quantifying impacts from dredging with documented effects limited to behavioural changes in grey and bowhead whales (see Richardson et al. 1995) and a recent investigation by Diederichs *et al.* 2010 showing that harbour porpoises temporarily avoided an area of sand extraction off the Island of Sylt in Germany. For their investigation Diederichs *et al.* 2010 used automated porpoise click detectors. They found that when the dredging vessel was closer than 600 m to the porpoise detector location, it took three times longer before a porpoise was again recorded than during times without sand extraction. However, after the ship left the area, the clicks were registered at the usual rate. The results are relevant as sound levels emitted from the dredger were reported (see Itap 2007). However, as sound transmission differs substantially between sites, the distance of 600 m is only valid for this specific dredging project and cannot be generalized to other dredging projects. Visual surveys using airplanes did not document any impacts (Diederichs *et al.* 2010).

7.1.3 Ship noise

During construction ship traffic will increase both from small and large vessels. This added noise will add to the overall background noise level. The large slow moving vessels are not expected to cause a significant elevation of the background noise level at the frequencies relevant for porpoises and seals as the main energy produced from these larger vessels is below 1 kHz (Richardson *et al.* 1995; McKenna *et al.* 2012). For the small and fast vessels, considerable energy may be generated at frequencies within the hearing range of both porpoises and seals (see review in OSPAR 2009).

7.1.4 Traffic

The increased ship traffic in connection with construction works can potentially increase the risk of ship strikes for seals and porpoises. Though ship strikes are commonly associated with large baleen whales, there is data to suggest that this may also be a significant source of mortality in small cetaceans in areas with a high density of ship traffic (Van Waerebeek *et al.* 2007). The risk of being struck by a vessel increases with the speed of the vessel (Carrillo & Ritter 2010). Ship strikes in seals are not well documented.

7.1.5 Suspension of sediments

Burying of cables and establishment of the foundations will cause some suspension of sediments in the water column inside the wind farm area and consequently increase turbidity in the wind farm area and potentially beyond. For foundations this will especially be the case for GBFs, as they may require both redistribution and removal of bottom substrate through dredging in order to reach suitable substrate and level out the bottom (Reach *et al.* 2012). Seabed disturbance through extraction, rejection and disposal of sediments, along with outwash of excess materials, can result in increased turbidity and the creation of sediment plumes.

Marine mammals often inhabit turbid environments and many utilise a sophisticated sonar system to sense the environment around them (see Au *et al.* 2000). Increases in turbidity should therefore have only a minor impact on the marine mammals at BŚ III. Some level of minor consequences may be possible for non-echolocating marine mammals that may rely partly on vision to forage and detect predators (Nairn *et al.* 2004), but there is no direct evidence for impact in this respect. (McConnell *et al.* 1999) reported that foraging areas and trip durations recorded for a blind grey seal in the North Sea were similar to those of other seals. This, along with the fact that seals often inhabit areas of high turbidity (Weiffen *et al.* 2006), suggests that visual cues are not essential for seals when exploring their environment; increased turbidity should have a minimal effect on their ability to carry out daily functions. So, although the suspension of sediments is not expected to have a direct effect on the porpoises and seals considered here, there may be an indirect effect through possible negative effects on their prey species.

7.1.6 Pollutants

The construction itself is not expected to cause the release of harmful chemicals that could pose a potential risk to porpoises or seals. The increased traffic during construction could lead to an increase in the discharge of pollutants into the water from exhaust and increase the risk of oil spill due to ship collision. This could temporarily impact the marine environment negatively. However, this risk is considered to be low.

7.1.7 Changes in habitat

With the establishment and construction of foundations, transformer/sub-stations and the burial of electricity cables will partly destroy the seabed within the wind farm and along the cable route to the transformer station. The physical destruction of the seabed will lead to habitat loss for benthic infauna (soft bottom species) and a temporary loss of benthic fauna biomass (E2 2006). The impacts from the foundations and the electricity cables within the park area will be local and will not lead to direct impacts on marine mammals. Results from Danish monitoring programmes at Danish offshore wind farm sites show that the biomass and abundance of the benthic fauna within the wind farms area only decrease during the construction phase, thereafter an increase in abundance and biomass occurs. The primary reason is increased heterogeneity of the seabed. New hard bottom habitats arise on the scour protection and turbine foundations which cause a shift from a pure sandy seabed to a mixture of sandy and hard bottom habitats (E2 2006; Bioconsult 2005). The results also show that the re-colonisation of the soft bottom seabed will occur relatively fast (within a period of 5 years), but the actual time depends on the benthic fauna structure (species composition, abundance and biomass). The temporary loss of benthic fauna biomass can have an indirect impact on the marine mammals that use the area as a habitat for food supply. But as the overall biomass and abundance do not change significantly, the indirect impact from shortage of food supply will only be short term. Hence this will not have a significant associated impact on marine mammals. It also has to be considered that marine mammals will most likely leave the immediate construction site during the installation process. Thus, any potential impacts due to short-term habitat changes in the construction phase will be masked by the reaction to underwater sound.

7.2 Operational phase

7.2.1 Operational noise

Measurements of small offshore wind turbines suggest that the noise from the operating wind turbines is relatively low in intensity and frequency with tonal components at frequencies below 1 kHz (Thomsen *et al.* 2006).

Based on data from small wind turbines (up to 2 MW), measurements of small offshore wind turbines suggest that the noise from the operating wind turbines is relatively low in intensity and frequency with tonal components at frequencies below 1 kHz (Wahlberg & Westerberg 2005; Madsen *et al.* 2006; Thomsen *et al.* 2006b).

Based on data from small wind turbines (up to 2 MW), (Tougaard & Henriksen 2009) concluded that harbour porpoises can only detect the noise from a turbine at a distance of few tens of metres whereas seals could potentially detect the sound at a distance of several hundred metres. This is in line with earlier modelling exercises by Thomsen *et al.* 2006b who concluded that operational noise of small turbines should only have very small impacts on marine mammals, if any.

Studies on the distribution of porpoises in relation to the construction and operation of wind farms have been undertaken at sites including Germany, Denmark and the Netherlands. Turbine types varied between 2 and 5 MW. Two studies indicate no negative effect (Tougaard *et al.* 2006; Thompson 2010). Studies at Nystedt offshore wind farm (Danish Baltic) demonstrate a decrease in porpoise abundance two years after construction (Carstensen *et al.* 2006) with an evidence now for a slow recovery (Teilmann & Carstensen 2012). One study in the Danish North Sea concluded on a positive effect (Scheidat *et al.* 2011). However, in the first study, porpoise density was relatively low from the start so the statistical evidence for a shift appears weak. In the case of the Dutch study there is now much evidence that proposed numbers in that section of the North Sea have been increasing in general (Thomsen *et al.* 2006a). Thus, it is possible that the observation is not related to the wind farm but reflects an overall trend.

A recent study by Marmo *et al.* 2013 performed numerical noise modelling and impact assessment of 6 MW turbines using monopiles, jacket foundations or gravity foundations. They found similar results for noise emission for monopiles and gravity foundations, with 147 dB re 1µPa at 125 Hz and 149 dB re 1µPa at 560 Hz at 5 m distance from the monopile, and for gravity foundations at 5 m the noise levels were 152 dB re 1µPa at 200 Hz and 143 dB re 1 µPa. Jacket foundations produce significantly higher noise levels at higher frequencies with noise levels of 177 dB re 1 µPa at 700 Hz and 191 dB re 1µPa at 925 Hz 5 meters from the source. (Marmo *et al.* 2013) further found that modelled monopole noise (6 MW) was audible to porpoises and seals up to 18 km. However, for seals no behavioural response was predicted. For porpoises, reactions could occur at high wind speeds (15 ms-1) at 18 km from the source. Yet, according to the criteria that was set only 10% of the animals would react. Thus, 90% of the porpoises in the modelling were not expected to show a reaction to operational sound from a monopile turbine. It must be mentioned here that Marmo *et al.* 2013 used rather conservative data for ambient noise (=lowest possible noise). Impact ranges are thus based on a worst case scenario. There is also no information on habituation to any behavioural response (Marmo *et al.* 2013).

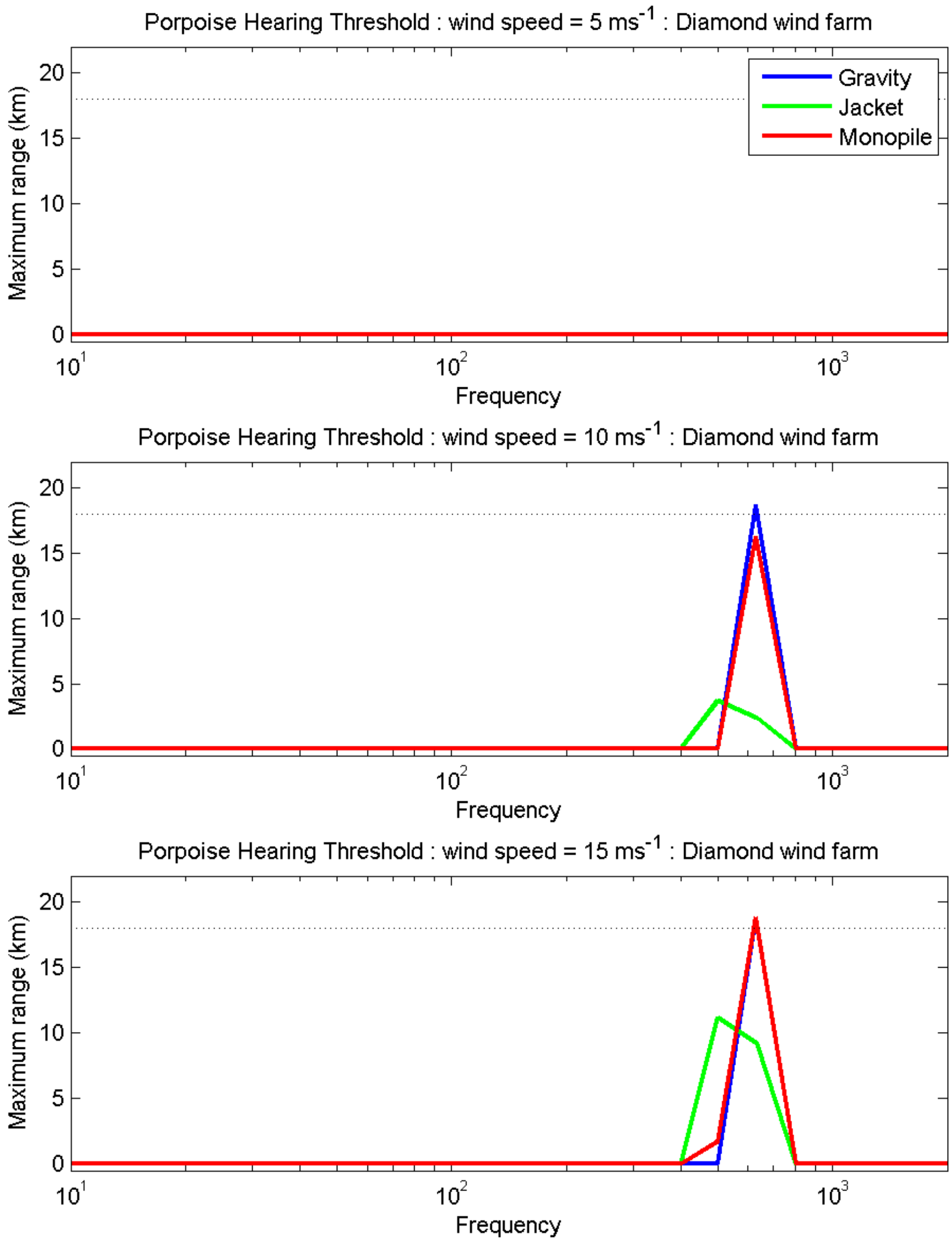

Figure 11 Maximum range at which a porpoise could hear a wind farm at different wind speeds. Gravity base, jacket and monopile foundations are compared. It is assumed that if the SPL is below the background noise, a porpoise could not hear the wind farm. The range is measured to the centre of the wind farm (taken from Marmo *et al.* 2013).

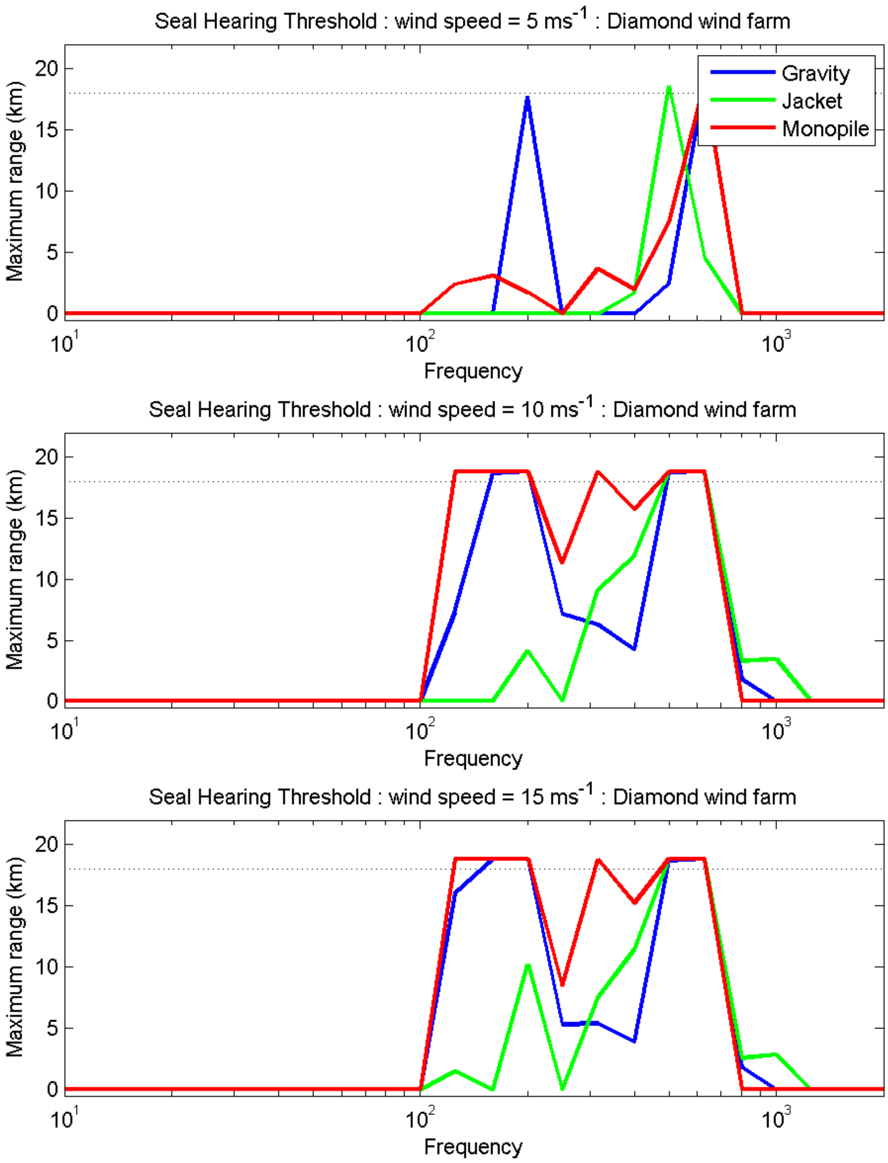

Figure 12 Maximum range at which a harbour seal could hear a wind farm at different wind speeds. Gravity base, jacket and monopile foundations are compared. It is assumed that if the SPL is below the background noise, a seal could not hear the wind farm. The range is measured to the centre of the wind farm (taken from Marmo *et al.* 2013).

7.2.2 Service and maintenance traffic

Service and maintenance activities for the turbines will probably also cause some disturbance as boats will be commuting to and from the area, as well as between turbines within the area. The level of activity will not be the same as during construction, but the vessels utilized are smaller and potentially faster, and generate noise at higher frequencies than the bigger vessels used during construction (Richardson *et al.* 1995). The use of faster vessels can also increase the risk of ship strikes for marine mammals in the area (Evans 2003).

7.2.3 Electromagnetic fields

The cabling within the wind farm and most prominently the cable from the wind farm to land will produce electromagnetic emissions that can be small to medium depending on the design of the turbines and cables (for review, see Gill *et al.* 2012). These EMF fields can potentially affect porpoises' travelling behaviour. Yet, it is so far unknown how this species and other cetaceans for that matter navigate (except for the use of sound of course). Some cetaceans comprise magnetic material in fatty structures, bones, muscles and brain matter. It has been speculated that these are used as magnetic receptors and that whales and dolphins orient themselves in relation to the earth magnetic field (Klinowska 1986). Yet, there is only indirect evidence for that hypothesis. Some mass stranding events could be related to disturbances of the magnetic field in some circumstances (Klinowska 1986). It is possible that the cable to land could lead to permanent changes in the EMF in the vicinity of the wind farm and beyond which in turn could affect the behaviour of porpoises. Still, there is not enough information to conclude on the exact nature and dimension of the impact. Some prey species may also be affected, but only very locally (see Gill *et al.* 2012), thus any effects are expected to be minimal.

7.2.4 Reef effects

The introduction of hard bottom substrate could create an artificial reef effect. The foundations are very likely to be colonized by algae and filter feeding epifauna which in turn attracts other species. This could ultimately lead to increased foraging opportunities for marine mammal predators (Scheidat *et al.* 2011; Reach *et al.* 2012; Leonhard *et al.* 2013; Gutow *et al.* 2014).

7.2.5 Visual effects

The visual appearance of the foundations below water and the windmills above water changes the area. This could potentially cause disturbance to porpoises and to a greater extent seals, as they are more visually oriented. However, the underwater appearance of the foundations would relatively fast begin to resemble that of other hard substrate areas, as it is colonized by different organisms. Above the water the operating wind turbines could cause glints of light or moving shadows that could be detected by seals (see Riedmann 1990 for seal vision),and perhaps by porpoises, but we assume they are not expected to cause any great disturbances as both species stay most of the time underwater and are thus rarely exposed to this potential disturbance. Depending on the distance to the nearest seal haul-out, there may be an effect if these changes are visible to seals out of the water.

7.3 Dismantling phase

There is no practical information about the activities involved in dismantling of wind farms offshore as this has not taken place yet. From related activities at oil and gas platforms, we know that decommissioning can involve the use of explosives with far reaching effects (see, for example dos Santos *et al.* 2010). However, according to our information (Haskoning 2014), no use of explosives is planned for the future decommissioning of BŚ III. In general, decommissioning involves activities such as drilling, shipping (with similar number and ship types as during construction) and cutting (Haskoning 2014). No information is available on underwater noise levels from cutting. Shipping for construction has been covered in (Thomsen & Schack 2013). No information is available on underwater noise levels from cutting. Shipping for construction has been covered in chapter 7.1.3. Drilling involves low frequency sound similar to shipping. Thus, impacts are likely to be low level behavioural but no TTs or injury.

8 Species being subject to the environmental impact assessment

Harbour porpoises, harbour seals and grey seals can be encountered within the boundaries of the OWF and the buffer zone. Here we will provide information on the three species with regard to their protection status, their abundance and distribution in Polish waters and the likely sensitivities to construction, operation and decommissioning of offshore wind farms. The information is provided here in summarised form, as much of the general biology and abundance of the three species has been already covered in the report on the research results. Please also note that detailed information on the sensitivities to underwater sound can also be found in the report background noise part 2 impact assessments. Relevant sections are repeated here as they are directly applicable to the sensitivity assessment. The sensitivity tables are accompanied by a short text only, as much of the information on documented impacts can be found in chapter 7.

8.1 Harbour porpoise

8.1.1 Protection status in Polish waters

The harbour porpoise is a protected species under the EU Habitat Directives Appendices II and IV. It is also an animal of major concern in the ASCOBANS agreement under the Bonn Convention, as well as protected under the HELCOM agreement of the Helsinki Convention and listed in the Appendix II of the CITES Convention. In Poland, the harbour porpoise is listed in the Appendix I of the Regulation of the Minister of Environment concerning species protection, as well as the Nature Conservation Act and The Polish Red Book of Animals.

8.1.2 Abundance and distribution in Polish waters

The abundance and distribution of harbour porpoise in the North Sea and the Baltic Sea have been sampled twice on a large scale indicating little change in the overall abundance between 1994 and 2005 (340,00 and 375,000) (Hammond et al. 2002, Hammond et al. 2013). Throughout their range the density of porpoise differs. In the Baltic, there is a sharp decrease in porpoise abundance from the inner Danish water towards the Baltic proper with very low densities reported in the latter, including Polish waters. Historical data indicates that porpoises were distributed widely throughout the Baltic and that the current situation is the result of a decline due to many factors with direct catches and by-catch in fisheries being the most severe factor (Koschinski 2002).

In Polish waters, the density of harbour porpoises has previously been investigated through visual and acoustic surveys in a single study (Gillespie *et al.* 2005) and through opportunistic records of by-caught animals (Skóra & Kuklik 2003). Recent visual and acoustic surveys have been carried out by Biola and DHI Poland in the BŚ III area near Słupsk Bank in the period from October 2012 - January 2013 and March - June 2013. Results from these surveys are in line with the observations reported by (Gillespie *et al.* 2005). New information on the density and distribution of harbour porpoises in the Baltic is expected from the large-scale EU project Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise (SAMBAH). Published detailed information is not yet available, however during the international SAMBAH conference held in Stockholm (December 2014) the preliminary results of the project were presented and made available to us (see Thomas and Burt 2014). Abundance estimates result in the range from 90-997 (mean = 447) harbour porpoises present in the north-east part of the Baltic Sea during summer. Results were presented by (Thomas and Burt 2014) for summer season as it is believed that animals present in the inner part of the Baltic Sea during their breeding season belong to the Baltic Sea harbour porpoise population. It has to be pointed out though that the exact population structure of porpoises in the Baltic is still under discussion (Palmé *et al.* 2008). The harbour porpoises in the Baltic may consist of two separate populations, one in Kattegat, Skagerrak and the Belt Seas, and one in the Baltic proper. The Baltic proper harbour porpoises are on the IUCN red list (see Hammond *et al.* 2008) and considered a critically endangered separate population. However, the evidence of a separation into two separate populations is not unambiguous. A study by Wiemann *et al.* 2010 provides some genetic support for a separation of the porpoises in the Kattegat, Skagerrak and Belt Sea and the inner Baltic Sea, with suggested geographical boundaries at the Linhamn/Dragør ridge and south of Fyn/Sjælland, perhaps as far east as Darss Sill (Wiemann *et al.* 2010). Galatius *et al.* 2012 investigated the presence of a separate Inner Baltic Sea population using a geometric morphometric method to compare harbour porpoises from different areas. Their results also indicate the presence of a separate population in the Inner Baltic Sea population, though they are not able to define any clear boundaries for this stock. The number of samples available for analysis dictates the power of genetic analysis of the population structure, which could be the reason for the inconclusive results so far presented. It is thus not conclusively proven that the porpoises of the Baltic proper can be viewed as a separate population meriting separate management.

8.1.3 Sensitivity to underwater sound

Hearing is the key modality for harbour porpoises for most aspects of their lives. The hearing sensitivity is extremely good and covers a vast frequency range in this species (Figure 13; Andersen 1970;Popov *et al.* 1986; Kastelein *et al.* 2002; Kastelein *et al.* 2010). The spectral analysis of incoming sounds can be described as using a series of bandpass filters, and in humans these auditory filters have a bandwidth of approximately 1/3 of an octave at frequencies above around 1000 Hz (Moore 2012). Similar findings have been described for other mammals, including the harbour porpoise (Kastelein *et al.* 2009). However this relationship may be more complicated at very high ultrasonic frequencies (Popov *et al.* 2006). The hearing abilities of harbour porpoises become increasingly directional with higher frequencies. This improves their echolocation capabilities by making them less susceptible to background noise and clutter echoes (i.e. returning echoes from other objects than the intended target; Figure 14; Kastelein *et al.* 2005).

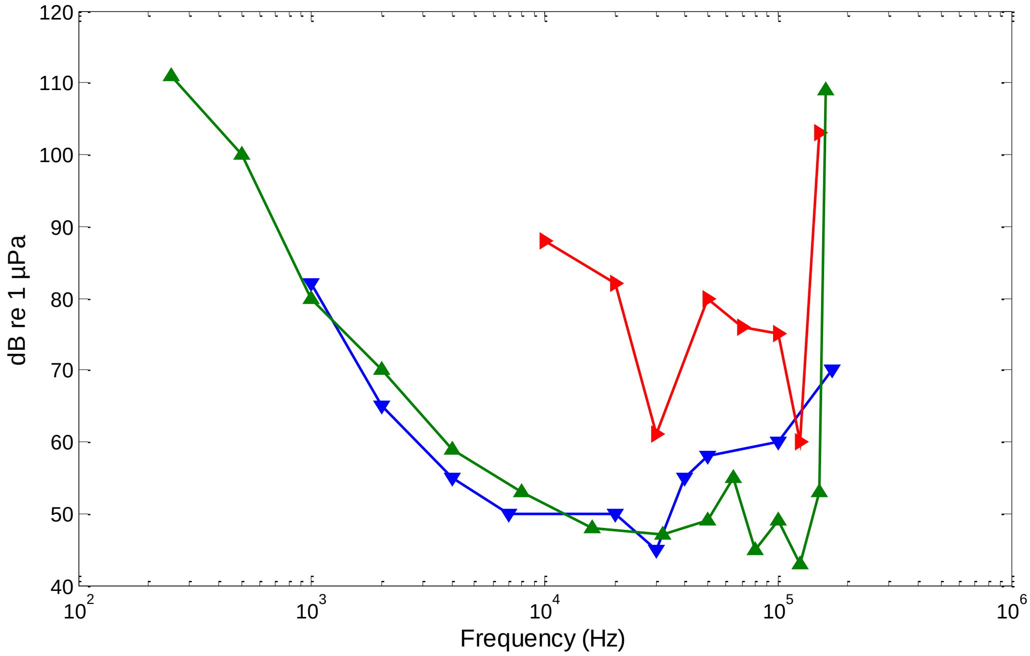

Figure 13 Audiograms for harbour porpoises modified from (Kastelein *et al.* 2005) (green), (Andersen 1970) (blue) and (Popov *et al.* 1986) (red).

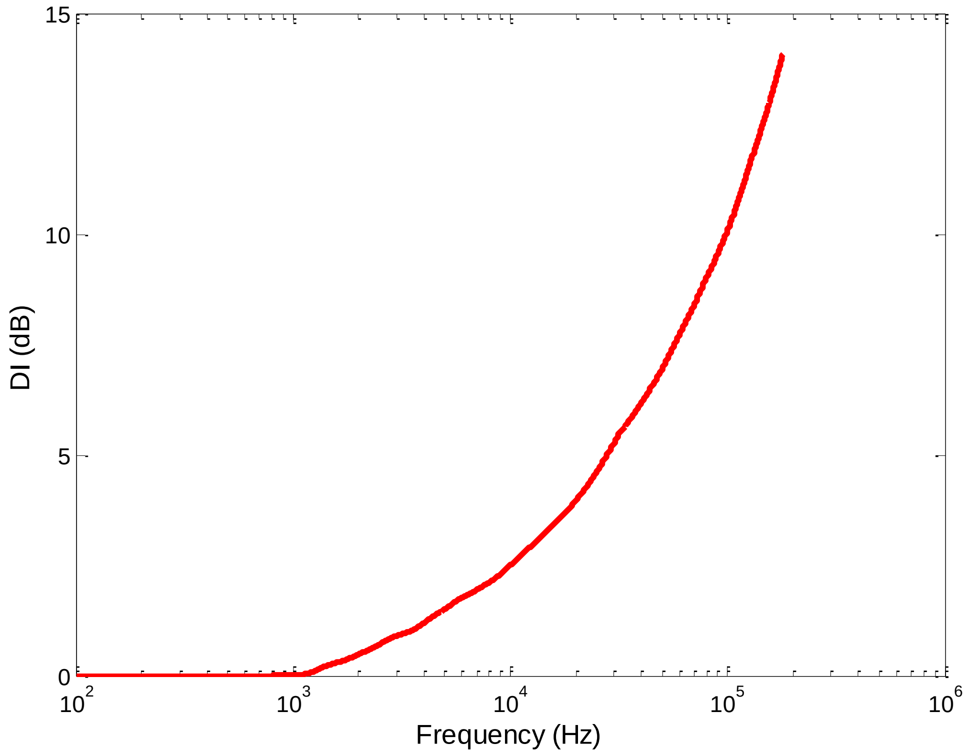

Figure 14 The directivity index (DI) is a measure of the directional hearing as a function of frequency in the harbour porpoise. Modified from (Kastelein *et al.* 2005).

8.1.4 Sensitivity to offshore wind farm construction

The construction phase of the offshore wind farm will probably cause disturbances to harbour porpoises in the Bałtyk Środkowy III area. Table 7 summarises the possible effects of construction of the wind farm on the harbour porpoise based on the four different types of foundation under consideration. The species' sensitivity to the different effects is evaluated based on a scale going from very high, high, moderate, and low to very low (negligible). How sensitive a species is to a particular effect is decidedly based on the scale of effects, whether they will be local within the wind farm area, regional, or even international. They are also evaluated based on the likelihood of occurrence, and on the expected duration of the effect, whether it is short-term or long-term.

For a detailed explanation of terms such as TTS and PTS, refer to the Glossary and chapter 9.

Table 7 Sensitivity of the harbour porpoise to construction of the OFW Bałtyk Środkowy III.

Sensitivity/vulnerability to the potential impact of the OWF							
Construction phase							
Species	**Impact factor**		**Effect**	**Scale**	**Likelihood**	**Duration**	**Sensitivity**
Harbour porpoise (*Phocoena phocoena*)	Noise	Monopile	PTS	Local	Low	Long-term	Low
			TTS	Regional	Medium	Short-term	High
			Avoidance behaviour	National	High	Short-term	High

Sensitivity/vulnerability to the potential impact of the OWF							
Construction phase							
Species	Impact factor		Effect	Scale	Likelihood	Duration	Sensitivity
		Tripod foundation	PTS	Local	Low	Long-term	Low
			TTS	Regional	Medium	Short-term	High
			Avoidance behaviour	Regional	High	Short-term	High
		Jacket foundation	PTS	Local	Low	Long-term	Low
			TTS	Regional	Medium	Short-term	High
			Avoidance behaviour	Regional	High	Short-term	High
		Gravity base foun-dation/ dredging noise	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	Medium	Short-term	Moderate
		Shipping	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Low	Short-term	Low
			Avoidance behaviour	Local	High	Short-term	Moderate
	Shipping		Ship strikes	Local	Low	Long-term	Low
	Suspension of sedi-ment		Affecting prey spe-cies	Local	Low	Short-term	Low
	Pollutants		Affecting prey spe-cies	Local	Negligible	Long-term	Very low
	Changes in habitat		Visual ef-fects	Local	Low	Long-term	Low

As can be seen in Table 7, sensitivity of harbour porpoises to noise produced during the pile driving resulting in avoidance behaviour and temporary threshold shift (TTS) is high, which concerns the monopole, tripod and jacket foundation. In case of these three foundations, the likelihood of avoid-ance behaviour is high, while TTS is moderate, and such changes occur in the short-term duration.

In the long term perspective, the permanent threshold shift (PTS) might appear, however the likelihood of it is low. For the gravity base foundation and dredging noise, there is a moderate likelihood that the avoidance behaviour on a short-term basis will occur, to which factor porpoises' sensitivity would be moderate. Noise produced by ships might very likely result in avoidance behaviour and moderate sensitiveness of porpoises.

8.1.5 Sensitivity to offshore wind farm operation

The operational phase of the offshore wind farm may also cause some disturbances to porpoises in the Bałtyk Środkowy III area, though the extent of disturbance is expected to be very limited in both time and scale. Table 8 summarises the possible effects of operation of the wind farm on the different marine mammal species based on the four different types of foundation under consideration.

Table 8 Sensitivity of the harbour porpoise to operation of the OFW Bałtyk Środkowy.

Sensitivity/vulnerability to the potential impact of the OWF							
Operational phase							
Species	**Impact factor**		**Effect**	**Scale**	**Likelihood**	**Duration**	**Sensitivity**
Harbour porpoise (*Phocoena phocoena*)	Turbine noise	Monopile	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	High	Short-term	Low
		Jacket foundation	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	High	Short-term	Low
		Gravity base foundation	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	High	Short-term	Low
		Service and maintenance traffic	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Low	Short-term	Low
			Avoidance behaviour	Local	High	Short-term	Moderate
	Shipping		Ship strikes	Local	Low	Long-term	Low
	Electromagnetic fields		Affecting prey species	Local	Negligible	Long-term	Very low
	Changes in habitat	Visual	Glints, moving shadows	Local	Negligible	Long-term	Very low

Sensitivity/vulnerability to the potential impact of the OWF							
Operational phase							
Species	Impact factor		Effect	Scale	Likelihood	Duration	Sensitivity
		Reef effects	Improved foraging opportunities	Local	High	Long-term	Positive

Table 8 shows that sensitivities of harbour porpoises to the factors occurring during the wind farm operation are generally very low and effects of these factors are in most cases negligible. Avoidance behaviour might very likely appear only due to service and maintenance traffic, which is a short-term change. There is a moderate likelihood that the reef effect will appear, which can have a positive effect on porpoises, thanks to improved foraging opportunities.

8.1.6 Sensitivity to offshore wind farm dismantling

According to the information provided about the decommissioning options, the use of explosives is not planned. Pile driving will most likely also not be used (Haskoning 2014).

Table 9 Sensitivity of the harbour porpoises to dismantling of the OFW Bałtyk Środkowy.

Sensitivity/vulnerability to the potential impact of the OWF						
Operational phase						
Species	Impact factor	Effect	Scale	Likelihood	Duration	Sensitivity
Harbour porpoise (*Phocoena phocoena*)	Decommissioning shipping	PTS	Local	Negligible	Short-term	Very low
		TTS	Local	Low	Short-term	Low
		Avoidance behaviour	Local	High	Short-term	Low
	Decommissioning shipping	Ship strikes	Local	Low	Short-term	Low
	Drilling	PTS	Local	Negligible	Short-term	Very low
		TTS	Local	Low	Short-term	Low
		Avoidance behaviour	Local	High	Short-term	Low

8.2 Grey seals

8.2.1 Protection status in Polish waters

Grey seals are listed in the EU Habitat Directives Appendix II, and under the Habitats Directive Special Areas of Conservation (SACs). Grey seals are also protected under the HELCOM agreement. In Polish law, the grey seal is listed in the Appendix I of the Regulation of the Minister of Environment concerning species protection, as well as in the Nature Conservation Act. The risks posed to these species in establishing the offshore wind farm Bałtyk Środkowy III should therefore be assessed.

8.2.2 Abundance and distribution in Polish waters

The number of grey seals in the inner Baltic Sea was estimated to be around 19,400 individuals in 2003, and the grey seal population in the Baltic has been increasing by an annual rate of 7.5% since 1990 (Harding 2007). The genetic structure of the population in the Baltic is not known, but there may be a population split between the Baltic proper and the Bothnian Bay (Jonas Teilmann pers. comm.). In recent years grey seals have been found more commonly in the south-western Baltic and Danish straits, though the number of individuals is still very limited after near extinction levels in the late 19^{th} century (Härkönen *et al.* 2007). (Dietz 2003) used satellite tags to track the movements of six grey seals from the Rødsand seal sanctuary. Results show that individual grey seals migrate through the Baltic proper to the inner Baltic Sea. Telemetry studies of the grey seals' migrations are also being conducted by WWF Poland and the Hel Marine Station of the University of Gdańsk, indicating that seals migrate around the whole Baltic including the BŚ III area (WWF Polska, 2013). (Kuklik & Skora 2005) reported low densities of grey seals in the Polish waters. This is in line with the findings of the survey carried out in the BŚ III area by Biola and DHI Poland. They reported a single confirmed observation of a grey seal.

8.2.3 Sensitivity to underwater sound (harbour and grey seals)

Harbour seals and grey seals are amphibious animals with acute hearing in air as well as under water. The hearing of harbour seals has been studied extensively (Figure 15; Møhl 1968; Terhune 1988; Kastak & Schusterman 1998). The hearing of grey seals on the other hand has only been investigated in a single study (Figure 15; Ridgway & Joyce 1975). This study was conducted using auditory evoked potentials, which are not directly comparable to the psychophysical data obtained from harbour seals. However, (Schusterman 1981) assumes that the hearing abilities in both species could be very similar. The hearing thresholds of harbour seals are generally recommended to be used as a conservative estimate of the hearing thresholds for those phocids, where the hearing has not been as thoroughly investigated (Southall *et al.* 2007).

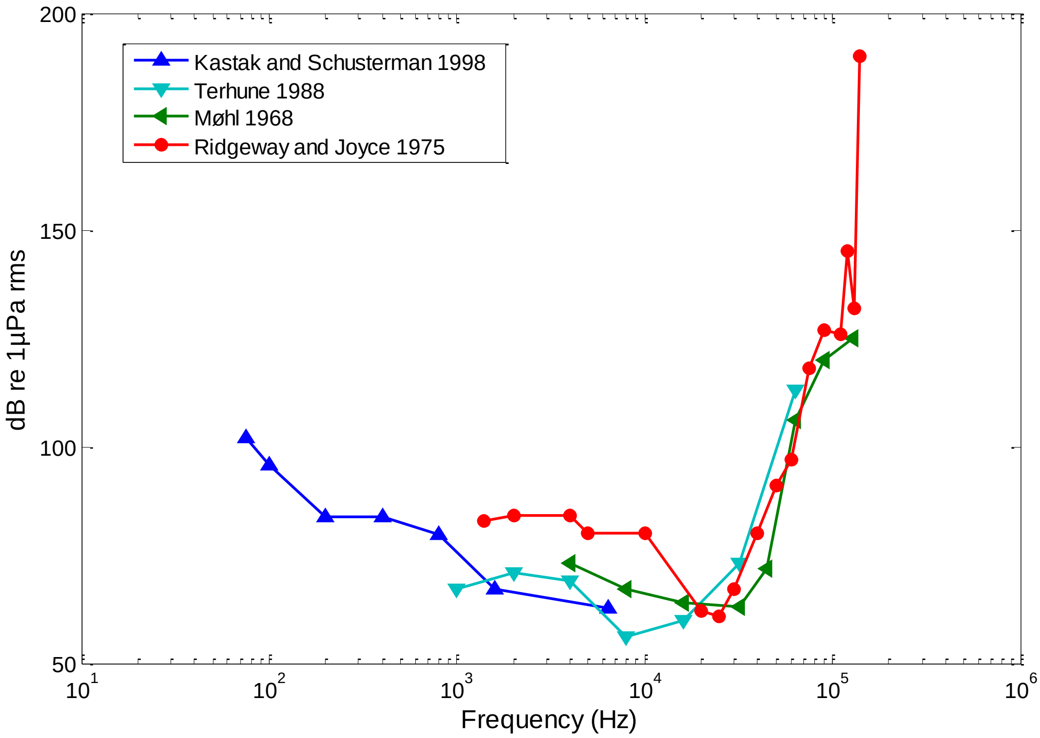

Figure 15 Audiograms for harbour seals modified from (Kastak & Schusterman 1998, Terhune 1988 and Møhl 1968). Audiogram for grey seals modified from (Ridgway & Joyce 1975).

8.2.4 Sensitivity to offshore wind farm construction

Table 10 Sensitivity of the grey seal to construction of the OFW Bałtyk Środkowy III.

Sensitivity/vulnerability to the potential impact of the OWF							
Construction phase							
Species	**Impact factor**		**Effect**	**Scale**	**Likelihood**	**Duration**	**Sensitivity**
Grey seal (*Halicho-erus grypus*) and	Noise	Monopile	PTS	Local	Medium	Long-term	Moderate
			TTS	Regional	Medium	Short-term	High
			Avoidance behaviour	Local	Medium	Short-term	Low
		Tripod foundation	PTS	Local	Low	Long-term	Moderate
			TTS	Regional	Medium	Short-term	High
			Avoidance behaviour	Local	Medium	Short-term	Low
		Jacket foundation	PTS	Local	Low	Long-term	Moderate

Sensitivity/vulnerability to the potential impact of the OWF						
Construction phase						
Species	Impact factor	Effect	Scale	Likelihood	Duration	Sensitivity
		TTS	Regional	Medium	Short-term	High
		Avoidance behaviour	Local	Medium	Short-term	Low
	Gravity base foundation/ dredging noise	PTS	Local	Negligible	Long-term	Very low
		TTS	Local	Negligible	Short-term	Very low
		Avoidance behaviour	Local	Negligible	Short-term	Very low
	Shipping	PTS	Local	Negligible	Long-term	Very low
		TTS	Local	Low	Short-term	Low
		Avoidance behaviour	Local	Low	Short-term	Low
	Ship strikes	Ship strikes	Local	Low	Long-term	Low
	Suspension of sediment	Affecting prey species	Local	Low	Short-term	Low
	Pollutants	Affecting prey species	Local	Negligible	Long-term	Low
	Changes in habitat	Visual effects	Local	Medium	Short-term	Moderate

As shown in the Table 10, the grey seal is highly sensitive to short term TTS caused by noise produced during pile driving of monopile, tripod and jacket foundations, which can appear with a medium likelihood. This impact factor, with a moderate likelihood might also result in long-term PTS, to which seals have moderate sensitiveness. Sensitivity of seals to the gravity base foundation, dredging noise and shipping noise is low and very low, and the likelihood of these factors impact is either low or negligible.

Table 11 Sensitivity of the grey seal to operation of the OFW Bałtyk Środkowy.

Sensitivity/vulnerability to the potential impact of the OWF								
Operational phase								
Species	**Impact factor**		**Effect**	**Scale**	**Likelihood**	**Duration**	**Sensitivity**
Grey seal (*Halichoerus grypus*)	Turbine noise	Monopile	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	Negligible	Short-term	Very low
		Jacket foundation	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	Negligible	Short-term	Very low
		Gravity base foundation	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Negligible	Short-term	Very low
			Avoidance behaviour	Local	Negligible	Short-term	Very low
		Service and maintenance traffic	PTS	Local	Negligible	Long-term	Very low
			TTS	Local	Low	Short-term	Low
			Avoidance behaviour	Local	High	Short-term	Moderate
	Shipping		Ship strikes	Local	Low	Long-term	Low
	Electromagnetic fields		Affecting prey species	Local	Negligible	Long-term	Very low
	Changes in habitat	Visual	Glints, moving shadows	Local	Low	Long-term	Low
		Reef effects	Improved foraging opportunities	Local	Medium	Long-term	Moderate/ Positive

As can be seen in the Table 11, effects of wind farm operation on seals are very similar to porpoises, with most of them being of a moderate likelihood. As for porpoises, the avoidance behaviour of seals might very probably appear during the maintenance traffic, as well as the positive reef effect can occur.

8.2.5 Sensitivity to offshore wind farm dismantling

According to the information provided about the decommissioning options, the use of explosives is not planned. Pile driving will most likely also not be used (Haskoning 2014).

Table 12 Sensitivity of the harbour porpoises to dismantling of the OFW Bałtyk Środkowy.

Sensitivity/vulnerability to the potential impact of the OWF						
Operational phase						
Species	**Impact factor**	**Effect**	**Scale**	**Likelihood**	**Duration**	**Sensitivity**
Harbour porpoise (*Phocoena phocoena*)	Decommissioning shipping	PTS	Local	Negligible	Short-term	Very low
		TTS	Local	Low	Short-term	Low
		Avoidance behaviour	Local	High	Short-term	Low
	Decommissioning shipping	Ship strikes	Local	Low	Short-term	Low
	Drilling	PTS	Local	Negligible	Short-term	Very low
		TTS	Local	Low	Short-term	Low
		Avoidance behaviour	Local	High	Short-term	Low

8.3 Harbour Seals

8.3.1 Protection status in Polish waters

Harbour seals are listed in the EU Habitat Directives Appendix II, and under the Habitats Directive Special Areas of Conservation (SACs). Harbour seals are also protected under the HELCOM agreement. In Polish law, the grey seal is listed in the Appendix I of the Regulation of the Minister of Environment concerning species protection, as well as in the Nature Conservation Act. The risks posed to these species when establishing the offshore wind farm Bałtyk Środkowy III should therefore be assessed.

8.3.2 Abundance and distribution in Polish waters

For harbour seals there are some uncertainties regarding the population numbers. There is some evidence that the harbour seals that could be encountered in Polish waters come from a separate subpopulation of seals with haul-out sites at Falsterbo, Saltholm and Bøgestrømmen. This subpopulation is somewhat isolated from harbour seals in Kattegat and Skagerrak Seas, with a split occurring around Gedser (Olsen *et al.* 2014). At the BŚ III site harbour seals occur only very sporadically.

8.3.3 Sensitivity to underwater sound

Please refer to section 8.2.3.

8.3.4 Effects of construction, operation and dismantling

It is likely that harbour seals have very similar sensitivities to grey seals with regard to offshore wind farms. The sensitivity tables are thus identical between the two species (please refer to Table 10 - Table 12).

9 Environmental impact assessment for the variant chosen for realisation and rational alternative variant

9.1 Project impact assessment

9.1.1 Construction

The four foundation types for the variant chosen for realisation and alternative rational variant considered for construction of the Bałtyk Środkowy III offshore wind farm were screened in order to assess the potential impact of the windfarm on marine mammals. The screening was undertaken on the basis of the overall acoustic footprint in the form of the cumulative sound exposure level (SEL) emitted into the water column as is documented in detail in the background report - *Numerical modelling of noise propagation from pile driving* (DHI 2015). It has to be mentioned that both variants were assessed to have the same acoustic footprint, and thus can be considered as having the same potential effect on marine mammals. Here, and in the following chapters, we will make use of the results of this detailed study in a summarised form.

There is a common understanding that physiological effects due to noise exposure are related to the dose of exposure which involves the duration of impact (Southall *et al.* 2007). The cumulative sound exposure level is the best analytical description of the 'acoustic dose' from an activity that covers the entire acoustic energy as emitted. In principle, the acoustic events (=single pile driving strikes) are added to one another to arrive at this dose. The term cumulative sound exposure level is used in underwater acoustics (see for example Gill *et al.* 2012). It should not be confused with 'cumulative impacts' that are usually used when impacts from several different locations (for example different projects) are analysed.

Based on the comparison of different 'acoustic doses' (=cumulative sound exposure level), the 7.5 m diameter and 10 m diameter monopile with impact pile driving turned out to be the worst-case.

Table 13 summarized the overall sound level of the different combinations used in the modelling, i.e. SEL, Cumulative SEL and SPL without and with mitigation, respectively. Table 13 summarises the input parameters for the detailed quantitative analysis of the pile driving sound.

Table 13 Summary of overall source levels for the variant chosen for realisation and rational alternative variant (8 MW and 7.5 m diameter pile; 10 MW and 10 m diameter pile).

Variable	Dimension
SL SEL dB re 1 μPa^{2}·s	220 dB re 1 μPa^{2}·s
SPL zero to peak (dB re 1μPa)	240 dB re 1 μPa
SEL_{cum} 1-hour period in (2800 strikes)	254,47 dB re 1 μPa^{2}·s
SEL_{cum} 24-hour period in (8400 strikes)	259,24 dB re 1 μPa^{2}·s
Mitigation SL SEL dB re 1 μPa^{2}·s	206 dB re 1 μPa^{2}·s
Mitigation SPL zero to peak (dB re 1μPa)	226 dB re 1 μPa
Mitigation SL SEL_{cum} 1-hour period in (2800 strikes)	240,47 dB re 1 μPa^{2}·s
Mitigation SL $SEL_{cum\ 24}$-hour period in (8400 strikes)	245,24 dB re 1 μPa^{2}·s

Zero state ambient noise input

In order to describe the change in the noise situation due to the construction of BŚ III, we used the background noise spectrum as recorded in spring 2013. This particular season was chosen because the acoustic modelling was also undertaken for spring conditions (=worst case). The spectrum is covering the 1/3 octave bands from 40 Hz to 10 kHz. 10 kHz was used as the upper limit as there was no considerable acoustic energy in the frequencies above that distance from the pile driving, so a comparison would be meaningless. As can be seen in Figure 16, the spectrum shows most energy below 1 kHz and a drop thereafter (the increase at around 5 kHz is probably an artefact due to clapping noise from the mooring system).

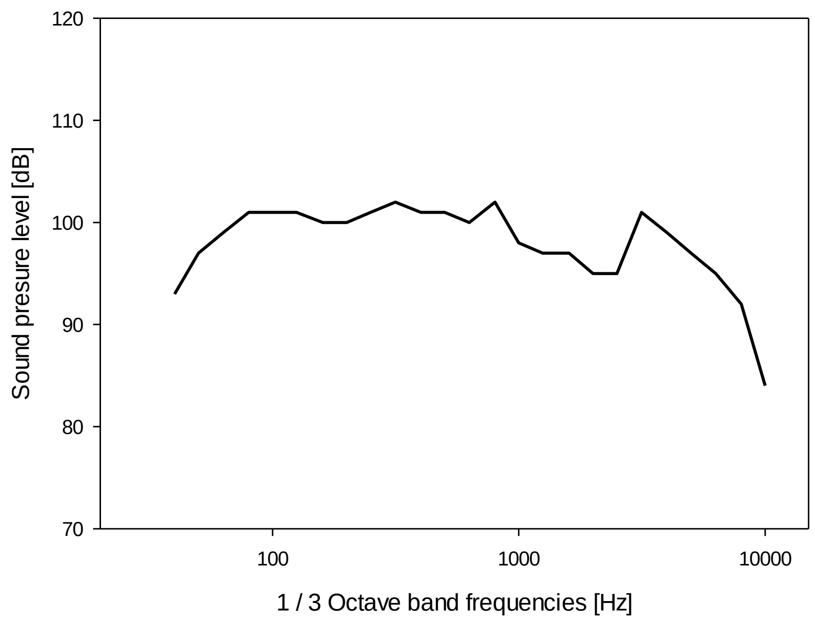

Figure 16 1/ 3 Octave band spectrum of mean ambient background sound recorded in spring 2013 at the BŚ III site.

Impact criteria for underwater noise for the variant chosen for realisation and rational alternative variant

Generally, the effect of noise on marine mammals can be divided into four broad categories that largely depend on the individual's proximity to the sound source:

- Detection
- Masking
- Behavioural changes/Cessation of normal behaviour
- Physical damages

It is important to note that the limits of each zone of impact are not sharp, and that there is a large overlap between the different zones. Behavioural changes, masking and detection also critically depend on the background noise level, and all impacts depend on the age, sex and general physiological and behavioural states of the animals (see, for example Southall *et al.* 2007) If there is a frequency-overlap between the produced noise and signals of relevance for an animal, there is a risk that the noise can mask relevant signals to some extent. Masking could reduce detection distances of communication signals and signals essential for foraging or navigation. For pulsed sounds as those produced by pile driving masking is in principle not relevant (Madsen *et al.* 2006 but see Thomsen *et al.* 2006b), but for noise from the associated increase in shipping this could be of some concern. For harbour porpoises masking is not relevant as there is no overlap between porpoise communication clicks (main frequency ~ 130 kHz, (Villadsgaard *et al.* 2007) and shipping noise with main frequencies below 1 kHz in most cases (Richardson *et al.* 1995). But for harbour seals and grey seals underwater communication sounds could overlap with shipping sound (Van Parijs *et al.* 2000) and masking of communication signals could occur at considerable distances (~75 km based on ship noise values from (Arveson and Vendittis 2000), and hearing thresholds from (Møhl 1968; Terhune 1988; Kastak & Schusterman 1998).

Behavioural changes range from very strong reactions, such as panic or flight, to more moderate reactions where the animal may orient itself towards the sound or move slowly away or will cease with an on-going behaviour. However, the animals' reaction may vary greatly depending on season, behavioural state, age, sex, as well as the intensity, frequency and time structure of the sound causing behavioural changes (see Nowacek *et al.* 2007).

Noise-induced threshold shifts in the hearing system can lead to changes in the animals' detection threshold either temporarily (TTS) or permanent (PTS). Noise-induced PTS has only been documented in a single laboratory study and is probably not very common in wild populations, as the animals need to be very close to the sound source for most kinds of anthropogenic sound sources. The hearing loss is therefore usually only temporary and the animal will regain its original detection abilities after a recovery period. However, prolonged exposures of continuous noise, where the ear is exposed to TTS inducing sound pressure levels before it has had time to recover, may result in a building TTS. TTS of 50 dB or more will often result in permanent hearing damage (Ketten 2012). For PTS and TTS the sound intensity is an important factor for the degree of hearing loss, as is the frequency, the exposure duration, and the length of the recovery time (Popov *et al.* 2011).

Harbour porpoises

Harbour porpoises are sensitive to a wide range of human sounds at relatively low exposure levels (Southall *et al.* 2007). (Lucke *et al.* 2009) found that captive harbour porpoises exposed to an airgun sound showed avoidance behaviour at received sound exposure levels ~145 dB re 1 μPa^{2}s. Studies looking at the behavioural impacts of pile driving in wild harbour porpoises have confirmed these findings and in cases even indicate lower reaction thresholds at app. 140 dB re 1 μPa$^{2 \cdot s}$ (Brandt *et al.* 2011, Dähne 2013; see Betke 2014). Based on these studies a behavioural threshold of 140 dB re 1 μPa^{2}s SEL was used to estimate the zone of avoidance.

PTS has not been investigated in the harbour porpoise, but (Lucke *et al.* 2009) also measured TTS in this species when exposed to a single sound pulse from an airgun array. The TTS limit was at 164 dB re 1 μPa^{2}s SEL (TTS = 6 dB, recovery of hearing after >4 h). A TTS of 6 dB will half the distance over which an animal can detect a sound at the TTS frequency. A study by Popov *et al.* 2011 investigated TTS in another Phocoenoid species, the Yangtze finless porpoise (*Neophocaena phocaenoides asiaeorientalis*). When exposed to prolonged noise (30 min) between 32 and 128 kHz, TTS could be induced at sound pressure levels as low as 140 dB re 1 μPa. (Popov *et al.* 2011). Kastelein *et al.* 2012b also induced TTS in a harbour porpoise using low levels of octave band noise centred around 4 kHz in longer duration exposures. An exposure of 124 dB re 1 μPa for 120 min caused a TTS of 6 dB. The TTS values found by Kastelein *et al.* 2012 and Popov *et al.* 2011 may be important when considering the effects of shipping and turbine noise, but are not relevant for discussing pulsed sounds from pile driving. It is important to consider, however, that in harbour porpoise, TTS happens close to the main frequency of the impact sounds both for continuous tones (Kastelein *et al.* 2013) and impulsive low frequency sounds (Lucke *et al.* 2009). Pile driving noise is broadband, but has most of its energy at the lower frequencies (i.e. < 1 kHz). There is no indication that TTS at these frequencies affects the ability of porpoises to navigate and forage using echolocation (harbour porpoise clicks are at ~ 130 kHz), (Villadsgaard *et al.* 2007). Potentially, the ability to detect low frequency vessels could be affected. However, as most vessel noise is much below 1 KHz where porpoise hearing is poor in the first place, the biological relevance of TTS at these low frequencies is difficult to assess.

Error! Reference source not found. Table 14 summarizes the criteria used for evaluating noise effects on harbour porpoises.

Table 14 Response criteria for harbour porpoises from Southall *et al.* 2007 and Lucke *et al.* 2009.

Harbour porpoises	PTS	TTS	Behaviour
SPL	230 dB re 1μPa peak	224 dB re 1μPa peak	-
SEL	198 dB re 1μPa^2-s (M_{hf})	183 dB re 1μPa^2-s (M_{hf})/ 164 dB re 1μPa^2·s	140 dB re 1μPa^2·s

Harbour seals and grey seals

According to (Southall *et al.* 2007) no studies have observed behavioural changes corresponding to strong avoidance in seals. This is in line with observations that both harbour seals and grey seals do not react to construction noise at haul out sites and are generally known to habituate fast, even to relatively loud sound levels (Edrén *et al.* 2010). (Southall *et al.* 2007) suggests a behavioural criterion for avoidance behaviour based on the criterion for TTS onset; this criterion will be adopted here.

For seals (Southall *et al.* 2007) gives a PTS limit of 218 dB re 1 μPa peak (186 dB re 1 μPa^{2}s SEL), and a TTS limit of 212 dB re 1 μPa (171 dB re 1 μPa^{2}s SEL) under water. These values are based on a study of a single harbour seal. TTS in a harbour seal exposed to longer duration noise has recently been investigated by (Kastelein *et al.* 2012a). TTS of approx. 6 dB was induced after 60 min. exposure to 136 dB re 1 μPa octave band noise centred around 4 kHz.

Table 15 summarizes the criteria used for evaluating noise effects on harbour seals and grey seals.

Table 15 Response criteria for harbour seals and grey seals ((Southall *et al.* 2007).

Harbour seal	PTS	TTS	Behaviour
SPL	218 dB re 1μPa peak	212 dB re 1μPa peak	-
SEL	186 dB re 1μPa^2-s (M_{hf})	171 dB re 1μPa^2-s (M_{pw})	171 dB re 1μPa2 -s (M_{pw})

Impact criteria for suspension of sediment

It is likely that there will be very little impact from the suspension of sediment on marine mammals, both in terms of impact on navigation and with regards to increased release of contaminants to the water column. It is therefore not relevant to propose response criteria for the suspension of sediments or contaminants.

Impact criteria for changes in habitat

The ranges of effects from changes in habitat due to construction and dismantling will most likely be minimal compared to the ranges for noise effects, and any negative effects will be negated, as the animals will be out of range due to noise effects. Effects of changes to the habitat during operation will most probably be positive. Response criteria for effects of behavioural changes are not feasible.

Results of the numerical modelling of noise from pile-driving for the variant chosen for realisation and rational alternative variant

The detailed results of the noise modelling are described in more detail in the accompanying noise modelling report. What follows is a summary of the results for a better understanding of the following assessment.

The results from the numerical underwater noise modelling for the variant chosen for realisation and rational alternative variant showed that the sound transmission was dependant on the water depth and the frequency of the pile driving sound.

Figure 17 shows the depth and range-dependent received sound exposure level for the variant chosen for realisation and rational alternative variant in spring which was the most conservative scenario, respectively, for the transect heading 30ºN (remainder see the acoustic modelling report).

The black line marks the depth with the highest sound level at any given range, corresponding to the level reported in Table 13.

From Figure 17 one may observe a horizontal propagation path of the sound at a depth of ~30 m. This is caused by the shape of the sound speed profile, which leads to an acoustic duct (please refer to the acoustic modelling report). Almost no interaction with the bottom is observed, which results in a slow attenuation of the sound.

The profiles from the 11 remaining directions can be found in Appendix A of the acoustic modelling report.

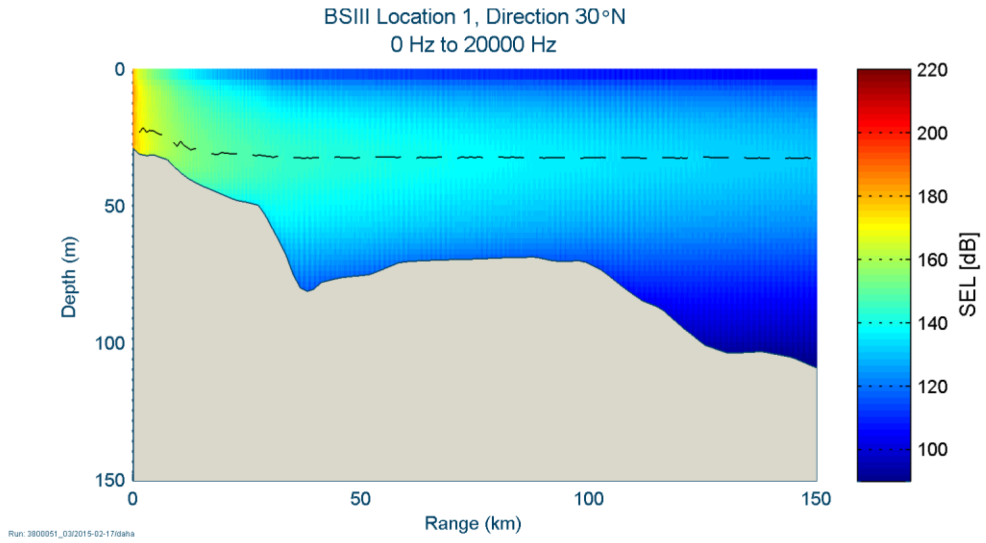

Figure 17 Received sound exposure level for the variant chosen for realisation and rational alternative variant. At different water depths at an exemplary position from the BS III planned site.

Figure 18 depicts the received sound exposure level for the variant chosen for realisation and rational alternative variant for frequencies above 2 kHz. When comparing the results with Figure 17, it is clear that higher frequencies attenuate fast and do not contribute to the received sound level at larger distances. This is an important finding as harbour porpoises have a better sensitivity at the higher frequencies (i.e. > 2 kHz) compared to lower ones (i.e. < 2 kHz).

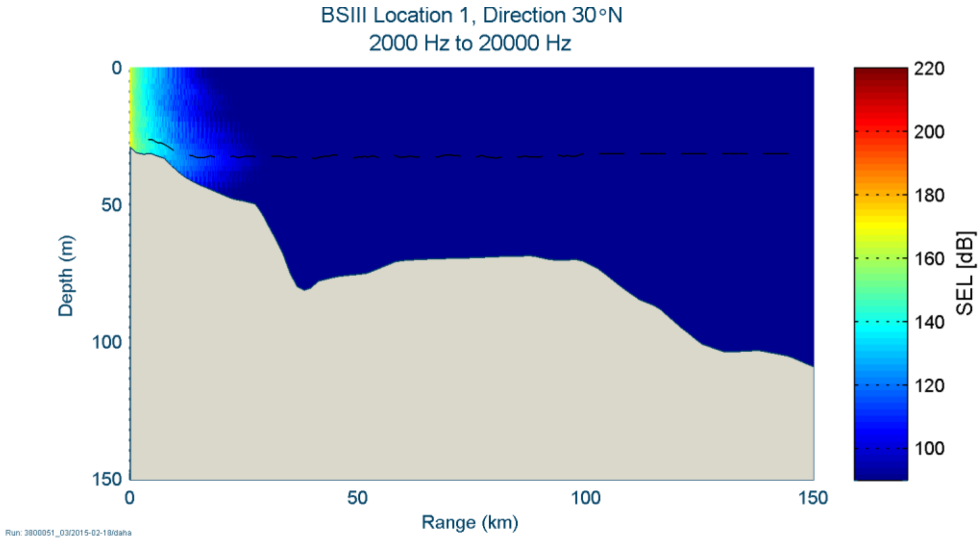

Figure 18 Received sound exposure level. Frequency range 2kHz - 20kHz.

Figure 19 shows the spectra of the received sound level for the variant chosen for realisation and rational alternative variant at different distances from the source, and reveals the frequency dependence of the attenuation. The figure also includes the ambient noise situation as measured in spring 2013 (= worst case which is directly comparable). It is important to consider here that the range over which the pile driving signal can be perceived and has an impact which is in general determined by the relationship between the intensity of the pile driving pulse and the level of ambient noise. It can be seen that at this position frequencies between app. 80 Hz and 700 Hz are well above ambient noise at 140 km and can thus have an impact on marine life that is sensitive in that frequency range.

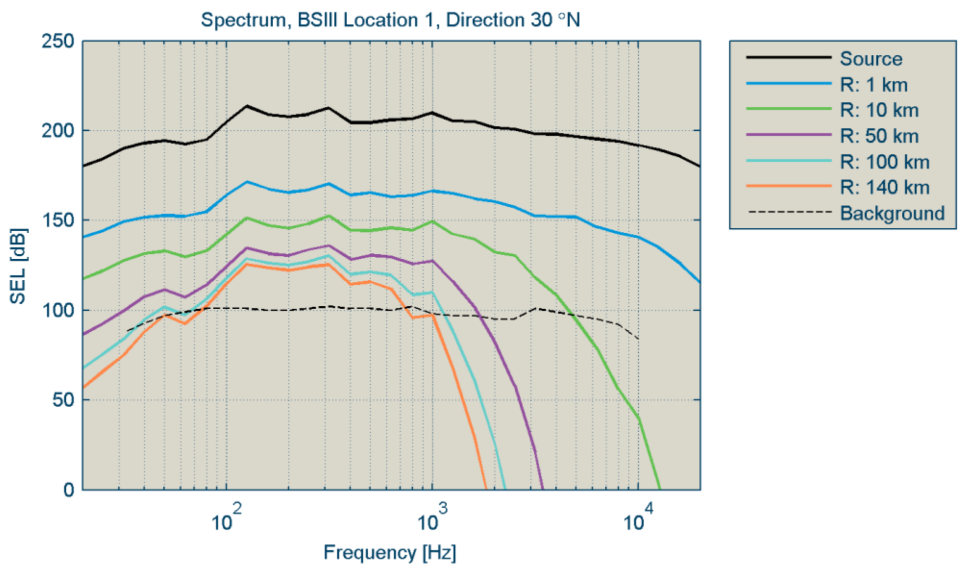

Figure 19 Spectra of received sound exposure level at various distances from the source in direction 30ºN. Note that the distances from the source are non-equidistant.

In total the acoustic modelling for the variant chosen for realisation and rational alternative variant was undertaken using 12 lines (=traces) out from the centre of the project area that had different length (maximum 150 km, depending on the distance to the coast). The effective range is the range at which the pile driving sound is above the ambient sound (frequency range 40 Hz – 10 kHz; distinct ranges can differ). It can be seen that at some positions the effective range was nearing the maximum of the modelling range, whereas at other positions it was much lower, depending on the exact bathymetric profile and the distance to land (see Table 16).

Table 16 Effective range of modelled 1 / 3 octave band noise from pile driving for the variant chosen for realisation and rational alternative variant at the planned BŚ III site (frequency range differs).

Modelling Position	Effective range of pile driving pulse [km]
0º N	> 50 < 100
30º N	> 140
60º N	< 140
90º N	> 50 < 100
120º N	> 10 < 50
150º N	> 10 < 50
180º N	> 10 < 50
210º N	> 10 < 50
240º N	> 50 < 100
270º N	50
300º N	> 140
330º N	> 140

Noise maps for the variant chosen for realisation and rational alternative variant

The directional variability of the sound spread can be further seen in the sound maps generated based on the modelling. It is visible that the ranges of sound differ in the horizontal plane. The directional differences in sound attenuation are caused by effects near the coast and bathymetric elevations (sandbanks). Cumulative sound levels (1 h) are much higher than single strike ones. For the full range of maps, please refer to Appendix 1.

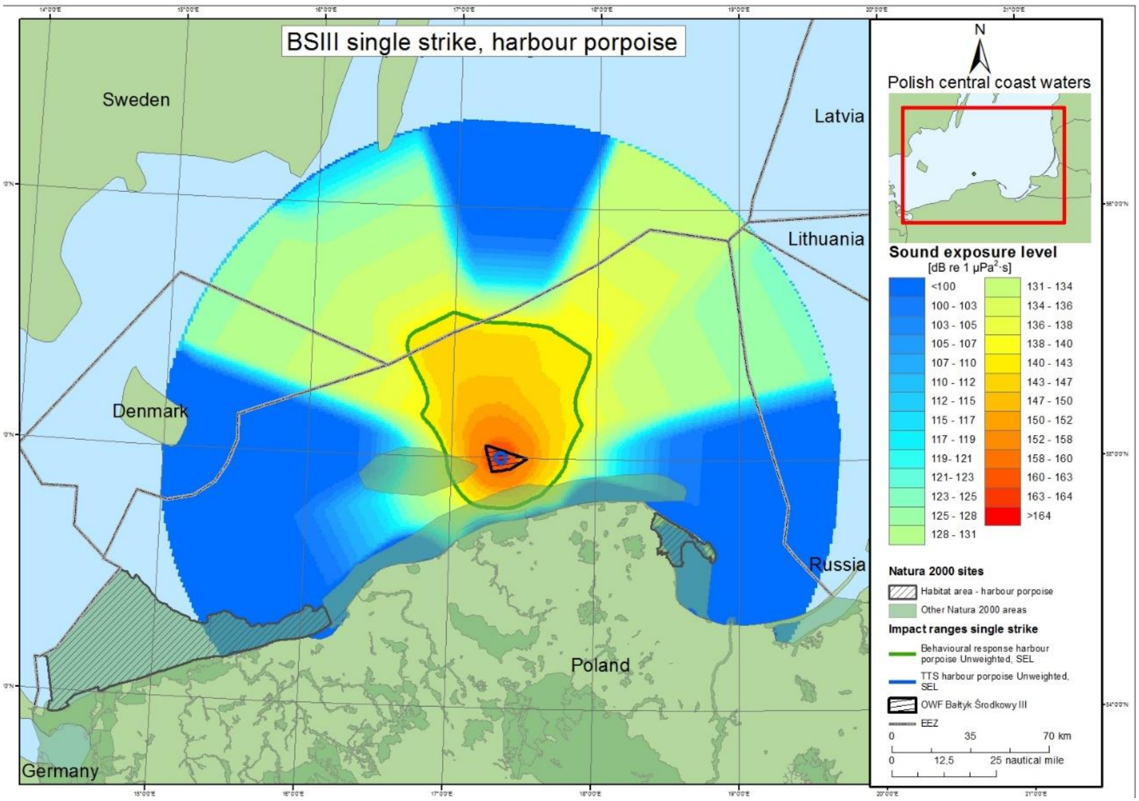

Figure 20 Sound map in SEL (= dB re 1μPa^2·s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant (7.5 -10 m pile diameter).

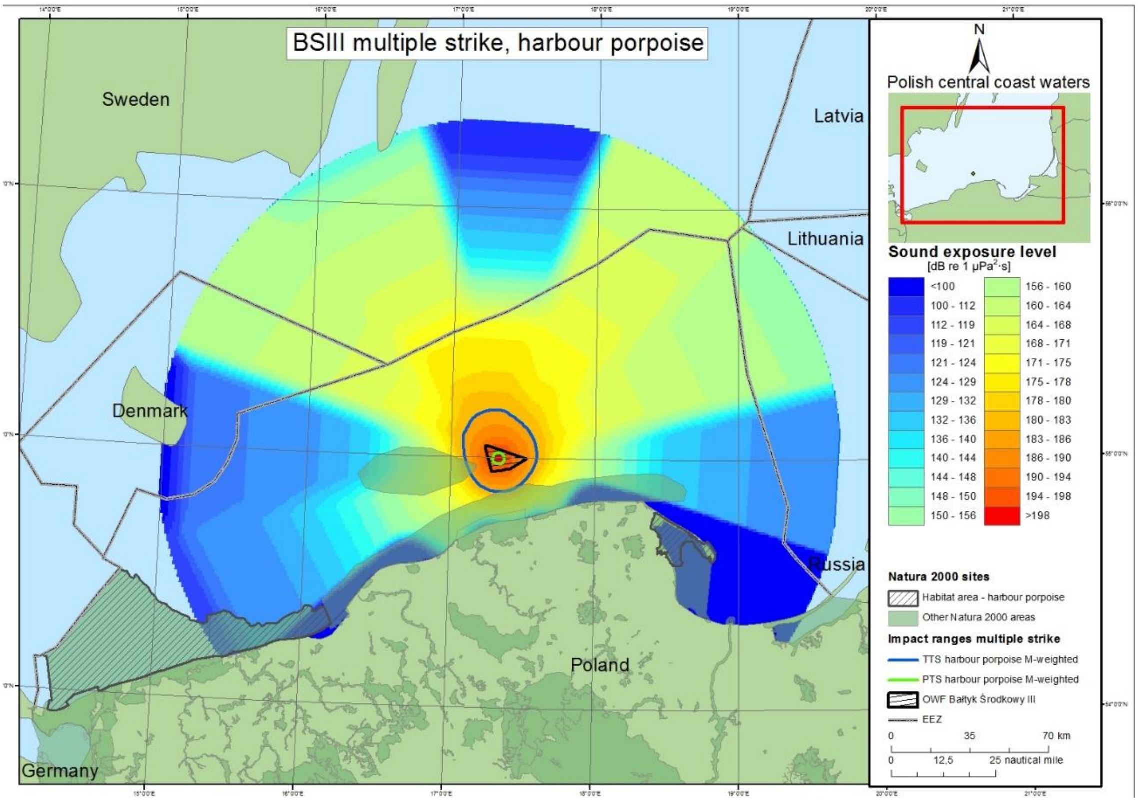

Figure 21 Sound map in SEL (= dB re 1μPa^2·s) of the sound transmission of pile strikes over 1 h duration of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant (7.5 -10 m pile diameter) (note that calculations are for high frequency cetaceans, so sound spread cannot be compared to Figure 20).

Impact on harbour porpoises

Based on the criteria for injury, noise induced threshold shifts and avoidance behaviour described above, impact ranges have been modelled using noise levels estimated for the variant chosen for realisation and rational alternative variant (7.5 and 10 m diameter single pile). The noise levels for the injury criteria were M-weighted based on the weighting curve for high frequency cetaceans from (Southall *et al.* 2007). The impact range results of the modelling for harbour porpoises are shown in Table 17. It is very clear from the assessment that any physical impacts (PTS) due to the exposure of a single strike are restricted to very close ranges from the source (<20 m). Temporary noise induced threshold shifts (TTS) can occur at considerable distances (approx. 6 km) from the noise source. However, the criterion for TTS is not an M-weighted criterion, therefore though the total energy may still be significant at 6 km, the energy that affects harbour porpoise hearing may not be as pronounced (NOAA 2013). Behavioural responses in harbour porpoises can occur at ranges of up to almost 70 km from the source. These large scale behavioural reactions will not lead to any barrier effect. A barrier effect can only occur, if animals of a distinct population are hindered in their migration to travel from one area to another, for example at narrow passages. The situation at BŚ III is different as the behaviour impact zone is located in an open water providing the possibility of both east to west and north to south movements. However, an exclusion from a habitat due to behavioural reactions is expected. But this will be short term (= during the whole construction period but not beyond). It has been shown by (Brandt *et al.* 2011), that pile driving can cause behavioural changes of porpoises up to 72 hours after pile driving has stopped. This effect was detectable up to 17.8 km. Recovery effect of porpoise abundance up to 4.7 km was longer than pauses between pile driving events in this study. According to these data it is most likely that porpoises will avoid an area where pile driving will take place and consequently porpoise activity due to pile driving in project areas may decrease for the whole pile driving period, as it was shown in (Brandt *et al.* 2011) study. It should be noted that avoidance of piling area by porpoises will reduce the possibility of TTS or PTS occurring due to a high noise levels, and habitat exclusion should not be considered only as a negative impact.

For cumulative strikes (= strikes that are emitted from one pile driver in succession) these distances increase substantially, with PTS occurring at distances of close to 5 km and TTS possibly occurring at distances of more than 22 km. These ranges are based on the assumption that it is the energy content of the signal that determines the threshold of TTS. So the higher the number of strikes the larger is the impact range. This assumption still needs to be tested experimentally for harbour porpoises before it can be verified. However there is some validation for this "equal energy hypothesis" for bottlenose dolphins (Finneran *et al.* 2005; NOAA 2013). The 164 SEL TTS criterion is also only validated for single strikes, it is therefore not used for assessing the cumulative exposure to multiple strikes.

Impact ranges for multiple strikes will thus be larger than for single strikes. But based on the uncertainties of the criteria for multiple strikes as well as the validity of the underlying assumptions, these ranges are fraught with some uncertainty. The noise modelling of multiple strikes was based on draft recommendations by (NOAA 2013) (currently under review). The recommendations advise using a period of 1 hour to assess the cumulative impacts, when animal movements cannot be included in the noise model. It is quite clear that the single strike TTS ranges will affect porpoises regardless of their movement, as they will not have the chance to leave the impact zone. With regard to multiple strikes it is likely that animals move out of the zone of danger. But since the exact reaction pattern in response to noise is not known, we opted for the 1-hour integration time as recommended by (NOAA 2013). As mentioned above, most probably animals will swim away due to behavioural response to noise, thus for the cumulative strikes the avoidance reaction range was assumed to be the same as for single strikes.

Table 17 Ranges of impact on harbour porpoises for single and cumulative pile strikes for the variant chosen for realisation and rational alternative variant (7,5 and 10 m diameter monopile) (see detailed results in the acoustic modelling report)).

Effect	Maximum range to threshold (single strike)	Maximum range to threshold (cumulative strikes)
PTS	20m	5000 m
TTS	5700 m	22100 m
Avoidance	68100 m	68100 m

Assessment of impact on harbour seals and grey seals

Similar to the porpoise assessment, the impact ranges for seals have been modelled using noise levels estimated for the variant chosen for realisation and rational alternative variant (7.5 and 10 m diameter single pile), and are based on the criteria for injury and noise induced threshold shifts described above. The noise levels for the injury criteria were M-weighted based on the weighting curve for pinnipeds under water from (Southall *et al.* 2007). Modelling of the underwater noise is described in more detail in the accompanying noise modelling report. The impact range results of the modelling for harbour seals and grey seals are shown in Table 18.

The impact ranges for both single and multiple strikes are in some cases larger for harbour seals and grey seals than for harbour porpoises. This is due to their relatively more sensitive hearing at the lower frequencies. Physical impacts (PTS) due to the exposure to a single strike are restricted to a relatively close range of the source (approx. 300 m) for both seal species; however, for cumulative strikes this range increases to 20 km. Temporary threshold shifts (TTS) can occur at considerable distances (approx. 3 km) from the noise source even for singles strikes, but for cumulative strikes this range is almost 85 km. For cumulative strikes these ranges thus increase significantly, but similar to the harbour porpoises the criteria for multiple strikes are fraught with uncertainty due to very few experimental data on a very limited number of individuals. The assumption of equal energy is not tested on pinnipeds either ((NOAA 2013) and see above discussion on porpoises)). The cumulative noise ranges are therefore still highly speculative.

There is very little information regarding behavioural changes in seals in response to noise. Behavioural changes are therefore not included in the assessment.

Table 18 Ranges of impact on harbour seals and grey seals for single and cumulative pile strikes for the variant chosen for realisation and rational alternative variant ((7.5 and 10 m diameter monopile) monopile (see detailed results in the acoustic modelling report)).

Effect	Maximum range to threshold (single strike)	Maximum range to threshold (cumulative strikes)
PTS	300 m	20900 m
TTS	2700 m	83700 m
Avoidance behaviour	2700 m	2700 m

Proportion of animals affected

The proportion of the harbour porpoise population that will be affected by noise emitted during the construction of the BŚ III offshore wind farm is highly dependent on the population size estimate of harbour porpoises in the Baltic. As described in chapter 8, the size of the population of harbour porpoises in the Baltic is still currently not known with certainty and highly debated. The accepted current census of harbour porpoises in the north-eastern part of the Baltic is from the SAMBAH investigations from 2014, with an estimated number of 447 animals (95% CI 90-997). The upper and lower values of the confidence interval, the impact ranges presented and SAMBAH density values, were used to estimate the number of animals and the proportion of the population affected by PTS and TTS inducing sound levels, as well as the number and proportion of animals expected to exhibit behavioural changes (Table 19). It is clear that the strongest impact is expected to be behavioural effects where between 1 and 11% of the population may be affected depending on the actual population size. The impacts on the population are therefore potentially substantial. However, harbour porpoises are not expected to be evenly spread out over the Baltic, but may be found in higher densities in local areas, such as the Puck Bay, where a land barrier will negate the effects of noise from the BŚ III area. The population effects presented here is therefore considered a worst case scenario. The very low densities of grey seals in the area (only 1 animal was sighted in the marine mammal monitoring programme presented in the accompanying marine mammal baseline report) indicates the number of individuals affected is likely very low, except for TTS for cumulative strikes where animals may be affected at distances of up to 84 km from the construction site. However, combined with a relatively large estimated population size (29 633 individuals in the Central and Southern Swedish Baltic and Western Estonian waters, (Jonas Teilmann pers. comm.)), the effect on the population will most likely still be very low.

The total number of harbour seals in the Baltic is relatively low, with an estimated population size of 1 563 individuals in the Western Baltic (NOVANA census, Jonas Teilmann pers. comm.). The majority of these animals haul-out at Falsterbo, Saltholm and Bøgestrømmen, and are not likely to move more than 50-100 km from their haul-sites (Olsen *et al.* 2014). The proportion of animals affected by any of the impacts associated with the construction is therefore very likely to be very low.

Table 19 Estimated number of harbour porpoises affected by construction of the Bałtyk Środkowy III offshore wind farm. Population numbers are the upper and lower 95% CI population size estimates together with denisty estimates from the SAMBAH project (2014). (Benke et al. 2014).

Effect	Area affected (km^2)	Estimated density within model area (individuals/ km^2)	Number of animals affected within the model area	Number of individuals in genetic population	Percent of animals affected within population
PTS – single strikes	0.0013	0.00068-0.0075	0	90 / 997	0
PTS – cumulative strikes	78.5	0.00068-0.0075	0-1	90 / 997	0
TTS – single strike	102	0.00068-0.0075	0-1	90 / 997	0
TTS – cumulative strikes	1534	0.00068-0.0075	1-12	90 / 997	1.2/ 1.15
Avoidance behaviour	14569	0.00068-0.0075	10-109	90 / 997	11 / 10,9

Noise from shipping

Small fast ships such as barges and supply ships produce noise with energy content primarily below 1 kHz (Richardson *et al.* 1995). However, there may still be considerable energy at frequencies also above 1 kHz. Harbour porpoises, harbour seals and grey seals are more sensitive at higher frequencies, the high-frequency components of vessel noise could thus potentially pose a problem for the animals, and the presence of boats in the area could result in displacement of porpoises. The severity of such disturbances depends on the kind and number of boats which in this case will be small- to medium-sized maintenance and construction ships and jack up vessels (Haskoning 2014). For harbour porpoises' reaction distances are approx. 1 km for vessel noise (based on measurements by (Arveson and Venditis 2000), on the criteria for effects of noise presented above, and assuming a transmission loss of 15 log(r)). Given that some of the most trafficked areas in Danish waters are also areas with a very high abundance of harbour porpoises (Sveegaard *et al.* 2011), any displacement of harbour porpoises due to shipping noise is therefore expected to be short-term, and over relatively short distances. The same is expected for the two seal species considered here.

There is a risk that increased noise from boats could cause TTS in the three marine mammal species considered here, but ambient noise levels are not expected to increase significantly from the increase in shipping due to construction. Therefore TTS is not expected as a consequence of construction associated shipping noise for either species.

Suspension of sediments

The suspension of sediments in association with construction is expected to be minimal, and is not likely to have an effect on harbour porpoises, harbour seals or grey seals. An increase in suspended contaminants as a consequence of suspension of sediments is probably also insignificant.

Changes in habitat

The changes in habitat associated with construction encompass changes to the sea floor and increased presence of vessels on the sea-surface. Any effects from these changes are most probably insignificant compared to the effects of noise from construction.

Assessment of the significance of impacts during construction

For the impact assessments, the methodology outlined by SMDI was used. The importance of grey seals and harbour seals is evaluated as moderate considering their protection status and the population numbers, but harbour porpoises are considered to be of high importance due to their protected status as well as their status as critically endangered, even though their presence in the BŚ III area must be considered low.

The scale of the exposure evaluates the range of the effect to be of local, regional, national or even international importance. TTS is a local to regional effect based on the number of strikes evaluated, whereas behavioural effects can be both regional and national depending on the species being considered. The frequency of the impact can be single, repetitive or constant, with pile-driving noise being repetitive. The duration of an effect is evaluated based on the persistence of the effect. PTS is long-term, while TTS is short-term. Behavioural impacts are assessed to be short-term (see chapter 7.1.1). The intensity describes the impacts effect on the animal affected, and can range from low to very high, where an effect such as TTS would be evaluated as a high impact. The reversibility of the impact is also an important factor when evaluating the overall severity of a given impact, which is finally evaluated on a scale ranging from insignificant to high.

The results of the impact assessment of construction are provided in Table 20. Please note that the overall significance is a combination between the scale of impact as identified here and the significance of the resource / importance. The latter one is ‘high’ for porpoises and ‘moderate’ for seals. As can be seen, the effects of noise on marine mammals are directly coupled to the activities, and for cumulative strikes these effects may be substantial, as the number of individuals affected can increase. It has to be noted that due to the number of turbines planned, the construction phase for the rational alternative variant will most likely be longer (200 monopiles compared to 120 monopiles for the variant chosen for realisation). Thus the variant chosen for realisation will be potentially less harmful for the marine life due to the shorter period of introducing high sound levels into the environment (pile driving activities).

Table 20 Overall effect of the construction activities on marine mammals (*based on DHI scoring, as this combination of scores was not found in SMDI methodology; NA = Not applicable as no impact was expected).

Species	Impact	Scale of exposure	Duration	Intensity	Frequency of impact	Reversibility	Scale of impact	Significance
Harbour porpoise (*Phocoena phocoena*)	PTS single	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PTS cumulative	Regional	Long-term	Very high	Repetitive	Irreversible	High	High
	TTS single	Regional	Short-term	High	Repetitive	Reversible	Low	Low
	TTS cumulative	National	Short-term	High	Repetitive	Reversible	Moderate	Moderate
	Avoidance behaviour	National	Short-term	Medium	Repetitive	Reversible	Low	Low
	Shipping noise	Local	Short-term	Low	Continuous	Reversible	Insignificant	Low
	Suspension of sediments	Local	Temporary	Low	Repetitive	Reversible	Insignificant	Low
	Changes in habitat	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Low
Harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*)	PTS single	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PTS cumulative	Regional	Long-term	Very high	Repetitive	Irreversible	High	Moderate
	TTS single	Regional	Short-term	High	Repetitive	Reversible	Low	Low
	TTS cumulative	International	Short-term	High	Repetitive	Reversible	High	Moderate
	Avoidance behaviour	Regional	Short-term	Medium	Repetitive	Reversible	Insignificant	Negligible
	Shipping noise	Local	Short-term	Low	Continuous	Reversible	Insignificant	Negligible
	Suspension of sediments	Local	Temporary	Low	Repetitive	Reversible	Insignificant	Negligible
	Changes in habitat	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Negligible

9.1.2 Operational phase

Noise from operating wind turbines

As outlined in detail in 7.2.1, the noise during operation of the wind farm will be on a much lower level than during construction. Yet, we have to consider here that it will be emitted over the course of the lifetime of the project which can well be in excess of 20 years.

The pre-2006 knowledge on noise emissions from operational offshore wind farms has been summarised by (Madsen *et al.* 2006) and (Thomsen *et al.* 2006b). Both studies indicated that existing wind farms only add to the existing ambient noise field to a very limited extent and consequently impacts on marine mammals have been assessed to be generally low. Since then (Nedwell *et al.* 2007) have provided a very comprehensive measurement campaign covering the operation of the North Hoyle, Scroby Sands, Kentish Flats and Barrow offshore wind farms in the UK (piles of 4 – 4.7 m diameter). They conclude that in general the level of noise created by operational windfarms was very low, and no evidence was found of noise levels that might have the capacity to cause marine animals to avoid the area. The environment of a wind farm was found to be on average about 2 dB noisier for fish, and no noisier for marine mammals than the surrounding area. This is no more than variations which might be encountered by these animals during their normal course of activity (see Nedwell *et al.* 2007).

Of relevance to the BŚ III variant chosen for realisation and rational alternative variant is the recent modelling of 6 MW wind farms undertaken by (Marmo *et al.* 2013) and documented already in 7.2.1. Figure 22 shows the detectability (= audibility) of the modelled wind farm designs above ambient noise. This figure is analogous to our assessment of the effective range of pile driving sound as shown in Figure 19 and Table 16. It is visible from the figure that depending on the foundation type and wind speed the noise emissions from that modelled wind farm are detectable at distances of up to 20 km from the source. Yet, we have to consider here that this amounts to frequencies below 1 kHz where most marine mammals – and harbour porpoise especially - are not very sensitive to sound. We should also consider that applying the data from (Wenz 1962) is a very precautionary approach as the Wenz levels are relatively low in energy. Under a realistic scenario, we conclude that although larger wind turbines and wind farms as those planned for BŚ III and assessed under variant chosen for realisation and rational alternative variant could be audible over some distance, the relevant frequencies are low and not particularly relevant to marine mammals.

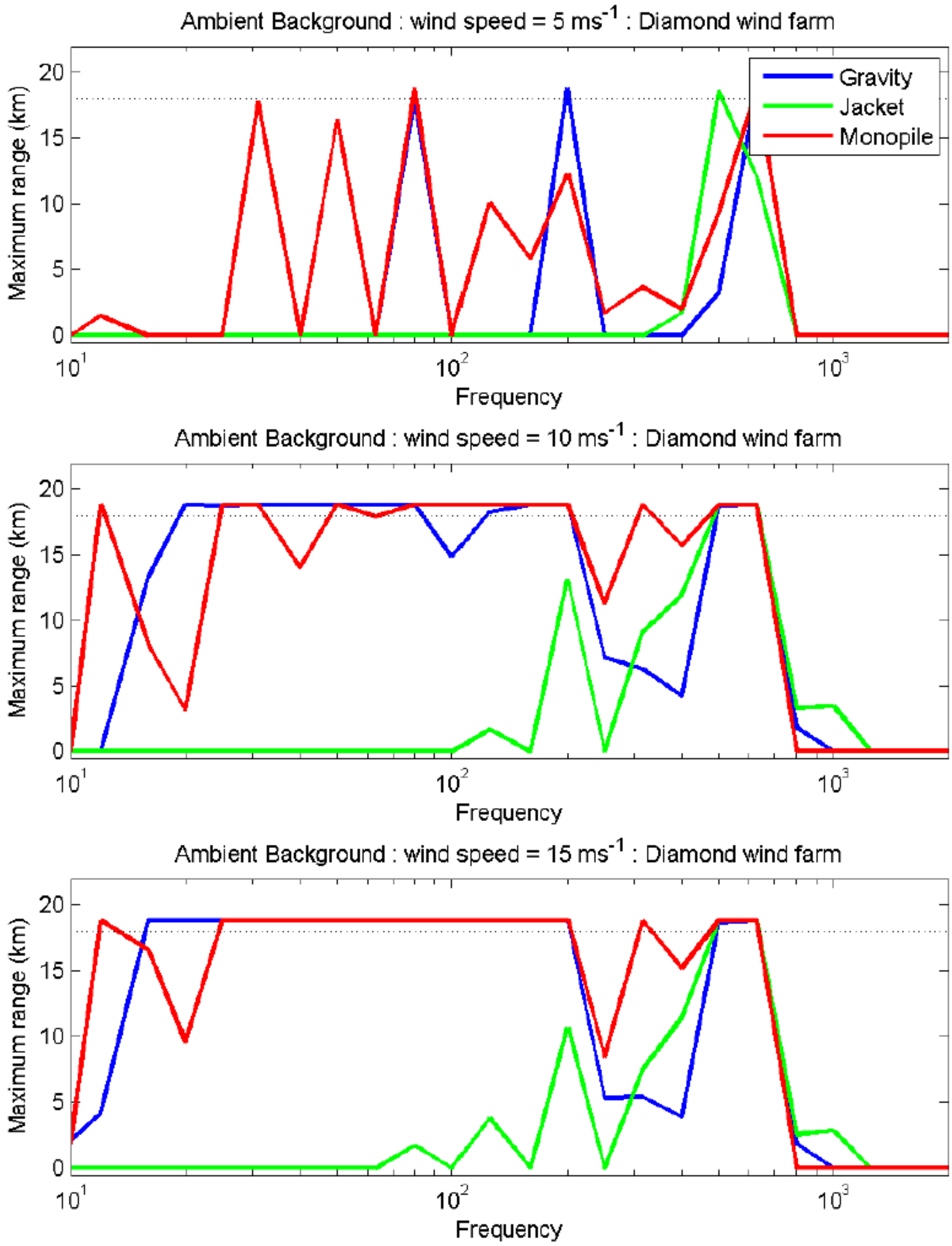

Figure 22 Maximum range from the centre of the of a wind farm where the wind farm noise is audible above the background noise as a function of frequency in Hz (dotted line = boundary of the modelling domain; ambient background noise after (Wenz 1962) for sea states 2, 4 and 6 bft, respectively ; number of turbines = 16; water depth = 30 m)

Looking at the modelling results with regard to behavioural responses, no effects are expected on seals. The impacts on porpoises would be defined as being local with an overall low significance.

Noise from service and maintenance activities

According to (Haskoning 2014), maintenance vessels will be used during 1 625 inspections for 25 years based on 2 inspections per turbine per year, 4 turbines per day, plus additional inspections for full OWF. These small- to medium-sized vessels will mainly emit sounds between 160-180 dB re 1µPa at 1 m; and will cover frequencies < 1kHz - > 10 kHz. It is likely that they will lead to an increase of the local acoustic field during the construction, covering frequencies that are partly relevant to marine mammals. Yet, since this will only be a limited amount at any given time, additions to the sound field will be localised and overall of low significance.

Electromagnetic fields

An electric sense has been demonstrated in one species of dolphin (Czech-Damal *et al.* 2011), but not in harbour porpoises. A magnetic sense has not been demonstrated in any cetacean, although there are speculations that navigation along EMF takes place (Klinowska 1986). The possible effects of electromagnetic fields from the power cables connected to the turbines are therefore not known, but it is unlikely that they should have a major impact on the harbour porpoises and seals in the Bałtyk Środkowy III area.

Changes in habitat

The visual impact of the operating wind farm underwater is likely to be minimal. Underwater parts of the foundation and scour protection quickly become overgrown and resemble other reef-like structures in the sea. In air the turbines with their rotating wings represent a major change to the visual scene, but it is unclear if and how this may affect porpoises and seals under water. Porpoise vision is poor in air, and though seals have acute vision, it is not known to what extent this would cause disturbance.

The introduction of hard bottom substrates in the form of foundations and scour protection on the sandy bottom will create changes to the habitat and may have a positive effect in the long run as they may serve as artificial reefs or as sheltered areas with lower noise levels compared to heavily trafficked areas (Scheidat *et al.* 2011; Teilmann & Carstensen 2012).

Harbour seals and grey seal could benefit from the same artificial reef effects, and as the wind farm is not close to seal haul-outs, the changes in habitat will most likely not cause significant disturbances.

Assessment of the significance of impacts during operation

The results of the impact assessment of the operational wind farm are assessed in Table 21. The effects on harbour porpoises and seals are generally thought to be minor during the operational phase. They may in some cases even prove to be positive due to reef effects that could increase foraging opportunities for all three species of marine mammals (see for example Leonhard *et al.* 2013).

Table 21 Overall effect of the operation activities on marine mammals.

Species	Effect	Scale of ex-posure	Duration	Intensity	Frequency of impact	Reversibility	Scale of im-pact	Significance
Harbour porpoise (*Pho-coena phocoena*)	Noise from operating turbines	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Low
	Noise from maintenance	Local	Short-term	Low	Continuous	Reversible	Insignificant	Low
	Electro-magnetic fields	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Low
	Visual effects	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Low
	Reef effects	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Positive
Harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*)	Noise from operating turbines	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Negligible
	Noise from maintenance	Local	Short-term	Low	Continuous	Reversible	Insignificant	Negligible
	Electro-magnetic fields	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Negligible
	Visual effects	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Negligible
	Reef effects	Local	Long-term	Low	Continuous	Irreversible	Insignificant	Positive

9.1.3 Dismantling phase

Haskoning 2014 states that the decommissioning process would follow a reverse of the installation procedure meaning that many of the activities used in decommissioning are similar to construction activities. Yet, pile driving and the use of explosives will probably not be involved. Looking at the High Level Design study in detail it will most likely not be involved. Looking at the High Level Design study in detail (see Haskoning 2014), the decommissioning of BŚ III monopoles would involve the following activities. The ones creating underwater noise are underlined:

- Mobilising a crane vessel, transport pontoon with tug and work vessel
- Connecting the crane hook to the transition piece of the monopile foundation
- <u>Cutting the cables just before they enter the J-tubes</u>
- <u>Remove soil from inside the pile until below cutting depth</u>
- <u>Cutting the monopile from inside with a cutting tool 3 m below sea bed level</u>
- <u>Lifting the monopile</u>
- Placing the monopile on the pontoon and fastening
- <u>Transportation to shore</u>
- Recycling and disposal of materials

From this list, the most likely noise generating activities which will have to be assessed are shipping (to and from the site and during the decommissioning works), cutting and drilling (for the soil removal process). However, there is no information on cutting sound. We shall therefore concentrate on noise from shipping and drilling from drill-ships and jack-up platforms.

Noise from drilling operations depends largely on the platform used for drilling. Drill-ships produce the highest noise levels, whereas noise from bottom founded drilling rigs such as jack-up rigs is likely to be low in both source levels and frequency content (<1.2 kHz; Richardson *et al.* 1995). Noise from two drill-ships is shown in Figure 23 and shall be viewed as the worst case scenario for drilling noise, as the noise will most likely not exceed these levels. The spectral energy of the noise from the two drilling-vessels is mainly found below 1 kHz, and any effects on the local background noise will be related to low frequency sound. Essentially, the noise during drilling will add locally to the ambient sound field that is already dominated by shipping sound.

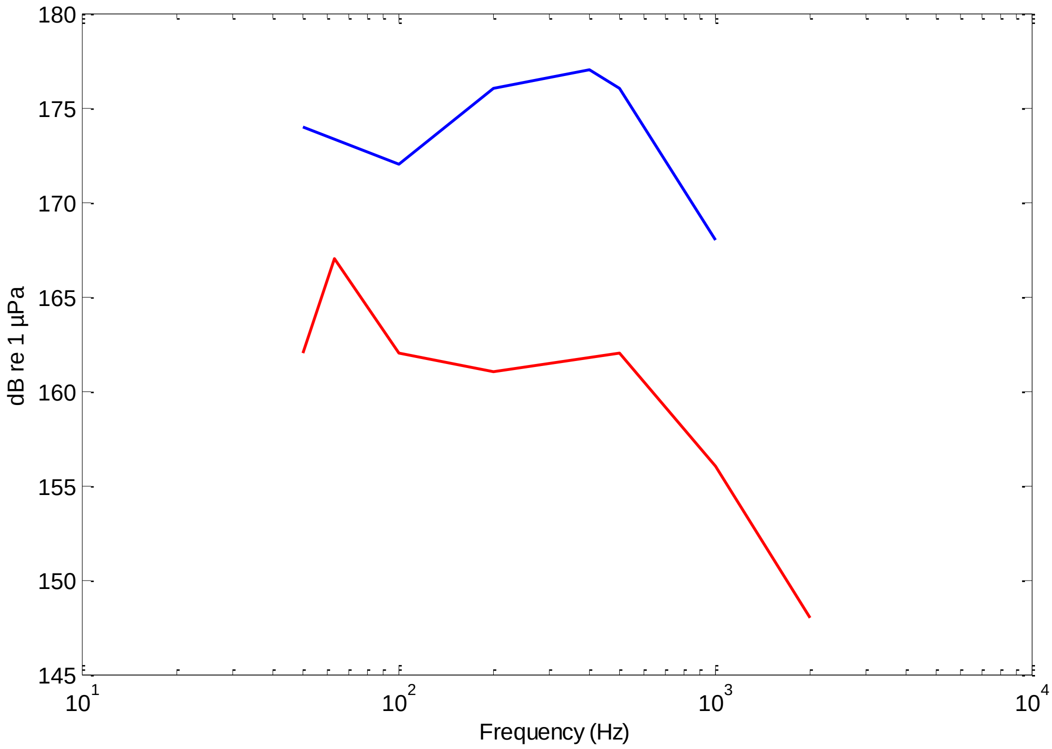

Figure 23 Source levels from two different drilling ships in 1/3 octave bands. Modified from (Richardson *et al.* 1995).

With regard to shipping we can repeat here what has been discussed in detail in chapter 7.1.3 (general description of shipping) and 9.1.1 (shipping during construction activities). As during construction, small- to medium-sized vessels will mainly emit sounds between 160-180 dB re 1µPa at 1 m; and will cover frequencies < 1kHz - > 10 kHz. It is likely that they will lead to an increase of the local acoustic field during the construction, covering frequencies that are partly relevant to marine mammals.

Assessment of the significance of impacts during dismantling

From what we have said above, it can be concluded that the dismantling of monopiles will involve activities such as cutting, drilling and shipping. Besides cutting, for which sound levels are not known, the latter two activities will only temporarily and locally raise the low frequency part of the existing ambient noise spectrum at BŚ III. It is possible that the dismantling phase will take several months due to the number of turbines that have to be decommissioned. Yet, impacts on the noise field would still be only local and temporary. Consequently, the significance of the noise field emitted during dismantling is assessed to be low.

Table 22 Overall effect of the dismantling activities on marine mammals (use of explosives given as option).

Species	Impact	Scale of ex-posure	Duration	Intensity	Frequency of impact	Reversibility	Scale of im-pact	Significance
Harbour porpoise (*Phocoena phocoena*)	Shipping noise	Local	Short-term	Low	Continuous	Reversible	Insignificant	Low
	Drilling	Local	Short-term	Low	Continuous	Reversible	Insignificant	Low
Harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*)	Shipping noise	Local	Short-term	Low	Continuous	Reversible	Insignificant	Negligible
	Drilling	Local	Short-term	Low	Continuous	Reversible	Insignificant	Negligible

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9.2 Cumulative impacts

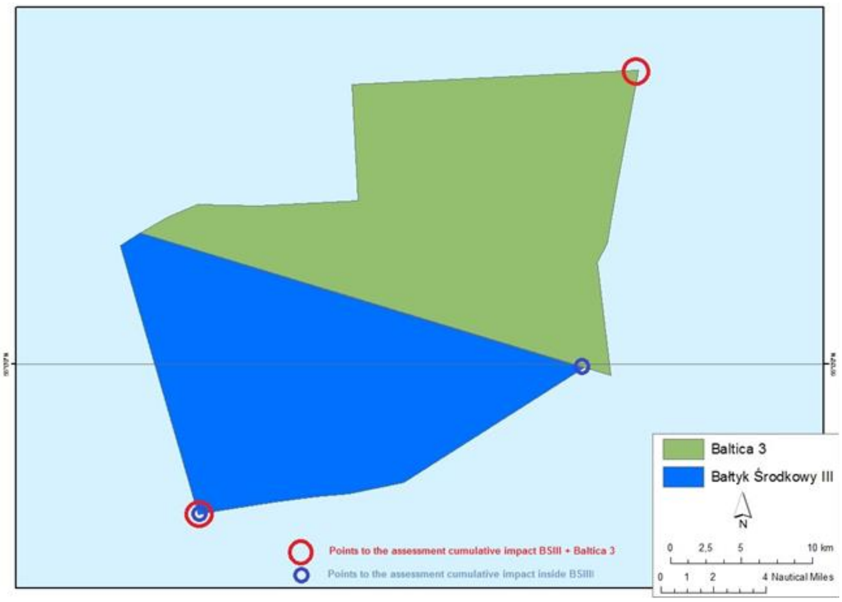
9.2.1 Construction

We have assessed the acoustic footprint and the cumulative sound exposure level for the variant chosen for realisation and rational alternative variant based on the assumption that the timing between the piling of different turbines is too long to lead to any accumulation of acoustic energy and hence cumulative TTS. Here we assess the impacts of similar elements for the variant chosen for realisation and rational alternative variant at the same time. In this case it comprises the piling of more than one foundation at any time. However, if more than one pile-driver in the area is active at the same time, there is a potential for the noise to cumulate, thus causing increased ranges over which marine mammals can be affected negatively. In order to evaluate the potential cumulative noise impact of two pile-drivers working simultaneously, modelling was undertaken to estimate possible cumulative noise in two different scenarios:

1) two pile-drivers operating simultaneously within the same project area

2) two pile-drivers operating simultaneously in neighbouring project areas

Two positions within the Bałtyk Środkowy III area were chosen to represent the first scenario, and one position in the Bałtyk Środkowy III area along with one position in the Baltica 3 area were chosen to represent the second scenario (Figure 24). Modelling should also be undertaken with two different pile diameters for variant chosen for realisation and rational alternative variant (10 m and 7.5 m respectively) as measurements of sound levels from pile driving have only been made for smaller diameter piles sound levels for a 7.5 diameter pile previously estimated using (Betke 2008). This was done assuming a linear increase in sound level, which must be considered worst case. The lack of knowledge regarding how sound levels increase with the diameter for larger piles sound levels for 7.5 m and 10 m diameter piles is assumed to be the same in this case.



Point	Coordinates (WGS84)	
red circle	17.55676	55.10442
blue circle	17.51658	54.99785
blue and red circle	17.28582	54.94810

Figure 24 The two project areas BŚ III (blue) and Baltica 3 (green). Positions used for the assessment of cumulative noise inside the BŚ III area are indicated as blue circles. Positions used to assess the cumulative impact of BŚ III and Baltica 3 are indicated as red circles.

The simulated results presented will illustrate the estimated noise impact in the two scenarios:

1. Simultaneous piling at two locations of the BŚ III wind farm.
2. Simultaneous piling at BŚ III and Baltica 3 wind farm.

It is judged that in each scenario the resulting received broadband sound level in the present environment is that of two incoherent sources. Modelling calculations were based on a hammer energy equal to 3000 kJ and 2800 piling strikes per hour.

Multiple piling operations at the same time are expected to increase the impact area. Based on these considerations we adopt the previously used modelling approach applied in two separate, simultaneous noise events at two source locations.

The individual sound levels are interpolated from the transects onto a 2D grid at a depth of 25 m, where the highest sound levels are expected due to the sound speed profile. The impact ranges are determined in consistency with the previous impact ranges, by searching in the cumulative sound field, along the original transects, to find the distance from the two source locations where the sound level is lower than the given threshold. The impact ranges are given as the mean and maximum of the distances of the transects.

Accumulation of identical impacts within the same project for the variant chosen for realisation and rational alternative variant

The results of the modelling for simultaneous piling at two locations at the BŚ III wind farm when no mitigation is implemented as well as with 14 dB reduction in sound level are presented below.

The cumulative noise is calculated based on one hour of pile-driving. However, for behavioural ranges it is based on single strike from the two different positions simultaneously. The difference in cumulating time is due to the assumption that animals will react behaviourally already at the first hammer strike.

Table 23 and

Table 24 summarise the results of the cumulative noise modelling without and with 14 dB reduction due to the mitigation measure in use. For each position, maximum and mean values are presented for each threshold. The maximum value given is from the direction from the sound source where the sound propagates the farthest.

Table 23 The cumulative impact ranges from each position in the first scenario with two pile-drivers operating simultaneously within the BŚ III project area, when no mitigation is undertaken.

Scenario 1 BŚ III NE – BŚ III SW					
Position		**BŚ III NE**		**BŚ III SW**	
Species	**Threshold** (dB re 1µPa^{2}s)	**Impact range** (Mean)	**Impact range** (Max)	**Impact range** (Mean)	**Impact range** (Max)
Harbour porpoise	**PTS** (198 dB SEL M-weighted)	1200 m	3000 m	15700 m	15700 m
	TTS (183 dB SELM-weighted)	21 100 m	30 500 m	20 600 m	34 600 m
	Behavioural changes (140 dB SEL unweighted)	46 100 m	84 300 m	45 900 m	99 200 m
Harbour- and grey seal	**PTS** (186 dB SEL M-weighted)	20 000 m	29 400 m	19 400 m	33 900 m
	TTS (171 dB SEL M-weighted)	51 500 m	110 200 m	51 100 m	123 100 m
	Behavioural changes (171 dB SEL M-weighted)	1 400 m	1 800 m	1 500 m	2 000 m

Table 24 The cumulative impact ranges from each position with two pile-drivers operating simultaneously within the BŚ III project area when sound levels are attenuated by 14 dB.

Scenario 1 BŚ III NE – BŚ III SW					
Position		**BŚ III NE**		**BŚ III SW**	
Species	**Threshold** (dB re 1µPa^{2}s)	**Impact range** (Mean)	**Impact range** (Max)	**Impact range** (Mean)	**Impact range** (Max)
Harbour porpoise	**PTS** (198 dB SEL M-weighted)	-	-	-	-
	TTS (183 dB SEL M-weighted)	3 400 m	4 900 m	4 000 m	18 400 m
	Behavioural changes (140 dB SEL unweighted)	17 200 m	27 400 m	16 600 m	32 100 m
Harbour- and grey seal	**PTS** (186 dB SEL M-weighted)	-	-	-	-
	TTS (171 dB SEL M-weighted)	21 800 m	30 300 m	21 100 m	35 500 m
	Behavioural changes (171 dB SEL M-weighted)	<1000 m	<1000 m	<1000 m	<1000 m

It has to be mentioned here that the impact ranges presented in Table 23 have to be assessed in conjunction with the noise maps presented further on to arrive at a comprehensive picture of noise impacts due to cumulative activities. This is because the cumulative modelling results in overlapping of the two noise maps created for each sound source separately leading to complex impact areas that can be further away from the source but still small, as is the case for PTS ranges. Thus in some cases the highest sound levels can occur not in the close vicinity of the sound source as can be expected, but further away from the piling site (see for example Figure 56 in Appendix 2).

The detailed impact ranges of the combined noise propagation for the two positions within the BŚ III project area for harbour porpoise, harbour and grey seal are shown on noise maps in the Appendix 2.

There is a marked difference in PTS ranges for harbour porpoises between the two areas. This discrepancy is probably caused by a 10 m difference in water depth between the two locations with BŚ III NE being at the lowest water depth. The difference in water depth has a strong influence on sound attenuation at the very high sound levels (see Appendix 3). Calculated PTS ranges for harbour and grey seals (up to 34 km) are significantly greater than those for harbour porpoises, this is due to the more sensitive hearing of pinnipeds at low frequencies. It is also the case for calculated TTS ranges, TTS can be expected up to 123 km for seals and only up to 35 km for harbour porpoises. It has to be noted that behavioural change ranges for single simultaneous strike for porpoises are much greater than 1 hour cumulative TTS and PTS ones, thus it can be expected that animals will leave the area before experiencing hearing damage. This is not the case for harbour and grey seals, as the behavioural change ranges are small (up to 2 km), thus animals can stay for a longer period of time in the potential PTS and TTS zone.

With the usage of a bubble curtain as an exemplary mitigation measure PTS based on 1 hour of cumulative noise both for harbour porpoise and seals can be ruled out. Comparing results with 14 dB reduction due to the mitigation measure undertaken to those from the unmitigated scenario significant reduction in TTS and behavioural change ranges can be seen. TTS range is reduced significantly to a maximum of 35.5 km for harbour and grey seals and up to 18.4 km for harbour porpoise.

While comparing results of the cumulative noise modelling with the results obtained for piling at one location (see chapter 9.1.1) it can be seen that the PTS and TTS ranges in the case of multiple strikes both for harbour porpoise and seals are similar. This is also the case while comparing the results obtained for behavioural response ranges for single strike pile driving at BŚ III alone and simultaneous piling at two locations in the BŚ III wind farm area. Thus, the overall cumulative impact due to simultaneous pile driving at BŚ III SW and BŚ III NE has been assessed as high.

Accumulation of different impacts within the project for the variant chosen for realisation and rational alternative variant

Other elements of the project can influence the baseline ambient noise field as well. These will be mainly in the form of construction ships. However, due to the relatively low sound pressure levels, any additional effects will be local and overall insignificant.

Accumulation of impacts from different projects for the variant chosen for realisation and rational alternative variant

Here, we consider the impact from the current project BŚ III in combination with other plans or projects in the area. Other plans and projects include those projects that have already been completed, those that have been approved by the planning authorities or those that are currently undergoing planning approval.

As seen from Figure 25 there are many activities in the south-eastern part of the Baltic Sea within the Polish EEZ. Below is the list of projects and plans, which have been possible to identify, and which potentially can have a cumulative impact together with impacts from BŚ III described in previous sections. Here, we shall focus on those that create noise as all the other construction-related impacts do not have a scale that goes beyond the wind farm construction site.

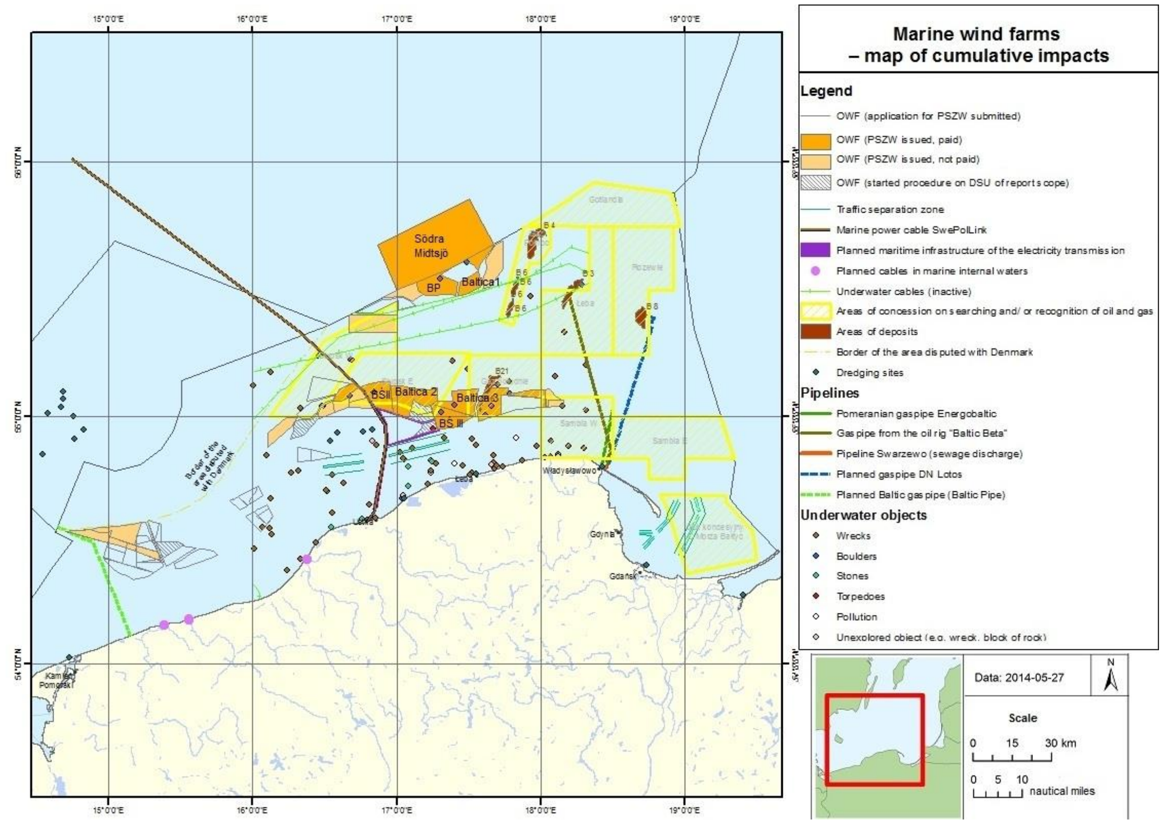


Figure 25 Present and planned use of the seabed space within the Polish EEZ Offshore wind farms

Between 2011 and 2013 a large number of applications for offshore wind farms within the Polish EEZ have been sent to the Ministry for Transport, Construction and Marine Economy.

In the surrounding area of the Słupsk Bank seven areas are likely to undergo a licensing procedure parallel to the construction of BŚ III. The relevant wind farms and the status of the project are listed in Table 25. As of yet there are no operating offshore wind farms within the Polish EEZ.

In the Swedish EEZ only one offshore wind farm can be relevant for the cumulative assessment; Södra Midtsjöbanken. This wind farm is located close to the Polish EEZ and is currently in the planning phase. An Environmental Impact Assessment has been prepared for the project. The maximum number of turbines will be 300 with a maximum height < 200 metres including rotor (EON 2012).

Table 25 List of offshore wind farms which can potentially have a cumulate impact together with impact from OWF Bałtyk Środkowy III.

Type and name of the project	Approximate Distance from OWF BŚ III (km)	Number of turbines/ maximal project capacity	Status
OWF Bałtyk Środkowy II (BŚ II)	30	Max 200 turbines	Planning phase
Baltica 2	18	Max 300 turbines, Max 1500 MW	Concept / Early planning
Baltica 3	9	Max 1050 MW, max 210 turbines	Concept / Early planning
Södra Midtsjöbanken	70	Max 300 turbines, 700 MW	Planning phase

Type and name of the project	Approximate Distance from OWF BŚ III (km)	Number of turbines/ maximal project capacity	Status
Baltica 1	60 km	1,202.5 MW*	Concept / Early planning
BP: Bałtyk Północny	50 km	1,200 MW*	Concept / Early planning
ORLEN	The Orlen OWF (Licence application #11) is situated 140 km from BŚ III.	Unknown	Unknown

Source: http://www.4coffshore.com/windfarms/windfarms.aspx?windfarmId=PL20, * turbine no. unknown

Cumulative impacts are expected if the offshore wind farms are constructed simultaneously (noise, vibrations, sediment spill). There are still no time schedules for the construction of any of the wind farms as none of these have been approved yet. However, the only likely scenario is a similar construction period of BŚ III together with Baltica 3 (stage 1). Independently of the exact scenario, the same applies here as outlined earlier: The addition of another construction site will add to the overall acoustic footprint; thus acoustic modelling was conducted in order to assess potential cumulative effects of simultaneous piling at BŚ III and Baltica 3 site (modelling methodology described at the beginning of this chapter).

The results of the modelling for simultaneous piling at BŚ III and Baltica 3 wind farm when no mitigation is implemented and with a 14 dB reduction in sound level are presented below.

The cumulative noise is calculated based on one hour of pile-driving. However, for behavioural ranges it is based on a single strike from the two different positions simultaneously. The difference in cumulating time is due to the assumption that animals will react behaviourally already at the first hammer strike.

Table 26 and Table 27 summarise the results from the scenario without and with 14 dB reduction due to the mitigation measure in use. For each position maximum and mean values are presented for each threshold. The maximum value is from the direction from the sound source where the sound propagates the farthest (see Appendix 3). The mean range is calculated based on the sound propagation in all directions.

Table 26 The cumulative impact ranges from each position with two pile-drivers operating simultaneously in two different project areas when no mitigation is undertaken.

Scenario 2 Baltica 3 N – BŚ III SW					
Position		**Baltica 3 N**		**BŚ III SW**	
Species	**Threshold** (dB re 1µPa^{2}s)	**Impact range** (Mean)	**Impact range** (Max)	**Impact range** (Mean)	**Impact range** (Max)
Harbour porpoise	**PTS** (198 dB SEL M-weighted)	2 400 m	3 700 m	<1000 m	<1000 m
	TTS (183 dB SEL M-weighted)	26 500 m	36 100 m	23 600 m	50 200 m
	Behavioural changes (140 dB SEL unweighted)	63 000 m	125 500 m	61 200 m	>150 000 m
Harbour- and grey seal	**PTS** (186 dB SEL M-weighted)	26 200 m	34 900 m	22 900 m	50 200 m

Scenario 2 Baltica 3 N – BŚ III SW					
Position		**Baltica 3 N**		**BŚ III SW**	
Species	**Threshold** (dB re 1µPa^{2}s)	**Impact range** (Mean)	**Impact range** (Max)	**Impact range** (Mean)	**Impact range** (Max)
	TTS (171 dB SEL M-weighted)	72 300 m	>150 000 m	65 000 m	>150 000 m
	Behavioural changes (171 dB SEL M-weighted)	1000 m	2000 m	1 500 m	2 000 m

Table 27 The cumulative impact ranges from each position with two pile-drivers operating simultaneously in two different project areas when sound levels have been attenuated by 14 dB.

Scenario 2 Baltica 3 N – BŚIII SW					
Position		**Baltica 3 N**		**BŚIII SW**	
Species	**Threshold** (dB re 1µPa^{2}s)	**Impact range** (Mean)	**Impact range** (Max)	**Impact range** (Mean)	**Impact range** (Max)
Harbour porpoise	**PTS** (198 dB SEL M-weighted)	-	-	-	-
	TTS (183 dB SEL M-weighted)	4 100 m	5 300 m	2 400 m	3 600 m
	Behavioural changes (140 dB SEL unweighted)	22 300 m	34 300 m	19 300 m	44 700 m
Harbour- and grey seal	**PTS** (186 dB SEL M-weighted)	-	-	-	-
	TTS (171 dB SEL M-weighted)	28 600 m	39 600 m	24 900 m	54 100 m
	Behavioural changes (171 dB SEL M-weighted)	<1000 m	<1000 m	<1000 m	<1000 m

The impact ranges of the combined noise propagation due to simultaneous piling at BŚ III and Baltica 3 wind farm for harbour porpoise, harbour seal and grey seal are shown on noise maps in Appendix 3.

Calculated PTS ranges for harbour and grey seals (up to 50.2 km) are much larger than those for harbour porpoises; this is due to the lower exposure criteria for pinnipeds. It is also the case for calculated TTS ranges. TTS can be expected over 150 km from the Baltica 3 sound source for seals and only up to 50.2 km for harbour porpoises. It must be noted that behavioural change ranges for single simultaneous strikes for porpoises are much larger than 1-hour cumulative TTS and PTS ones; thus it can be expected that animals will leave the area before experiencing hearing damage. This is not the case for harbour and grey seals, as the behavioural change ranges are small (up to 2 km), thus animals can potentially stay for a longer period of time in the potential PTS and TTS zone.

With the usage of a bubble curtain as an exemplary mitigation measure PTS based on 1 hour of cumulative noise both for harbour porpoise and seals can be ruled out. Comparing results with 14 dB reduction due to the mitigation measure undertaken to those from the unmitigated scenario significant reduction in TTS and behavioural change ranges can be seen. TTS range for harbour and grey seals is reduced significantly for harbour and grey seals and harbour porpoises. In case of subsequent construction of wind farms for extended periods, it is impossible to foresee the overall impacts without any reasonable information on proposed timing. We have outlined that behavioural response is likely to cease once the construction of one turbine has been finished, or after the construction period for one wind farms has ended. As indicated in the impact assessment, this can happen from several hours to a few days after the end of the construction period. So in consequence, it is possible that subsequent construction of wind farms will lead to extended behavioural effects but there will also be recovery periods between different projects, and impact ranges will differ based on each wind farm location.

While comparing results of the cumulative noise modelling with the results obtained for piling at one location it can be seen that the PTS ranges in the case of multiple strikes both for harbour porpoise and seals are similar. Thus cumulative TTS ranges are significantly larger, especially for harbour and grey seal (up to 150 km). This is also the case for the behavioural response of porpoises to a simultaneous single strike at BŚ III and Baltics 3 piling locations (in the worst case the range exceeds 150 km). Taking the above into account the overall cumulative impact due to simultaneous pile driving at BŚ III SW and Baltica 3 N site has been assessed as high.

Installations of oil and gas fields and exploration areas

LOTOS Petrobaltic holds eight concessions for exploration and appraisal within the Baltic Sea (Table 28) and has concessions for oil and gas exploration & production from fields B3, B4, B6, and B8 (Figure 25, Lotos 2013).

Currently, planned production from field B3 and field B8 is under appraisal before production commences. In the southern part of the Baltic Sea near Słupsk Bank there are three platforms; one drilling rig (Petrobaltic) and two production rigs (Baltic Beta and PG-1). Baltic Beta is anchored in the centre of infield B3. They all belong to Poland and the oil is transported by ships to the harbour of Gdansk (Lotos 2013). For Słupsk E and W areas, licence applications for exploration of “shale” natural gas have been submitted.

Table 28 Specification of concessions for exploration and appraisal licenses for oil and gas in the Baltic Sea.

Type and name of the project	Area (km^2)
Gotlandia	881
Rozewie	1,172
Leba	1,154
Gaz Poludnie	887
Sambia W	888
Sambia E	1,092
Słupsk W	*
Słupsk E	*

* Exact size of area unknown

It is possible that noise during drilling is adding to the sound field created during the construction of BŚ III. Yet, since drilling noise is relatively low, this will only add locally to sound fields and will not have any significant impact on the overall acoustic dose (for a review, see Genesis 2011).

Pipelines

SwePol link is a high voltage power submarine cable between Poland and Sweden (Figure 25). The cable was commissioned in 2000. Nord Stream pipeline is a gas pipeline which transports gas from Russia to Europe. The sound emissions associated with the pipeline laying will involve local shipping and will not add significantly to the overall acoustic footprint during the construction of BŚ III.

Mining

Within the Słupsk Bank there are three deposits of sand and gravel (Figure 25). There are no information of current excavation activities at these sites. The associated sound profiles from sand and gravel activities have been detailed in 7.1.2, and it is not expected that they will add significantly to the noise field created during BŚ III construction.

Transport logistics

There is heavy ship transport in the Baltic Sea and much traffic passes by the wind farm area. Yet, according to our baseline measurements (see 4.6.1), the BŚ III area can be characterised as having medium pressure due to existing noise. Ship noise is continuous and much lower than pile driving pulses. Thus, it is not expected that the existing shipping will add significantly to the noise profiles generated during the construction of BŚ III.

9.2.2 Operation

Accumulation of identical impacts within the same project

This would involve the noise from more than one operational turbine which has been analysed by (Nedwell *et al.* 2007) as insignificant. The modelling by (Marmo *et al.* 2013) indicates that noise from the whole wind farm can be detected at a distance of several km under a worst case scenario using very low levels of ambient noise. Yet, the detection frequencies are very low. Thus, the addition to the noise field due to the accumulation of several turbine emissions covers frequencies that are of little relevance to marine mammals.

Accumulation of different impacts within the project

Other elements of the project can influence the baseline ambient noise field as well. These will be mainly operational ships. However, due to the relatively low sound pressure levels, any additional effects will be local and overall insignificant.

Accumulation of impacts from different projects

Here, we consider the impact from the current project BŚ III in combination with other plans or projects in the area during operation. Other plans and projects have been described in detail in chapter 9.2 .

Cumulative noise impacts are expected if the offshore wind farms are constructed and then operated simultaneously (noise, vibrations, sediment spill). It is possible that Baltica 3 (stage 1) is constructed in parallel to the operation of BŚ III. In this case the added noise field of the construction would change the ambient noise situation as described in chapter 9.1.1. In case of the subsequent operation of another wind farm there would be an addition of another low frequency noise source that can be detected over several km. But again, due to the low frequencies emitted, the effects on the sound field that is relevant to marine mammals are expected to be modest at best.

Other activities

It is possible that noise during drilling is adding to the sound field created during the operation of BŚ III. Yet, since drilling noise is relatively low, this will only add locally to sound fields and will not have any significant impact on the overall acoustic dose (for a review, see Genesis 2011).

The laying of the power submarine cable between Poland and Sweden (Figure 25) will involve local shipping and will not add significantly to the overall acoustic footprint during the operation of BŚ III. The associated sound profiles from sand and gravel activities have been detailed in 7.1.2, and it is not expected that they will add significantly to the noise field created during BŚ III construction. Ship noise is continuous and much lower than pile driving pulses. Thus, it is not expected that the existing shipping will add significantly to the noise profiles generated during the construction of BŚ III.

9.2.3 Dismantling

Accumulation of identical impacts within the same project

This would concern more than one platform being decommissioned at any given time. This is an unlikely case as there are possibly not enough vessels to accommodate a simultaneous decommissioning at several sites. However, even in the unlikely event of it occurring the parallel decommissioning work would only add another low-level impact to the noise field and it would be only temporary.

Accumulation of different impacts within the project

There will be no other activities than those already mentioned above that could add to the noise field during decommissioning.

Accumulation of impacts from different projects

Here, we consider the impact from the current project BŚ III in combination with other plans or projects in the area during operation. Other plans and projects have been described in detail above.

Cumulative noise impacts are expected if the offshore wind farms are constructed, operated and decommissioned simultaneously to the decommissioning work at BŚ III. The added noise field of the construction would change the ambient noise situation as described in chapter 9.1.1. In case of the parallel operation of another wind farm, there would be an addition of another low frequency noise source that can be detected over several km. But again, due to the low frequencies emitted, the effects on the sound field that is relevant to marine mammals are expected to be modest at best. Parallel decommissioning would only add another local low frequency addition to the existing noise field.

9.3 Impact assessment on Natura 2000 sites

Natura 2000 is the term for a network of protected areas in the European Union. The network includes protected areas designated under the EU Habitats Directive (Council Directive 92/43/EEC) and the EU Birds Directive (Directive 2009/147/EC). Under the Habitats Directive Special Areas of Conservation Special Areas of Conservation (SACs) and Sites of Community Importance (SCI) are designated for species other than birds, and for habitats. Similarly, the Special Protection Areas (SPAs) are designated under the Birds Directive to protect bird species. Together, SPAs and SAC/SCIs make up the Natura 2000 network of protected areas. The aim of the network is to ensure favourable conservation status for the designation basis of the area. The designation basis is composed of a number of physical habitats and species.

The Habitats Directive Article 6 states:

"*3. Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives. In the light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public.*

The general assessment of the requirements of Article 6 is a step-by-step approach which contains the following four elements:

1. Screening
2. Appropriate Assessment
3. Assessment of an alternative solution
4. Assessment of compensatory measures

An objective screening of the likely effects on a Natura 2000 area from a project must be carried out before a project can be approved by the Authorities. Cumulative impacts arising from co-occurrence of other planned projects or plans must also be assessed. If the conclusion of the screening on the impacts is that significant effects are likely or that sufficient uncertainty remains (impacts arising from the project cannot be excluded in the screening process), an Appropriate Assessment must be prepared subsequent to the screening.

The Appropriate Assessment is an assessment of the impact on the integrity of the Natura 2000 site of the project or plan, either alone or in combination with other projects or plans. The assessment is executed with respect to marine mammals and the structure and function and its conservation objectives.

Elements 3 and 4 are not assessed in this report.

The screening and the Appropriate Assessment of the potential impacts on marine mammals in this document have been performed in compliance with the Habitats and Birds Directives (Council Directive 92/43/EEC, Directive 2009/147/EC). The Directives are implemented in the Polish laws and directives:

- *Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody (Dz. U. z 2009 r. Nr 151, poz. 1220, z późn. zm.)*
- *Dyrektywa Rady 97/11/WE z dnia 3 marca 1997 r.*
- *Dyrektywa 2003/35/WE Parlamentu Europejskiego i Rady z dnia 26 maja 2003 r. przewidująca udział społeczeństwa w odniesieniu do sporządzania niektórych planów i programów w zakresie środowiska oraz zmieniająca w odniesieniu do udziału społeczeństwa i dostępu do wymiaru sprawiedliwości dyrektywy Rady 85/337/EWG i 96/61/WE Ustawa z dnia 3 października 2008 r. o udostępnianiu informacji o środowisku i jego ochronie, udziale społeczeństwa w ochronie środowiska oraz ocenach oddziaływania na środowisko (Dz. U. z 2008 nr 199, poz. 1227 z późn. zm.)*

The decision-making approach in the screening of the impact significance uses the precautionary principle; if there is not enough information to rule out any impact, an Appropriate Assessment should be undertaken.

For this Natura 2000 screening of the offshore wind farm BŚ III the selection of relevant Natura 2000 sites has been based on the project description and the potential environmental impacts described in the following sections, experiences from environmental impact assessments of other offshore wind farm projects and expert knowledge.

The assessments will be done for each parameter of the variant chosen for realisation and rational alternative variant.

9.3.1 Environmental impacts on Natura 2000 sites

The expected impacts from the different stages of the wind farm life-cycle have been detailed in chapter 0 and the detailed assessment has been undertaken in chapter 9. Here we will only summarise the information based on these two chapters.

Construction phase

The predicted potential effects of the establishment of a wind farm include impacts on both the physical and the biological environment. The impacts can be divided into:

- Habitat changes
- Suspended sediment
- Noise and vibrations
- Traffic
- Pollutants

The description of the impacts in details can be seen in Section 7.1.

Operational phase

During the operation of the wind farm the predicted and potential impacts include.

- Changes in habitats
- Noise and vibrations
- Service and maintenance traffic

Detailed description of the impacts can be studied in Section 7.2.

Dismantling phase

As for the construction of the wind farm dismantling or decommissioning can also have an impact on the marine environment and hence marine protected areas. For details on possible impacts, please consult section 7.3.

9.3.2 Cumulative impacts from current threats and planned projects and plans

Cumulative impacts are the impact from the current project BŚ III in combination with other plans or projects in the area. Other plans and projects include those projects that have already been completed, those that have been approved by the planning authorities or those that are currently undergoing planning approval.

For each of the Natura 2000 sites the cumulative impacts from BŚ III and the planned projects and plans and current threats will be assessed. The following sections will describe the potential cumulative impacts from the current threats and planned projects and plans.

Current threats, which are already impacting the Natura 2000 sites, are defined in the standard data forms for the specific areas. In general current threats for marine areas are:

- Wind farms
- Mining (sand/mud excavation)
- Professional fishing
- Water pollution
- Discharges
- Recreational activities
- Coastal protection works
- Sea defence
- Climate change

The current threats which are relevant in connection with marine mammals are described in Chapter 4.

The list of projects which are relevant for the cumulative impact assessment is being described in chapter 9.2. As can be seen in chapter 9.2 there are many activities in the south-eastern part of the Baltic Sea within the Polish EEZ which can potentially have a cumulative impact together with impacts from BŚ III described in previous sections. The cumulative impacts on marine mammals are described in detail in chapter 8.5. For the screening, we have used the list of projects described in 8.5 and the described assessment. However, in the following screening, we will make a more specific analysis of the cumulative impacts of the activities with regard to each site.

9.3.3 Natura 2000 site screening

The conclusion of Natura 2000 screening for each site will be either:

1. It can be objectively concluded that there are not likely to be significant effects on the marine mammals or

2 The information provided either suggests that significant effects are likely or that sufficient uncertainty remains to indicate that an appropriate assessment should be carried out.

For this Natura 2000 screening of the offshore wind farm BŚ III the selection of relevant Natura 2000 areas has been based on the project description and the potential environmental impacts described in previous sections, experiences from environmental impact assessments of other offshore wind farm projects and expert knowledge. The screening includes marine Natura 2000 areas. In Poland there are four areas where harbour porpoises are listed as a part of the designation basis and seven marine areas for Grey seal. There are no other marine mammals protected by Natura 2000 legislation in Poland. There are no areas within the other Baltic countries which have marine mammals on the designation basis, which are within the range of project selection criteria (see below text).

For the selection of the relevant Natura 2000 sites a number of selection criteria has been applied. For the marine mammals the distance of noise impacts has been used as identified in chapter 9. The distance at which harbour porpoises are expected to react aversively is expected to reach 68 km and the cumulative noise impact from multiple pile-strikes may cause TTS in porpoises at considerable distances (22 km). For seals, the TTS range for multiple strikes was 83.7 km. Following a precautionary approach, Natura 2000 areas, which include marine mammals in the designation basis, will be screened within a radius of 100 km.

In Table 29 relevant Natura 2000 sites have been listed together with information on the shortest distance to the wind farm, the size of the Natura 2000 area.

This section presents a separate screening of all the Natura 2000 sites where marine mammals are included in the designation basis for the relevant Natura 2000 sites.

There is one Natura 2000 site in the vicinity of the project area (Figure 26) and two further away which are both included due to marine mammals. One of the areas is strictly marine sites and one is both marine and terrestrial sites. None of the Natura 2000 areas are found within the borders of the project area. All areas are Polish. Best practice areas were identified based on scope criteria.

With regard to harbour porpoise and seals, we have to consider that both are essentially non-migratory but use a home range (= an extended area) for the performance of life functions. This area usage can vary, but there is no migration between ‘feeding’ and ‘breeding’ area as for other marine mammals. Thus, little relationship exists between different Natura 2000 sites which would require assessment of impacts on the Natura 200 network (see for example Dietz 2003; Teilmann *et al.* 2008).

The information on the different Natura 2000 areas is based on the standard data forms, which the responsible authorities are obliged to complete for each area.

Table 29 Natura 2000 sites in the Southern Baltic Sea relevant for the project BŚ III. The approximate distance is shown as the shortest distance in km.

Natura 2000 name and site code	Area name	Terrestrial or marine	Total area (km^2)	Approximate distance to project area
Habitat area PLH220023	Ostoja Słowińska	Marine/ terrestrial	322	19
Habitat area PLH220032	Zatoka Pucka i Półwysep Helski	Marine/ terrestrial	266	53
Habitat area PLH220072	Kaszubskie Klify	Marine/ terrestrial	2.33	55

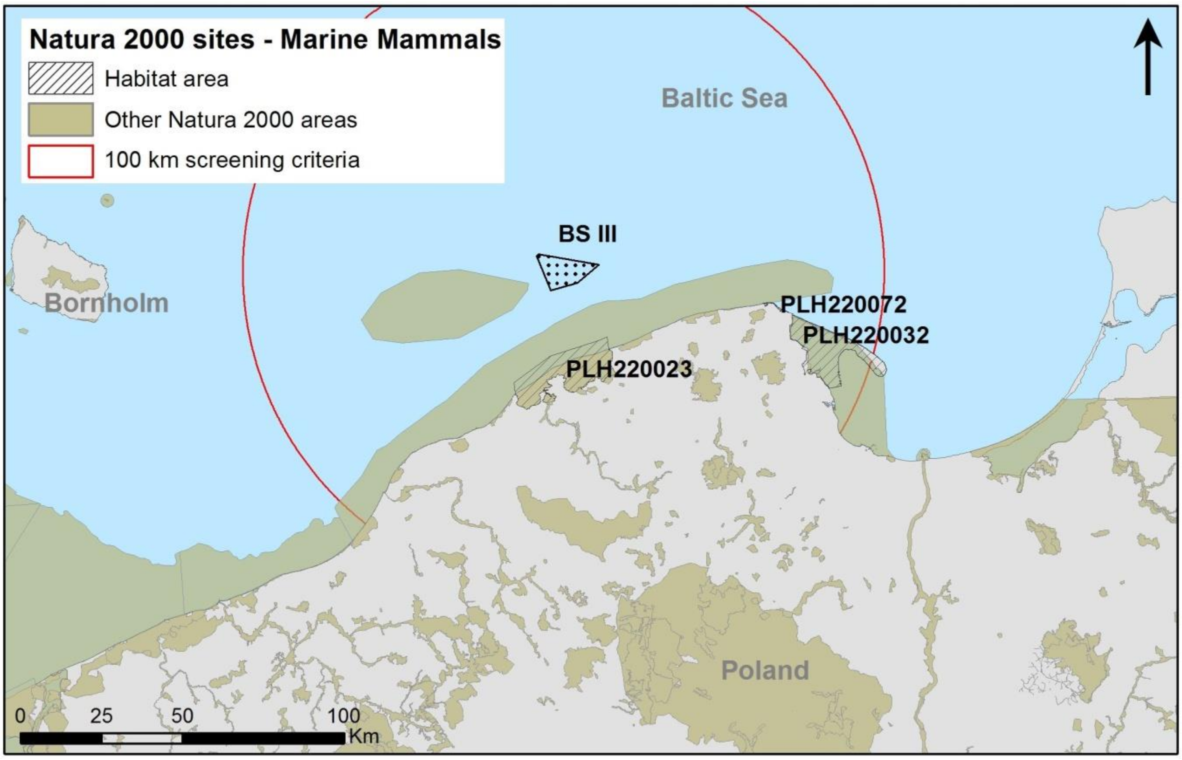


Figure 26 Natura 2000 sites in the vicinity of the project area, BŚ III. Other Natura 2000 areas are not relevant for BŚ III. BŚ II is the planned Bałtyk Środkowy II offshore wind farm. In this report PLH 220023 and PLH 220032 are assessed.

Ostoja Słowińska

Area description

PLH220023 - Ostoja Słowińska is a habitat site (SCI) located approximately 19 km south of BŚ III. The area is primarily terrestrial, which is also reflected in the designation basis. The marine part of the site stretches approximately 33 km along the Baltic coast with a 3.7 km wide belt of shallow coastal waters. The size of the area is 32,955.3 ha. The rivers Łeba and Łupawa run out in the Baltic Sea. The site consists of mobile sand dunes, coastal brackish lakes, peatbogs, marshes, and forests. It is an important resting site for migrating waterbirds and a high concentration of ducks, geese and swans together with various species of waders passes through the area. The habitat and the species diversity are rich, especially on land.

The habitat site is coinciding with the Ramsar area 757 - Słowiński National Park (Słowiński Park Narodowy). Furthermore, it should be noted that in connection with the Ostoja Słowińska the SPA site, PLB220003, Pobrzeze Słowińskie is found.

A summary of the marine mammals on the designation basis for the Natura 2000 site is listed in Table 30.

Table 30 Relevant designation basis for marine species for SCI for PLH220023 - Ostoja Słowińska. Information on population size and site assessment is from the standard data form.

Species Annex II	Population size				Site assessment			
	Resident	Migratory			% of national population	Conservation status	Isolation	Global value
		Breeding	Winter	Stage				
Halichoerus grypus				P	0-2%	Good	Not[1]	Good
Phocoena phocoena				P	2-15%	Good	Not[1]	Good

[1.] Population not-isolated, but on margins of area distribution
P=presence

Mammals have good conservation status. The significance of the area for grey seals is not given but since only a very small fraction of the national population occurs there and the area is not known to be a breeding site for grey seals, it is probably of low significance.

Screening

Harbour porpoises and grey seals are both species on the designation basis for the Natura 2000 site. Harbour porpoises have been documented to react to pile-driving noise at distances larger than 20 km from the construction site, and are estimated to react at distances of 68 km in this case. As the distance between the construction site and the Natura 2000 site is 19 km, noise levels high enough to cause aversive behaviour in harbour porpoises could be reached within the Natura 2000 site. The cumulative noise levels of multiple hammer strikes may also be sufficient to cause TTS in porpoises at this distance. Noise levels high enough to elicit behavioural responses from grey seals are not expected within the Natura 2000 area; however, increased shipping noise associated with the construction could mask signals relevant to the seals. TTS is also possible in seals due to multiple strikes.

The impact on the Natura 2000 site may be significant during construction of the wind farm. As outlined in chapter 9, a behavioural effect can occur at a large distance but will be short-term in many cases. Yet, TTS can occur in both taxa. Since noise can - under a worst case scenario – only lead to behavioural reactions in a small proportion of harbour porpoise (if any are in the vicinity) at 18 km (see chapter 9), noise effects on either harbour porpoises or grey seals are expected within the Natura 2000 site.

The conclusion for marine mammals is that a significant impact during construction cannot be ruled out and an appropriate assessment must be prepared (included in this report).

Cumulative impacts

Depending on the methods used regarding sea defence and coast protection and the removal of sediment (e.g. dredging for sediment removal, pile-driving of smaller diameter piles for sea defence, and coast protection) there is a potential for a significant cumulative impact between these activities and the construction of the wind farm, as these other activities could also have the potential to cause some disturbances to harbour porpoises in the Natura 2000 site. This is also relevant for the construction of other wind farms either simultaneously or in succession with BŚ III. So depending on the methods chosen for the other activities, the cumulative impact could potentially cause a long-term or even permanent displacement of harbour porpoises from the area. See also section 8.5.

Conclusion

A significant impact on harbour porpoises listed on the designation basis cannot be excluded; hence an appropriate assessment must be prepared for PLH220023 - Ostoja Słowińska.

Zatoka Pucka i Półwysep Helski

Area description

Habitat area SCI-PLH220032-Zatoka Pucka i Półwysep Helski is situated approximately 53 km east of the project area. The area includes the Hel Peninsula, the Bay of Puck and the inner part of the coast from Władysławowa to Mechelinek and is 26,566.43 ha in total. The area is designated due to a large number of habitats, both terrestrial and marine and to a large number of species associated to land and marine areas.

Marine mammals on the designation basis for the Natura 2000 site are listed in Table 31.

Table 31 Relevant designation basis for marine species for SCI for Zatoka Pucka i Półwysep Helski. Information on population size and site assessment is from the standard data form.

Species Annex II	Population size				Site assessment			
	Resident	Migratory			% of national population	Conservation status	Isolation	Global value
		Breed	Winter	Stage				
Halichoerus grypus				P	15-100%	Good	Not[1]	Good
Phocoena phocoena				P	15-100%	Good	Not[1]	Excellent

[1.] Population not-isolated, but on margins of area distribution
P=presence

The conservation status of the marine mammals, harbour porpoises (*Phocoena phocoena)* and grey seals (*Halichoerus grypus*) is good.

Though the area is within the potential distance of possible TTS for grey seals as well as avoidance reactions in porpoises, the acoustic modelling results have clearly shown that the peninsula sheltering the bay will serve as a complete barrier for noise, thus preventing any measurable effects of noise on harbour porpoises or grey seals within the Natura 2000 site (see acoustic modelling report and chapter 9.1.1; and noise maps in the Appendix to the document starting with Figure 27).

The impact on the marine mammals will hence not be significant.

Cumulative impacts

According to the Natura 2000 standard data form, the main threats to the Natura 2000 site are pollution, uncontrolled tourist pressure and the rapid development of recreation (trampling, construction of recreational facilities in the wrong places, excessive traffic). Furthermore, threats are listed as the exploitation of sand from the Bay of Puck, which is used for stabilisation and restoration of the Hel Peninsula beaches. Furthermore, the construction of other wind farms could be relevant, most notably Baltica 3 (for a complete list of activities, see also Section 8.5). Yet, as in the case of BŚ III, due to the land barrier, there will be no cumulative impact from the wind farm and the listed pressures in the Natura 2000 site.

Conclusion

It is assessed that impacts from BŚ III will not be significant for marine mammals on the designation basis of PLH220032 - Zatoka Pucka i Półwysep Helski.

Kaszubskie Klify

Area description

Habitat area SCI-PLH220072- Kaszubskie Klify includes a 9 km stretch of shore cliff (over 200 acres), stretching from Władysławowo to Jastrzębia Góra. The area adjacent to the cliff includes a sandy beach area. The marine area covers 0.4 km^2.

Marine mammals on the designation basis for the Natura 2000 site are listed in Table 32.

Table 32 Relevant designation basis for marine species for SCI for Kaszubskie Klify. Information on population size and site assessment is from the standard data form.

Species Annex II	Population size				Site assessment			
	Resident	Migratory			% of national population	Conservation status	Isolation	Global value
		Breed	Winter	Stage				
Halichoerus grypus					<2%	Good	Not[1]	Significant value

[1.] Population not-isolated, but on margins of area distribution

The conservation status of grey seal (*Halichoerus grypus*) is good.

Screening

Due to the distance to the project area, the only disturbance from the project which potentially can impact the designation basis is underwater noise.

The conservation status of grey seal (*Halichoerus grypus*) is good.

Screening

Due to the distance to the project area, the only disturbance from the project which can potentially impact the designation basis is underwater noise.

Though the area is within the potential distance of possible masking effects for grey seals, the acoustic modelling has indicated that sound ranges are decreasing rapidly in the shallow areas to the south of the wind farm. Thus, most of the noise will be attenuated and levels will be too low to cause any impact. The impact on the marine mammals will hence not be significant.

Cumulative impacts

It is from the standard data form not evident what the main threats to the Natura 2000 site are. According to chapter 8.5 cumulative impacts can arise from other wind farms (construction), installations of oil and gas fields (drilling), pipelines, mining and transport logistics. All activities except wind farms will potentially lead to a local increase in the ambient noise field which will be insignificant.

Due to the very poor sound propagation in shallow water, there will be no cumulative impact from the wind farm and the listed pressures in the Natura 2000 site; see also noise maps and impact ranges in the Appendix to the document starting with Figure 27).

Conclusion

It is assessed that impacts from BŚ III will not be significant for marine mammals on the designation basis of PLH220072PLH220072 - Kaszubskie Klify.

9.3.4 Natura 2000 Appropriate Assessment

The following section presents an Appropriate Assessment (AA) for the Natura 2000 site. Regarding the screening of the impacts the conclusion of the AA is that significant effects are likely or that sufficient uncertainty remains (impacts arising from the project cannot be excluded in the screening process).

The Appropriate Assessment is an assessment of the impact on the integrity of the Natura 2000 site of the project or plan, either alone or in combination with other projects or plans. The assessment is executed with respect to marine mammals and the structure and function and its conservation objectives.

The AA contains an assessment of the impact on the integrity of marine mammals of the Natura 2000 site of BŚ III, either alone or in combination with other projects or plans. The assessment is executed with respect to the structure and function and its conservation objectives. The focus on the assessment will be to investigate if there is evidence to support that there will be no adverse effects on the integrity of the Natura 2000 site. The assessments are based on the results from the EIA-part of the report.

Ostoja Słowińska

The area description is found in section 9.3.3.

Conservation objectives and status

The overall goal for Natura 2000 is to maintain or restore a favourable conservation status for the habitats and species constituting the basis for designation. Marine mammals on the designation basis have a good conservation status.

Assessment of integrity

The BŚ III wind farm area is app. 19 km from the Natura 2000 site. During construction of the wind farms single strikes will not lead to any impact in the Natura 2000 site expect for avoidance response for harbour porpoise (maximum range 68 km). Yet, as can be seen in Figure 27, the southern extension of the behaviour impact range is just outside the Natura 2000 area. We have to consider here that in some cases – for example during construction of piles in the southern part of the wind farm area, behavioural effects might happen within the Natura 2000 area. Yet, only a small fraction of animals would be impacted, and thus the overall impacts can be regarded as insignificant.

For multiple strikes (1 h exposure period) harbour porpoises present in the Natura 2000 area will be outside the TTS-inducing noise levels zone (see Figure 30). For grey seals the Natura 2000 area is just within the range of TTS-inducing noise levels from cumulative pile strikes if construction is performed in the centre of the wind farm area (Figure 37). We have to note here that the assessment of multiple strikes is very speculative as it is not clear how series of strikes accumulate at the receiver. Furthermore, the time over which signals have to be integrated is currently under discussion (see NOAA 2013). Finally, it is possible that some animals will leave the area of TTS within the accumulation period (1 h) due to avoidance - at least in harbour porpoises. Thus our conclusions have to be viewed as precautionary. Without implementing mitigation measures to reduce the noise levels, it is possible that the impact on the Natura 2000 area is substantial and severe causing an adverse impact on the integrity of the conservation status for grey seals in the Natura 2000 area. (For an indication of the sound spread from the wind farm area to the coast and the vicinity of Ostoja Słowińska, please see noise maps in the Appendix 1 to this report).

Noise from construction can be attenuated by different methods such as installing bubble curtains around the pile being driven. A reduction of 14 dB using a bubble curtain with small bubbles would reduce the impact ranges significantly (see noise modelling report and noise maps in Appendix 1). The PTS, TTS and behavioural impacts would then be insignificant.

Noise from the operating wind farm as well as from increased shipping during construction and operation are not expected to have an adverse impact.

It is likely that the area functions for grey seals mainly as a haul-out site where noise impacts would be non-existent. Effects can occur when seals travel to their feeding grounds which are presumably further away (see for example Edrén *et al.* 2010). It is likely that harbour porpoises would leave the area during construction if they are in areas where noise exposure is high enough to cause behavioural reactions. They will most likely temporarily relocate to other areas within their home range. The Natura 2000 coherence is not affected.

Cumulative assessment

There is a potential for cumulative impacts from the construction of other wind farms in the Baltic as well as from oil and gas exploration activities as identified in section 9.2, but any cumulative impacts are highly dependent the distance to the Natura 2000 site and on overlap in timing of the noise causing events, as well as the implementation of mitigation measures.

For the projects and activities listed in chapter 9.2 the impacts will most likely only involve a local increase of the noise field and thus not lead to overall significant impacts. Yet, cumulative impacts for the construction of BŚ III together with Baltica 3 (stage 1) have to be investigated in more detail. The addition of another construction site will add to the overall acoustic footprint.

- In case of parallel construction at two sites at the BŚ III wind farm area (BŚ III SW and BŚ III N) impact ranges for multiple strikes will increase, but both PTS and TTS ranges for harbour porpoise will be located outside the Nature 2000 area. This is not the case for the behavioural response zone as it is expected that behavioural reaction may occur in the small area located to the north-east of Ostoja Słowińska (Figure 44). It is worth mentioning that calculated behavioural response ranges are based on parallel single strikes on both piling sites, as it is expected that animals will react to noise and leave the area. No PTS, TTS and behavioural response for grey seals due to simultaneous pile driving at the BŚ III wind farm area is expected. Obtained impact ranges change significantly when mitigation measures have been applied in the modelling (bubble curtain) assuming 14 dB reduction is sound levels due to pile driving activities. In this case no behavioural reaction of porpoises within the Nature 2000 sites is expected (Figure 48). Although it has to be noted that impact ranges can change depending on the pile driving site at BŚ III in the worst case scenario when two piling sites will be located in the southern part of the area TTS, and behavioural change impacts on marine mammals cannot be ruled out.

- In case of parallel construction at BŚ III and the Baltica 3 wind farm area the impact ranges for multiple strikes will increase significantly, especially for TTS and behaviour response ranges, although many of these will occur in Ostoja Słowińska, both for harbour porpoises and grey seals. This is the case for pile driving, both with and without mitigation measure applied (bubble curtain). Although it has to be noted that impact ranges can change depending on the pile driving site at BŚ III and Baltica 3 in the worst case scenario when two piling sites will be located in the southern parts of the areas, meaning that TTS and behavioural change impacts on marine mammals cannot be ruled out.

- In case of subsequent construction of wind farms for extended periods it is impossible to foresee the overall impacts without any reasonable information on proposed timing. We have outlined that behavioural response will probably cease once the construction of one turbine has been finished, or after the construction period for one wind farms has ended. As indicated in the impact assessment, this can happen from several hours to a few days after the end of the construction period. Thus, in consequence it is possible that subsequent construction of wind farms will lead to extended behavioural effects in the Natura 2000 site, but there will also be recovery periods between different projects, and impact ranges will differ based on each wind farm location. If construction works are mitigated, no severe impact are expected.

Taking into account what is mentioned above, it is assumed that cumulative impact on harbour porpoises due to simultaneous piling at two sites (BŚ III NE and BŚ III SW) within the Nature 2000 area cannot be ruled out. This is the case for behavioural reaction on the north-east borders of the Ostoja

Słowińska area, which will affect the integrity of the Nature 2000 site. Although, if mitigation measures are applied in the form of e.g. a bubble curtain this can be avoided.

There are no negative impacts on grey seals and harbour porpoises within the Nature 2000 area due to simultaneous piling at BŚ III and Baltica 3 (BŚ III SW and Baltica 3 N) while piling with and without mitigation. It has to be pointed out that impact ranges can change due to different piling sites at both BŚ III and Baltica 3 areas, potential impact on animals within Nature 2000, and thus adverse effect on site integrity cannot be ruled out when simultaneous piling will take place in the southern parts of the project areas.

9.4 Mitigation measures

9.4.1 Harbour porpoises

In principle, noise mitigation measures can target the source (i.e. methods to reduce sounds at the source), the channel between source and receiver (i.e. using bubble curtains) and the receiver (devices that scare marine mammals out of the zone of injury). The latter devices are known as Acoustic Management Devices (AMDs) and can effectively deter marine mammals at distances of app. 7.5 km around the source, i.e. the zone of injury and / or PTS (Brandt et al.2013). Yet, not all animals react in the same way, so that one cannot guarantee that all animals have left the 'danger zone' (zone of PTS / TTS) due to the pinger (Brandt et al. 2013) The zones of impact for series of strikes are too large for AMDs to work effectively for BŚ III. They could, however, be applied in combination with other methods.

As the impacts described above are very high, especially for behavioural effects, modelling of the scenario with a mitigation measure for the variant chosen for realisation and rational alternative variant was undertaken. Primary mitigation measures that reduce sound pressure source levels, such as pile-caps or vibro-piling are not feasible for the monopiles with large diameters, whereas secondary mitigation measures such as bubble curtains are more cost-effective (Carlson & Weiland 2007). A scenario modelling a 14 dB reduction by a bubble curtain similar in frequency dampening effects to the one used in the construction of the Borkum West offshore wind farm was therefore used as a realistic mitigation scenario (see noise modelling report for a more detailed description (Pehlke *et al.* 2013).

Table 33 shows the impact ranges based on the new scenario. A 14 dB reduction in source level roughly corresponds to a 3 time reduction of range, but the dampening of higher frequencies is even larger using a bubble curtain with smaller-sized bubbles (Pehlke *et al.* 2013). This becomes apparent when looking at the ranges presented below. Though ranges for behavioural disturbances are still comparatively large, this reduction in distance will effectively reduce the affected area by 20-fold.

Table 33 Ranges of impact on harbour porpoises for single and cumulative pile strikes for a 7.5 m and 10 m diameter monopile (rational alternative variant and the variant chosen for realisation) with noise attenuation of 14 dB from a bubble curtain (see detailed results in the acoustic modelling report).

Effect	Maximum range to threshold (single strike)	Maximum range to threshold (cumulative strikes)
PTS	<10m	400 m
TTS	1000 m	3500 m
Avoidance behaviour	15700 m	15700 m

9.4.2 Grey seals and harbour seals

As for the harbour porpoises an alternative scenario with an attenuated source level of 14 dB was modelled for comparison.

Table 34 shows the impact ranges based on the new scenario. The PTS range is reduced from approx. 20 km to around 5 km, and the TTS range is roughly a quarter of what it was. The range for TTS remains large, but the reduction in PTS range results in a significant reduction of the affected area.

Table 34 Ranges of impact on harbour seals and grey seals for single and cumulative pile strikes for a 7.5 and 10 m diameter monopile (rational alternative variant and the variant chosen for realisation) with noise attenuation of 14 dB from a bubble curtain (see detailed results in the acoustic modelling report).

Effect	Maximum range to threshold (single strike)	Maximum range to threshold (cumulative strikes)
PTS	20 m	4700 m
TTS	300 m	20700 m
Avoidance behaviour	300 m	300 m

Table 35 Overall effect of the construction activities on marine mammals with implemented mitigation measures

Species	Impact	Scale of exposure	Duration	Intensity	Frequency of impact	Reversibility	Scale of impact	Significance
Harbour porpoise (*Phocoena phocoena*)	PTS single	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PTS cumulative	Local	Long-term	Very high	Repetitive	Irreversible	Moderate	Moderate
	TTS single	Local	Short-term	High	Repetitive	Reversible	Insignificant	Low
	TTS cumulative	Regional	Short-term	High	Repetitive	Reversible	Low	Low
	Avoidance behaviour	Regional	Short term	Medium	Repetitive	Reversible	Insignificant	Low
Harbour seals (*Phoca vitulina*) and grey seals (*Halichoerus grypus*)	PTS single	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	PTS cumulative	Regional	Long-term	Very high	Repetitive	Irreversible	High	Moderate
	TTS single	Local	Short-term	High	Repetitive	Reversible	Insignificant	Negligible
	TTS cumulative	Regional	Short-term	High	Repetitive	Reversible	Low	Low
	Avoidance behaviour	Local	Short-term	Low	Continuous	Reversible	Insignificant	Negligible

10 Associated impacts

The related impacts are defined as the accumulation of all interactions that affect the respective receptor, in this case marine mammals. The aim of the evaluation of the related impacts is the verification whether the impacts which individually have no significant influence on the environment, in conjunction with one another will not ultimately become a source of significant negative impact. In this kind of situation the use of additional actions aiming at minimizing such effects becomes necessary.

In order to identify the potential, related impacts, verification of interdependencies between resources/subjects of impact (receptors) was made. The matrix with the results of the analysis is presented in Table 36 below.

Along the vertical axis, the receptors of the first category are listed, which are a potential source of impacts on receptors listed along the horizontal axis (of the second category). The category in question and analysed here is colour coded. "X" indicates the existence of a potential, direct relationship between particular receptors, which should be analysed in detail within the impact assessment.

It can be seen from Table 36 that marine mammals affect a limited number of receptors. We will outline main effects, and then consider how the analysed changes to other receptors could influence marine mammals.

Table 36 Matrix of the relationships between the receptors of impacts

	Hydrology, hydrochemistry	Seabed	Sediments	Mineral resources	Acoustic environment	Atmosphere	Benthos	Fish	Marine mammals	Birds	Bats	Fishery	Shipping and navigation	Military operations	Military aviation	Civil aviation	radar systems	Landscape	Tourism and recreation	Material goods	Marine industry	Human life and health	Cultural heritage
Hydrology, hydrochemistry									x														
Seabed									x														
Sediments									x														
Mineral resources																							
Acoustic environment									x														
Atmosphere																							
Benthos									x														
Fish									x														
Marine mammals					x			x											x				
Birds																							
Bats																							
Fishery									x														
Shipping and navigation									x														
Military operations									x														
Military aviation									x														

	Hydrology, hydrochem-istry	Seabed	Sediments	Mineral resources	Acoustic environment	Atmosphere	Benthos	Fish	Marine mammals	Birds	Bats	Fishery	Shipping and navigation	Military operations	Military aviation	Civil aviation	radar systems	Landscape	Tourism and recreation	Material goods	Marine industry	Human life and health	Cultural heritage
Civil aviation																							
Radar systems																							
Landscape																							
Tourism and recreation									x														
Material goods																							
Marine industry									x														
Human life and health																							
Cultural herit-age																							

10.1 Impacts resulting from changes to marine mammals

Marine mammals produce a wide variety of sounds and can thus affect the acoustic environment (for a review see Richardson *et al.* 1995). However, since the baseline studies at BŚ III clearly indicate that all three species (harbour porpoise, grey seal and harbour seal) appear only in very low numbers in the planning area, their contribution to background noise at BŚ III will be minimal and any changes in their distribution due to the construction or operation of the planned farm will not affect background noise levels. It is also perhaps possible that marine mammals affect tourism but again, numbers in the project area are too low to warrant any dedicated whale or seal watching industry.

10.2 Other components affecting marine mammals

There is a variety of other receptors affecting marine mammals. Abiotic components will undergo changes due to the construction and operation of the wind farms, but knock-on effects on marine mammals will most likely be insignificant. Many other receptors – comprising a variety of human activities – will be reduced and most likely have positive effects on marine mammals. Hydrological changes, seabed alterations and changes to the sediment can affect the foraging behaviour of marine mammals, but the impacts due to construction and operation will be small and hence impacts on marine mammals is likely to be insignificant. We have covered the changes to the acoustic environment and knock-on effects on all three marine mammal species extensively in this report.

Changes to benthos and fish communities are probably due to the introduction of hard substrate and the creation of artificial reefs leading to an increase in diversity and number of fish (see, for example Leonhard *et al.* 2013; Gutow *et al.* 2014). Possible positive effects could be an increase in food items which could make the offshore wind farm site more attractive for marine mammals (see for example Scheidat *et al.* 2011). Effects on fishery could be a reduction of the fishing effort due to the wind farm area being fully or partly closed for fishing activities. This could reduce bycatch pressure, at least to some extent and also reduce noise levels making the wind farm area more attractive, especially to porpoises (see case study by Scheidat *et al.* 2011). Noise levels will most likely also be reduced in the area as other shipping activities will be reduced as well. The wind farm could also result in a restriction of military operations (including aviation) due to access restrictions and no-fly areas. This could reduce pressure on seals and porpoises in the BŚ III area. Tourism - in the form of tour boats or private fishing charters - will probably also be prohibited in the future site, further reducing potential disturbance to marine mammals in the form of underwater noise emissions. Finally, the introduction of marine industries – for example mining or dredging - would be highly unlikely to happen at BŚ III. Thus, any negative effects due to introduction of underwater noise would be minimised.

11 Transboundary impacts

11.1 Construction

From the assessment undertaken in chapter 9 it can be concluded that the construction of BŚ III will lead to an increase in noise levels that can be detected - depending on the distance to land and local bathymetry – over distances of at least 150 km (see Figure 20; Table 16). Thus, under the worst case scenario, the construction noise at BŚ III will be audible in parts of the EEZ's of Denmark, Sweden, Lithuania, Latvia and Russia. According to Figure 20, the received noise level in other EEZ will reach levels of between 100 – 138 dB re 1 µPa^2·s, except of Sweden, where in the most southern part of Swedish EEZ sound levels will reach 140 dB SEL. There are no reliable measurements of ambient noise from other areas except Sweden where similar ambient noise levels were recorded to those found at BŚ III (Johansson & Andersson 2012). Looking at this and the Swedish study, the range of ambient noise is 109 – 116 dB re 1 µPa. Thus the pile driving sound exceeds ambient noise values across EEZ's. These levels add to the noise field but they are probably not high enough to result in any effects on marine life, except in the most southern part of Swedish EEZ where behavioural impact on harbour porpoises can be expected to occur due to a single strike pile driving at the BŚ III site (see Southall *et al.* 2007 for sound exposure criteria).

However after the application of a bubble curtain as a mitigation measure this negative effect can be avoided. This is also the case for multiple strike TTS range for harbour and grey seals, where without the mitigation measure applied, due to the sound propagation properties, temporary hearing threshold shift can be expected to occur at the very south of Swedish EEZ. Thus, although pile driving sound transmits across boundaries, levels causing TTS and behaviour response in marine mammals can be expected to occur only at the Swedish EEZ, and can be eliminated with the application of a bubble curtain as a mitigation measure.

No significant resulting effects are expected in the EEZ's of other neighbouring countries.

Following the precautionary approach – we have treated the harbour porpoise in the Baltic as one unit in the impact assessment - the designation of harbour porpoises into a distinct Baltic population is not without uncertainties (see, for example Koschinski 2002 and chapter 8.1.2). A division into even smaller units appears unlikely so that effects of construction noise, although relatively far ranging with regard to behavioural avoidance, will not lead to any barrier effects on subpopulations. Moreover, porpoises are opportunistic feeders and are known to travel long distances following their prey (Koschinski 2002). Thus, individuals most likely travel around the whole Baltic region and just by chance cross the BŚ III area. Exclusion of this area during the disturbance periods could cause a change in the travelling and perhaps also the foraging patterns of individuals but will not be significant at a population level.

It is likely that harbour seals only travel through the area on a very random basis as numbers in this part of the Baltic are very low. The grey seals in the Baltic proper can be viewed as one population (see chapter 8.2.2) and effect ranges are not large enough to affect a proposed separate population in the Bothnian Bay.

11.2 Operation

Sound levels during operation are not high enough to lead to any transboundary impacts.

11.3 Dismantling

Sound levels during dismantling are not high enough to lead to any transboundary impacts.

12 Monitoring proposal

12.1 Aim of the monitoring

The monitoring should investigate the impacts of the construction noise on harbour porpoises. Post-construction monitoring shall be undertaken to verify the return of the usage of the area by porpoises to baseline levels.

Moreover, the monitoring should investigate the impacts of the construction sound on the local sound field. This should help to further identify impact ranges for marine life. Post-construction monitoring shall be undertaken to verify that acoustic emissions during operation are not adding significantly to the background noise at BŚ III.

12.2 Description of planned activities

Due to the very low number of porpoise detections, any monitoring with the aim to detect a signal of construction activity will be very challenging. It is suggested that the aerial surveys can be terminated in any case as their main function – verification of the CPOD data and proof that porpoises actually do exists in these waters – has been fulfilled.

We suggest that the monitoring should be undertaken with CPODs similar to the baseline monitoring.

In general, the sound field monitoring shall follow the guidelines for Environmental Impact Assessment for Offshore Wind Farms as set forth by BSH 2011, 2013.

- Measurement of construction noise during noise intensive construction work (i.e. pile driving).
- Measurement of operational noise capturing. The measurements shall capture the three performance ranges “low”, “medium” and “rated output” (according to different wind classes)

The German guidelines have been developed by an exert group and are tailor-made for offshore wind farm EIAs. They are therefore suitable to be used at BŚ III as well.

12.2.1 Construction monitoring

At least three PODs shall be placed in the vicinity of the wind farm, preferably at the same sites as during the baseline monitoring. In addition, 3 PODs shall be installed at two reference sites at least 20 km away from the impact site (for behavioural ranges of pile driving, see for example Brandt *et al.* 2011). Two reference sites are better than one as with this method biases due to gradients in distribution with regard to distance to land or horizontal distributions could be countered. It is also recommended to use more PODs compared to the baseline to increase the chances of detection of porpoises.

The exact placement of these reference stations shall undergo a detailed scoping exercise.

The details of the noise level construction measurements are found in BSH 2011. Here we will summarise the key parameters of the measurement campaign

- Measurements with calibrated underwater microphones (=hydrophones); frequency range 10 Hz – 20 kHz

- The measuring sites have to be determined at a certain distance from the pile driver. BSH 2011 advises 750 m and 5,000 m from the foundation structure and in the closest nature conservation area, provided that it is more than 5 km away from the project site. Yet, this is based on German regulation including noise exposure criteria that should not be exceeded at 750 m. Thus, for BŚ III, the exact distance shall be determined at the later application stage.

12.2.2 Operation monitoring

Post-construction monitoring of harbour porpoises shall be undertaken for a period of 24 months using the same method as during construction.

The operation monitoring of the background noise levels is necessary to verify the predictions made in the EIA.

- Data has to be collected on a random basis at individual turbines of the wind farm. The sound measurements have to be carried out at about 100 m from the sound source and in the middle of the wind farm.
- Additionally, measurements have to be done outside the wind farm at a distance of 1,000 m and in the nearest nature conservation area, provided that it is not more than 5 km away from the project site. Is no nature conservation area in the vicinity, a sound measurement must be carried out at 5 km distance to the wind farm.

12.3 Period of the monitoring

Harbour porpoise monitoring should take place no later than 6 months prior to the construction, throughout the construction period and at least one year post-construction.

During the construction period noise level measurements shall be undertaken throughout ramming at fixed intervals. But the exact timing depends on the agreement with the regulator and whether noise exposure criteria will be set. During the operational phase, measurements shall be undertaken once for each wind class bft 2, 4, 6.

12.4 Consequences of the monitoring for the project

The consequences of harbour porpoise monitoring for the construction will be the needed costs for the monitoring period. The consequences of the noise level construction monitoring depend on the exact regulation of the activity. If noise exposure criteria are set, then monitoring would have to be undertaken for each turbine ramming exercise which could lead to significant additional costs for the investor. For the operational monitoring, the costs are very moderate.

13 Summary and conclusions

- In a first step, the existing anthropogenic pressures acting on marine mammals at BŚ III were mentioned and described in detail (see chapter 0). Existing pressures are by-catch contaminants, eutrophication, shipping (collisions), tourism and recreation and underwater noise.

- In the second step we analysed the 'zero variant' under three scenarios (see chapter 5). Under the assumption that no wind farms would be developed in the Polish maritime area, noise levels would increase due to the increase in shipping over the next decades and the remaining pressures would act on marine mammal populations as well. Under the second assumption that wind energy will be developed in the Polish marine area, but that the BŚ III project will not be implemented, the construction noise levels of other wind farms would add significantly but temporarily to the existing noise levels. Finally, if we assume that wind energy will not be developed in the Polish Marine Area, but mining industry is developed, these activities will to some extent add to the overall increasing shipping noise. It is likely that despite the pressures, the grey seal population will continue to increase while no statements can be made on harbour seals (they are sporadic travellers through the area) and harbour porpoises (no population trends available).

- In the third step we listed all potential impacts that can effect marine mammals (see chapter 0). Construction related impacts can be caused by impact pile driving, dredging, construction shipping, suspension of sediments, release of pollutants and changes in habitat. Impacts during operation can be caused by noise from turbines and service and maintenance traffic, electromagnetic fields, reef effects and visual effects. Dismantling activities will mainly involve drilling and shipping similar to the situation during construction although pile driving will most likely not be used.

- In the fourth step we have included the species being subject to the impact assessment (see chapter 8). This involves harbour porpoises, grey seals and harbour seals. Harbour porpoises are protected in Polish waters under various mechanisms. The exact number of porpoises inhabiting the Polish waters is unknown but it is likely to be an area of low to very low density. New SAMBAH project results indicate that between 90 and 997 porpoises inhabit the north-eastern part of the Baltic (Thomas and Burt 2014). Porpoises are very sensitive to underwater sound and are potentially vulnerable to the high noise levels that go along with the construction of the planned wind farm. Their sensitivity to the operating wind farm is lower compared to the situation during construction. Grey seals are protected amongst others under the EU Habitats Directive Appendix II. Studies indicate that grey seal numbers are relatively low in Polish waters but that counts have been increasing over the last years. Grey seals are sensitive to underwater sound, although their range of best hearing is smaller compared to harbour porpoises. Their sensitivity to offshore wind farm construction is most likely to be high. Harbour seals have the same protection status in Polish waters as the grey seals do. Their status in Polish waters is not clear but numbers at the BŚ III site are very low. Their sensitivity to sound and wind farm construction is identical to that of grey seals. Both species are probably not very sensitive to wind farms in operation.

- In the fifth step, we performed the impact assessment (chapter 9) for the variant chosen for realisation and rational alternative variant. We found that under variants mentioned above (10 m diameter monopile and 7.5 m diameter monopile), the sound generated by impact pile driving will have the same, large effective range (= range over ambient noise) of between > 10 and at least 150 km, depending on the distance to land and the bathymetry. Thus, pile driving will add significantly to the existing noise, although the activity will be temporary. Impacts of construction noise will be moderate for single sound emissions (= single strikes) for both harbour porpoises and seals, but for multiple strikes (= cumulative strikes) the impacts are likely to be high for porpoises and moderate for seals (due to their sporadic appearance in the BŚ III area). It has to be noted that due to the number of turbines planned, the construction phase for the rational alternative variant will most likely be longer (200 monopiles compared to 120 monopiles for the variant chosen for realisation). Thus the variant chosen for realisation will be potentially less harmful for the marine life due to the shorter period of introducing high sound levels into the environment (pile driving activities). The operational phase will have low impact although marine mammals will be able to detect operational sound at a distance of several km. It is not expected that seals will react to the operation noise, but a small proportion of harbour porpoises exposed to operational sound could react at a distance of several km under very low background noise conditions. However, it is extremely unlikely that this reaction will sustain for any longer time. There is a potential for positive effects due to the creation of artificial reefs and the accompanied increase in fish. The dismantling of the wind farm will have low significance for marine mammals. Cumulative impacts are possible during the construction activity both resulting from more than one pile driving activity at any given time (although that is very unlikely) and the simultaneous construction of another wind farm. The exact impact ranges are difficult to define due to the complexities of the interactions of the acoustic fields emitted from the two parallel activities. Impacts on Natura 2000 sites are possible with regard to Ostoja Słowińska (PLH220023). Here, likely effects are behavioural disturbance and temporary loss of hearing in both grey seals and harbour porpoises. However, since the area is close to the coast, sound will be attenuated and effects will not occur at the same intensity in the whole area. The described impacts can be mitigated effectively using sound reduction measures such as cofferdams (an air-filled steel pipe around the pile river) and bubble curtains (= a curtain of air bubbles around the pile driver).

- In the sixth step, the associated impacts were investigated (see chapter 10). Marine mammals produce a wide variety of sounds and can thus affect the acoustic environment. However, since the baseline studies at BŚ III clearly indicate that all three species (harbour porpoise, grey seal and harbour seal) appear only in very low numbers in the planning area, their contribution to background noise at BŚ III will be minimal and any changes in their distribution due to the construction or operation of the planned farm will not affect background noise levels. The same can be said for their effect on fish and tourism. There is a variety of other receptors which affect marine mammals. Abiotic components will undergo changes due to the construction and operation of the wind farms but knock-on effects on marine mammals will most likely be insignificant. Many other receptors - comprising a variety of human activities - will be reduced and will most likely have positive effects on marine mammals.

- In the seventh step, we investigated transboundary impacts (see chapter 0). It is clear from the assessment that behavioural disturbance ranges for harbour porpoise and TTS for seals could become a transboundary issue as the maximum disturbance range was identified as being 68 km (single strike). Yet, it has to be pointed out that using the suggested mitigation measures will result in a sufficient alleviation of the impact so that transboundary issues can be kept at a minimum. Effects of construction noise, although relatively far ranging with regard to behavioural avoidance – will not lead to any barrier effects on subpopulations. It is likely that harbour seals only travel through the area on a very random basis as numbers in this part of the Baltic are very low. The grey seals in the Baltic proper can be viewed as one population (see chapter 8.2.2) and effect ranges are not large enough to affect a proposed separate population in the Bothnian Bay. Thus, transboundary effects affecting other populations can be ruled out. No transboundary impacts are expected during operation or dismantling of BŚ III.

- In the eight step, a monitoring proposal was developed (refer to chapter 0). The monitoring should investigate the impacts of the construction noise on harbour porpoises. Post-construction monitoring shall be undertaken to verify the return of the usage of the area by porpoises to baseline levels.

14 Technical deficiencies and gaps in the current knowledge

The lack of knowledge regarding the distribution, population size and density estimates of the marine mammal species in the Baltic makes the conclusions regarding effects on populations somewhat speculative, and should be viewed with caution.

The noise impact assessment we are presenting here comes with a number of uncertainties, especially during the construction phase. Pile driving is broadband but has most of its energy at the lower frequencies (i.e. < 1 kHz). There is no indication that a TTS at these frequencies can affect the ability of porpoises to navigate and forage using echolocation (main frequencies around 130 kHz). Potentially, the ability to detect low frequency vessels could be affected. However, most vessel noise is much below 1 kHz where porpoise hearing is poor. The biological relevance of a low frequency TTS is thus difficult to assess, although it is considered a temporary physical damage to the animal (see Kastelein et al. 2012a for a discussion on this point).

We have shown that impact ranges for multiple strikes will be larger than for single strikes. But based on the uncertainties of the criteria for multiple strikes as well as the validity of the underlying assumptions, these ranges are fraught with some uncertainty. For example, in the noise modelling we have followed best practice by assessing the cumulative exposure over 1 hour. It is not known whether this criterion is sufficient, especially as we would expect porpoises (and other marine mammals) to avoid aversive sound fields resulting in a constant change of the acoustic dose received. We have followed the draft recommendations by NOAA (NOAA 2013), that are currently under review, to base the assessment of cumulative impacts on 1-hour periods to account for responsive movement.

For harbour porpoises, the behavioural impact ranges during construction have been estimated to be very large. However, the 140 SEL criterion is unweighted meaning broad band levels of the sound without consideration of the detection characteristics of porpoises. As pile driving mainly consists of low frequency noise it is outside the range of best hearing of harbour porpoises. At ranges of several tens of km, the frequencies at which harbour porpoises are most sensitive will have been attenuated more than the lower frequencies in the sound. Therefore, though the total energy may still be significant at 90 km, the energy that affects harbour porpoise behaviour may not be as pronounced. A behaviour disturbance range of 96 km is thus still speculative for porpoises.

The long-term effects of this displacement are also uncertain. In some cases porpoises have returned (or other animals have entered the area) to the wind farm site shortly after the end of the construction period (Tougaard et al. 2006; Scheidat et al. 2011). Still, at Nysted Offshore Wind Farm animals may be very slow in returning or be permanently displaced (Teilmann & Carstensen 2012).

For seals the impact ranges for cumulative strikes increase very drastically, but similar to the harbour porpoises the criteria for multiple strikes are fraught with uncertainty due to very few experimental data on a very limited number of individuals. The assumption of equal energy is not tested on pinnipeds either ((NOAA 2013) and see discussion above on porpoises). In addition, we have to consider that NOAA is currently revising the TTS and PTS criteria for pinnipeds. The cumulative noise effect ranges are therefore still speculative.

However, besides these uncertainties, most experts nowadays would agree that impacts due to underwater noise emissions from offshore wind farm construction could lead to significant impacts on marine mammals. Mitigation measures have been suggested here that can greatly alleviate impacts and these are also undergoing continuous development both with regard to efficiency and price.

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16 List of Figures

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18 Appendix 1 Noise maps for the variant chosen for realisation and rational alternative variant

18.1 Harbour porpoise

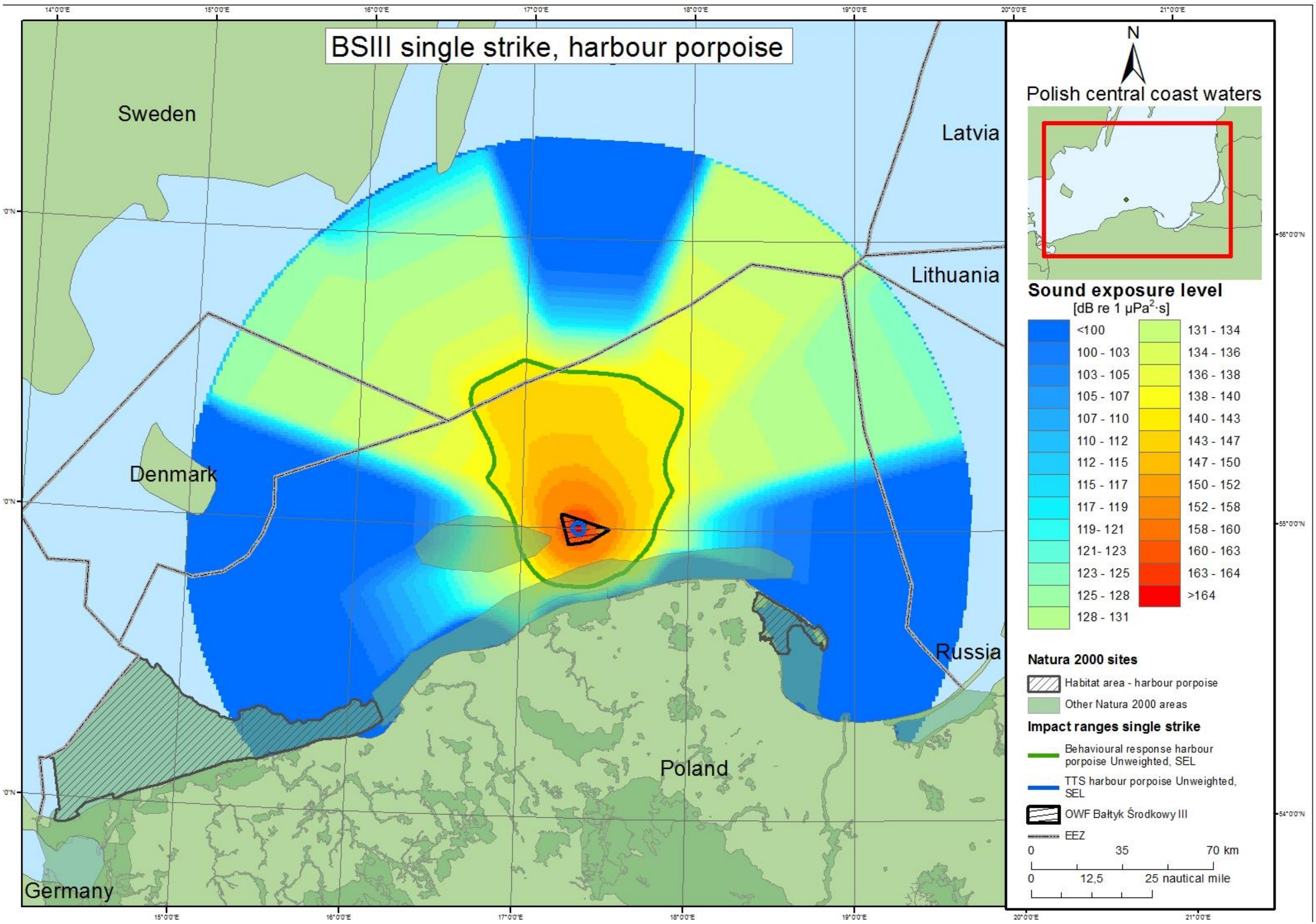

Figure 27 Noise map of the single strike sound exposure levels with associated impact ranges for harbour porpoise including Nature2000 areas.

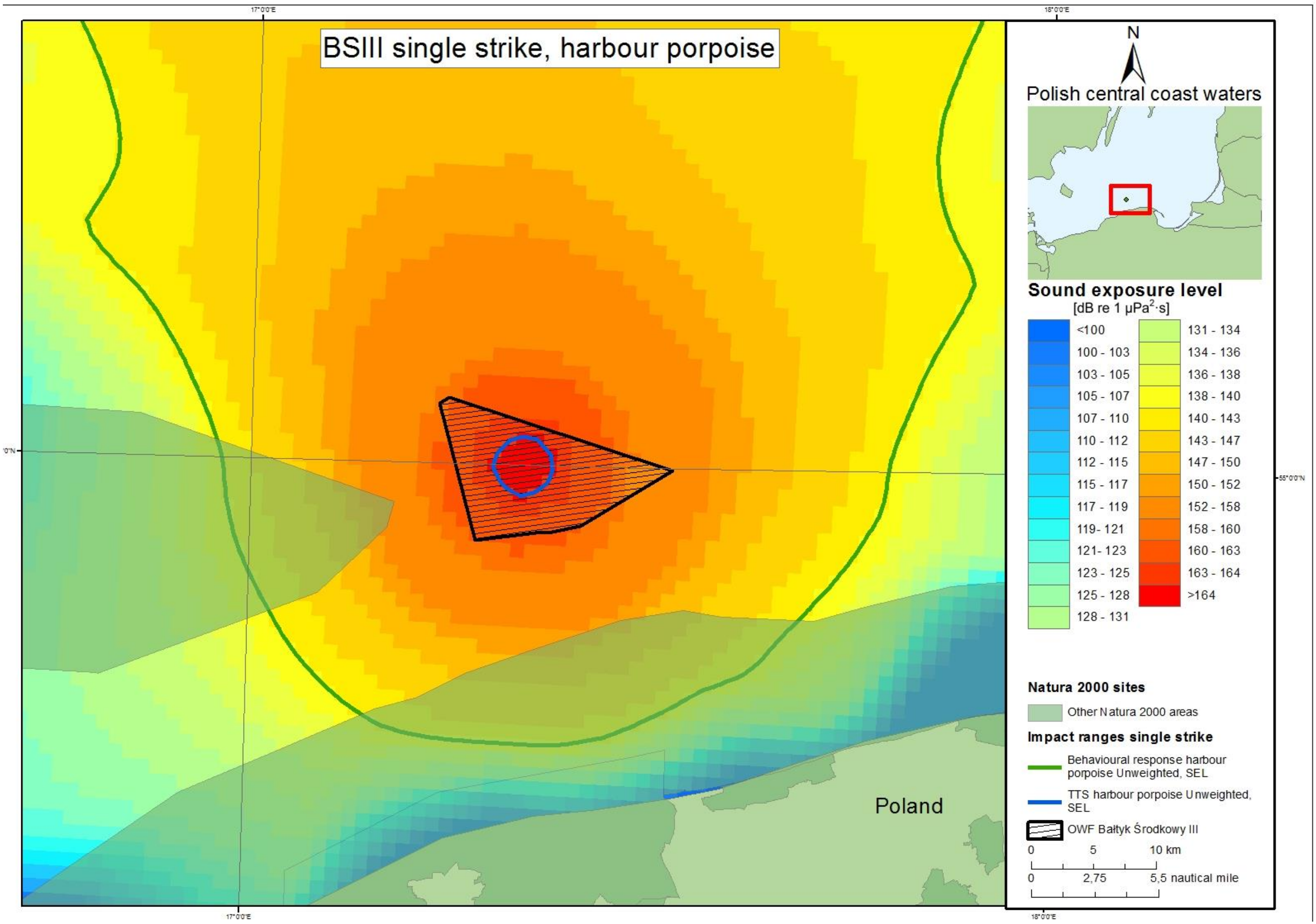

Figure 28 Noise map of the single strike sound exposure level with associated impact ranges for harbour porpoise (zoomed in including Nature2000 areas).

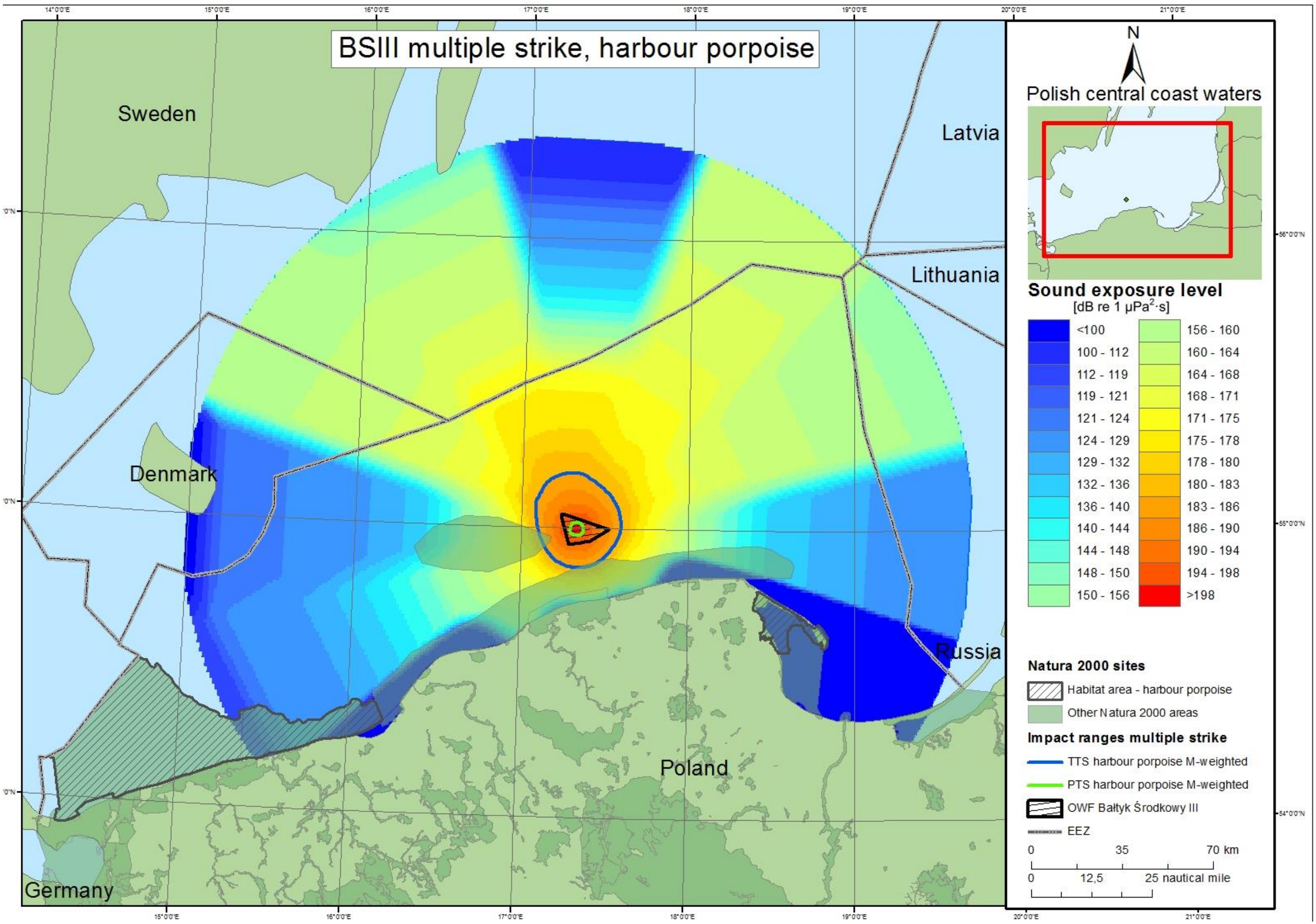

Figure 29 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour porpoise including Nature2000 areas.

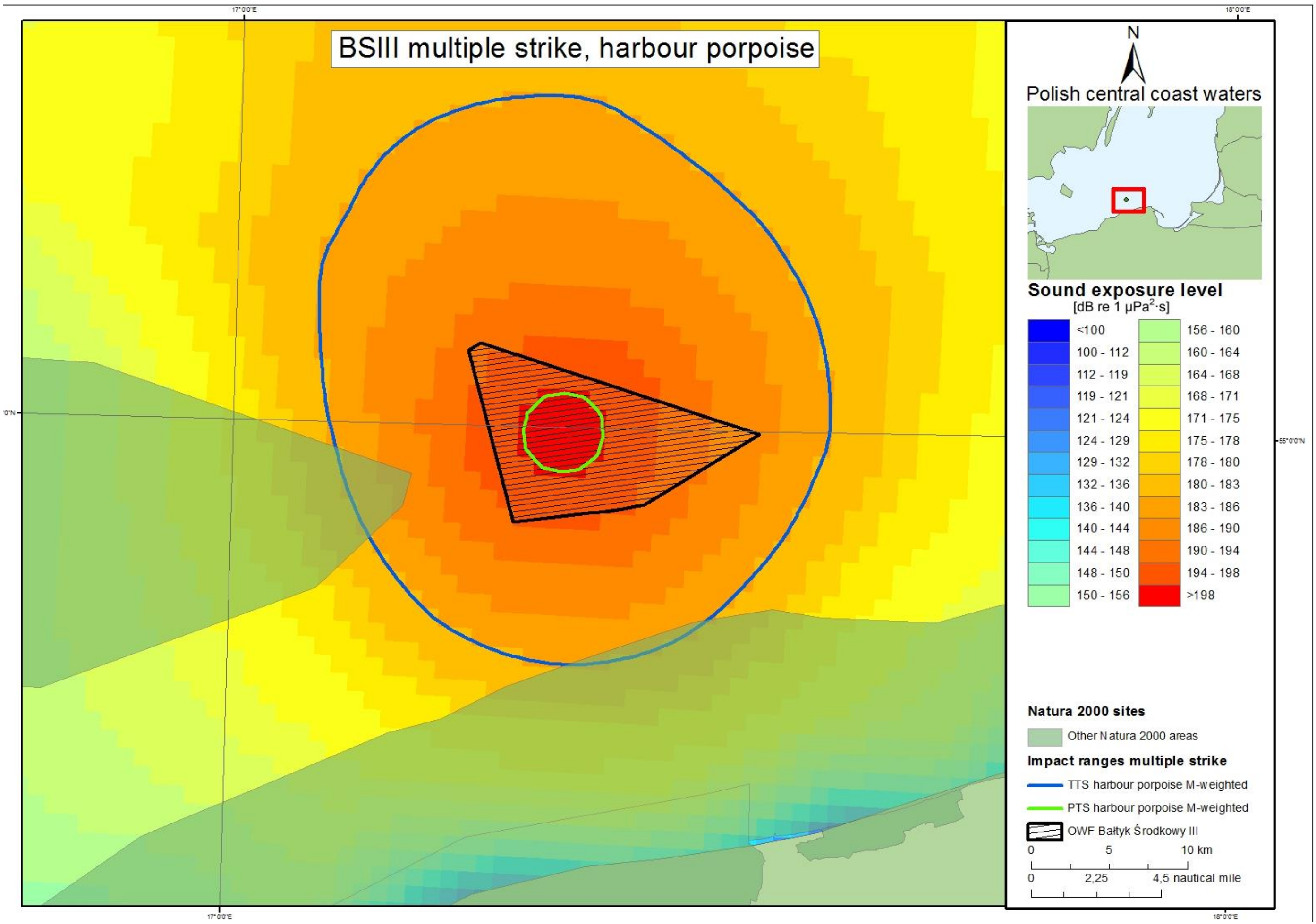

Figure 30 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour porpoise (zoomed in including Nature2000 areas).

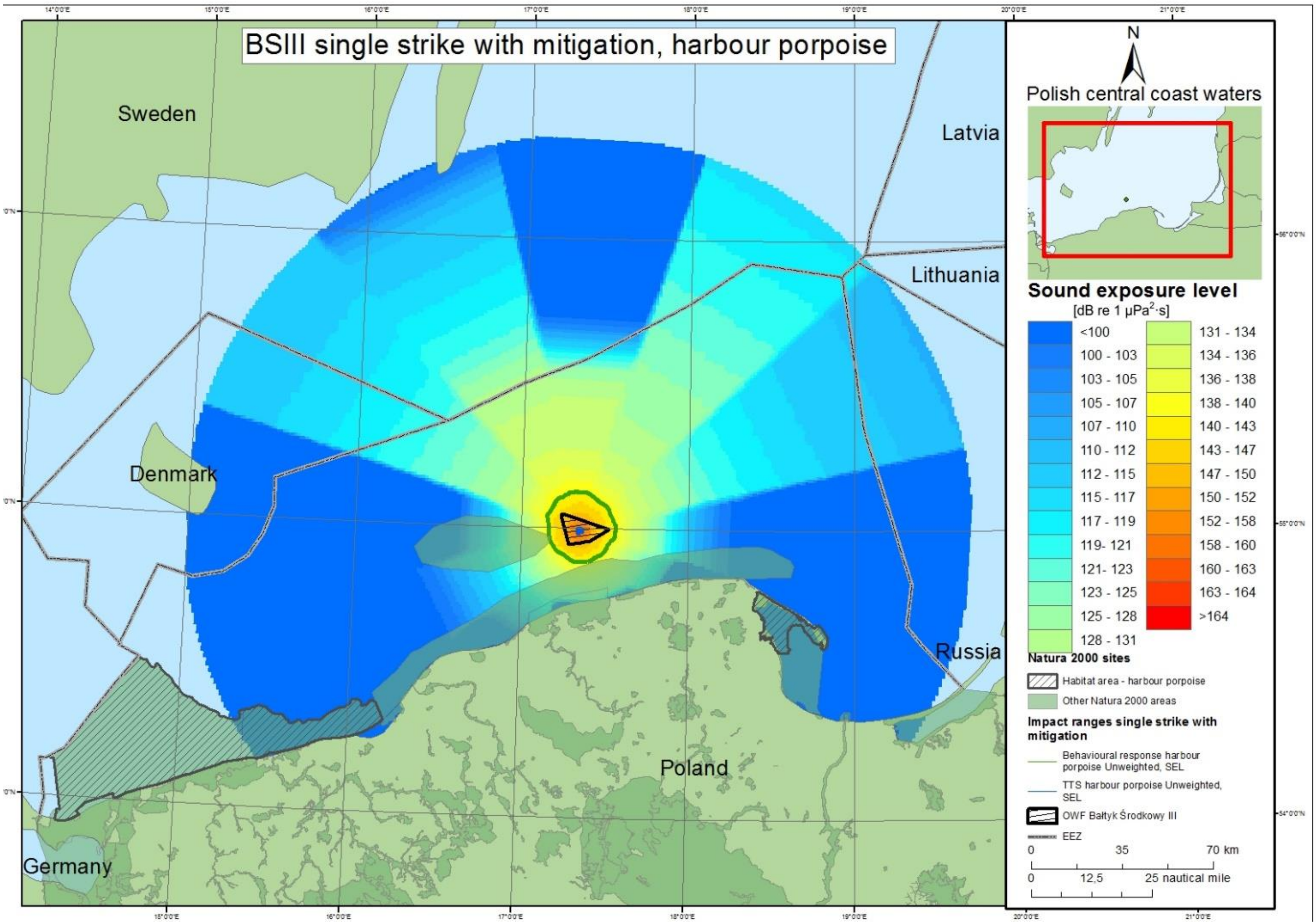

Figure 31 Noise map of the single strike sound exposure level with associated impact ranges for harbour porpoise with bubble curtain mitigation.

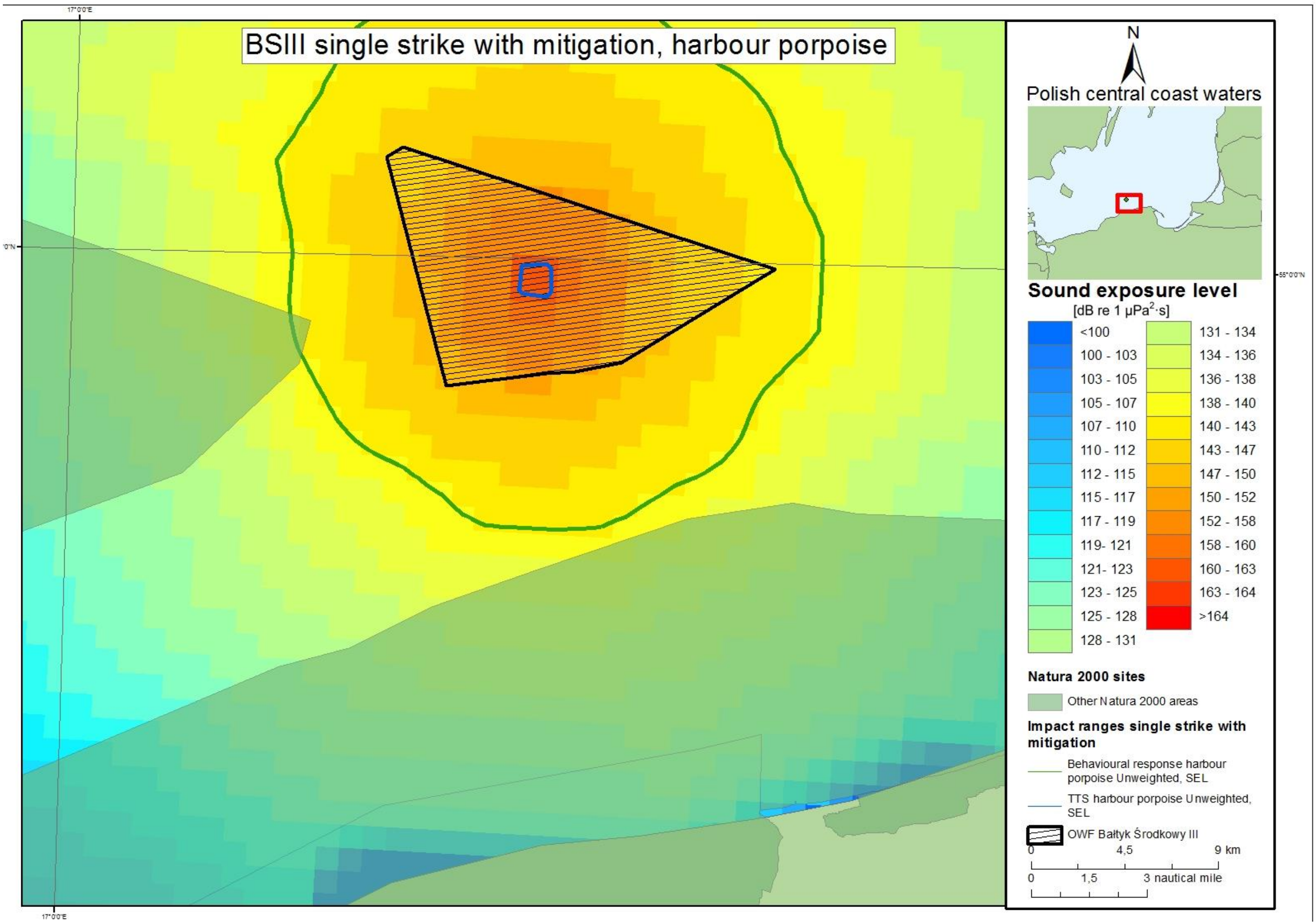

Figure 32 Noise map of the single strike sound exposure level with associated impact ranges for harbour porpoise with bubble curtain mitigation (zoomed in including Nature2000 areas).

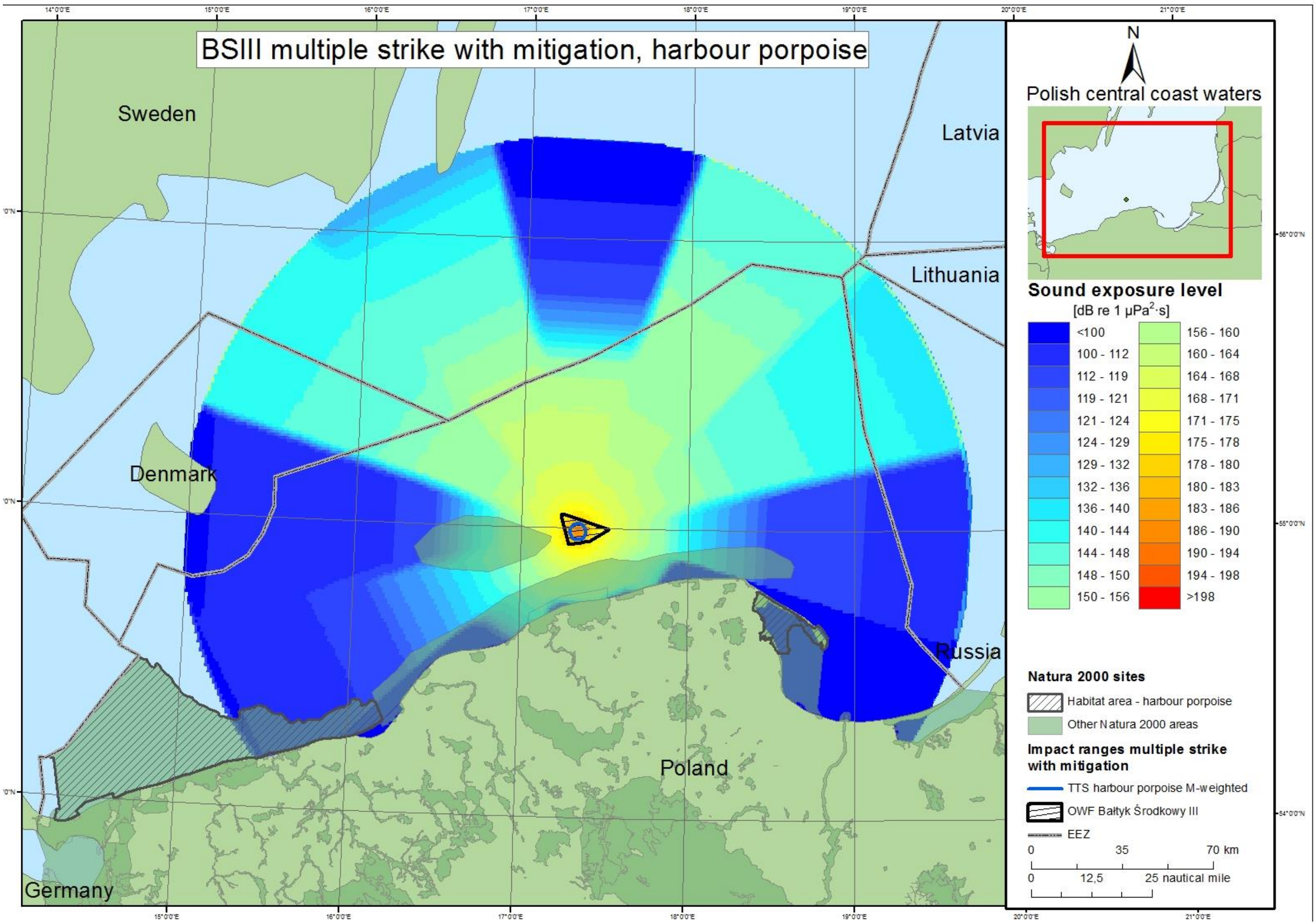

Figure 33 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour porpoise with bubble curtain mitigation.

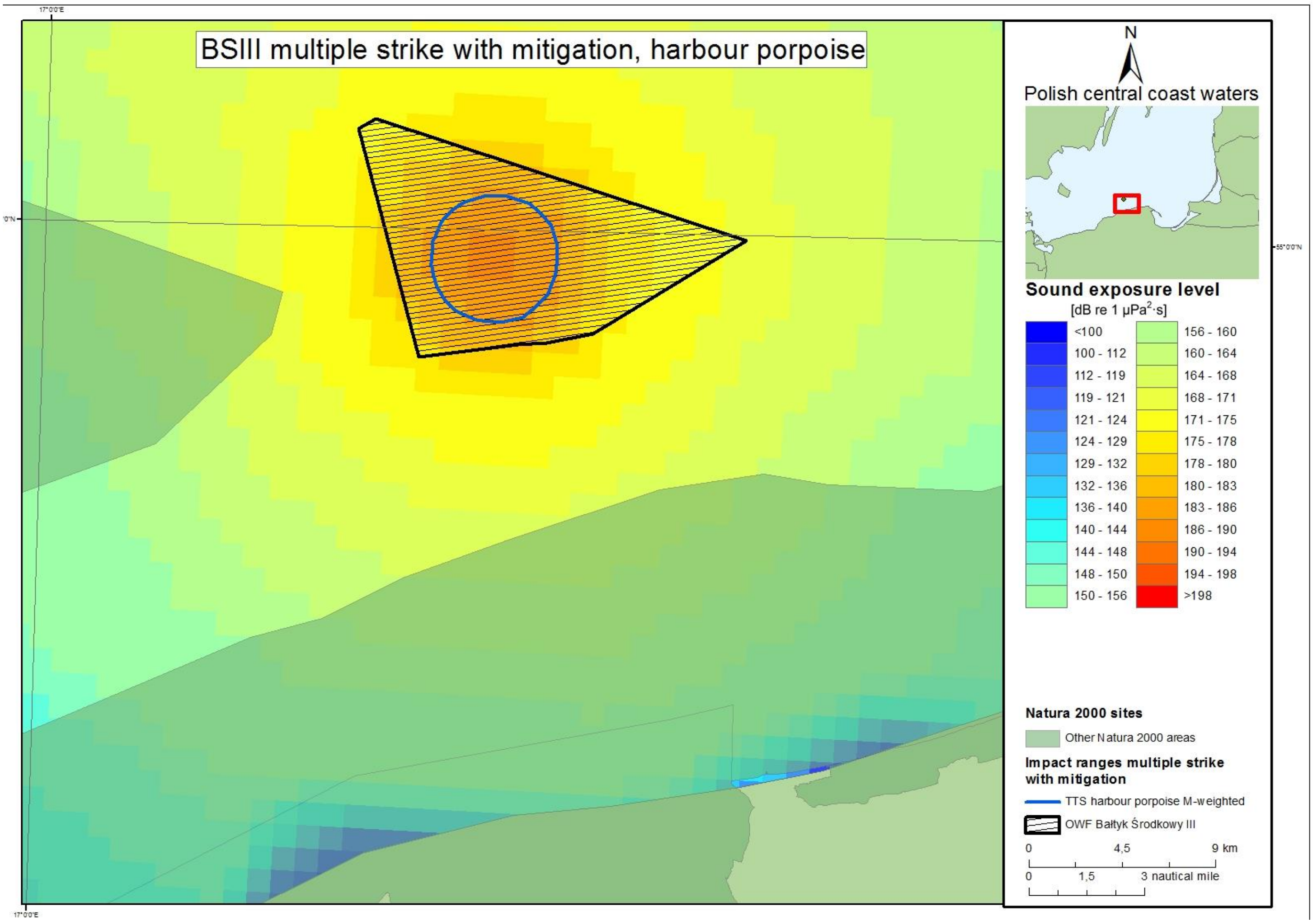

Figure 34 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour porpoise with bubble curtain mitigation (zoomed in including Nature2000 areas).

18.2 Harbour and grey seal

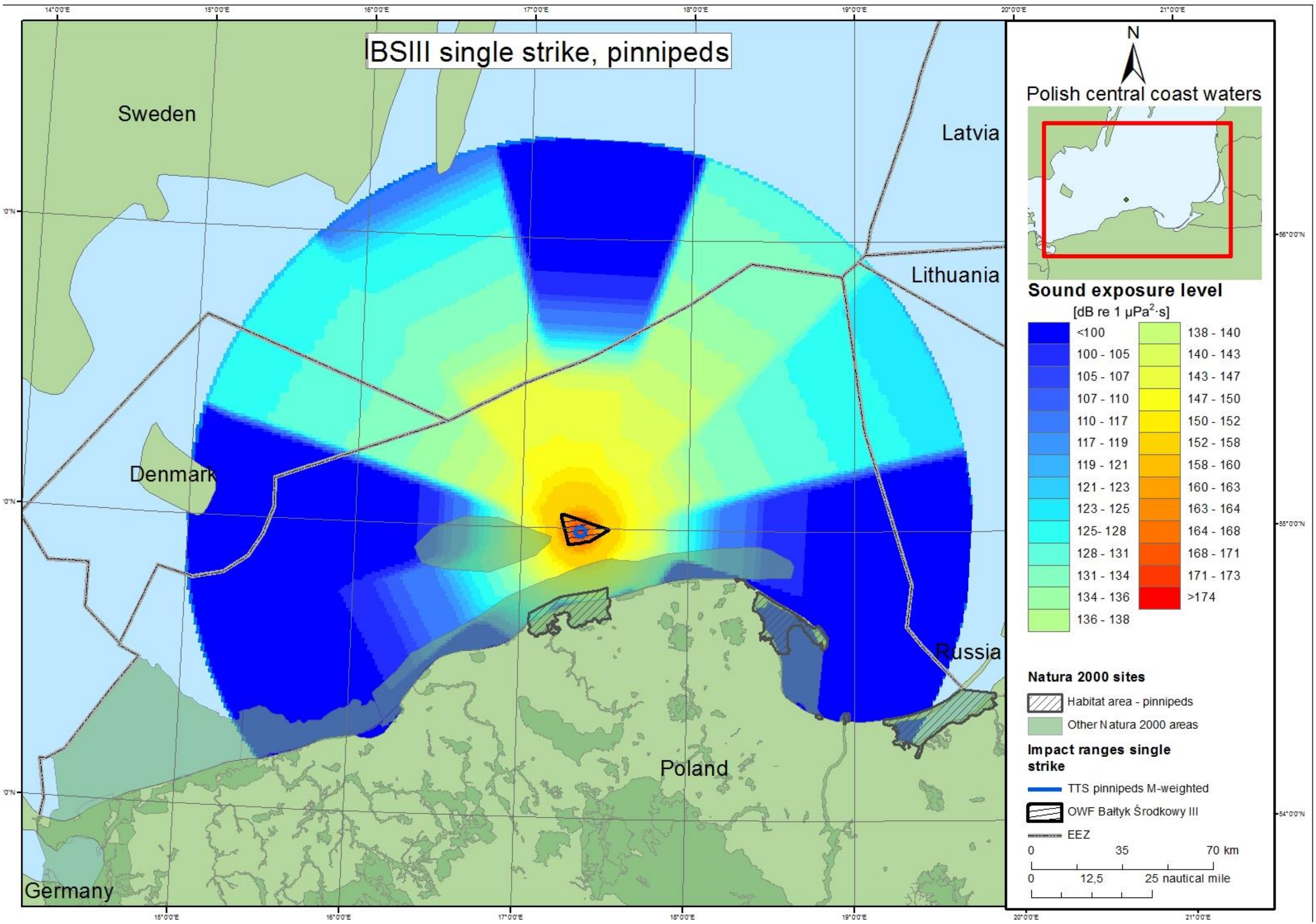

Figure 35 Noise map of the single strike sound exposure levels with associated impact ranges for harbour and grey seals including Nature2000 areas (note that TTS and behavioural impact range are identical).

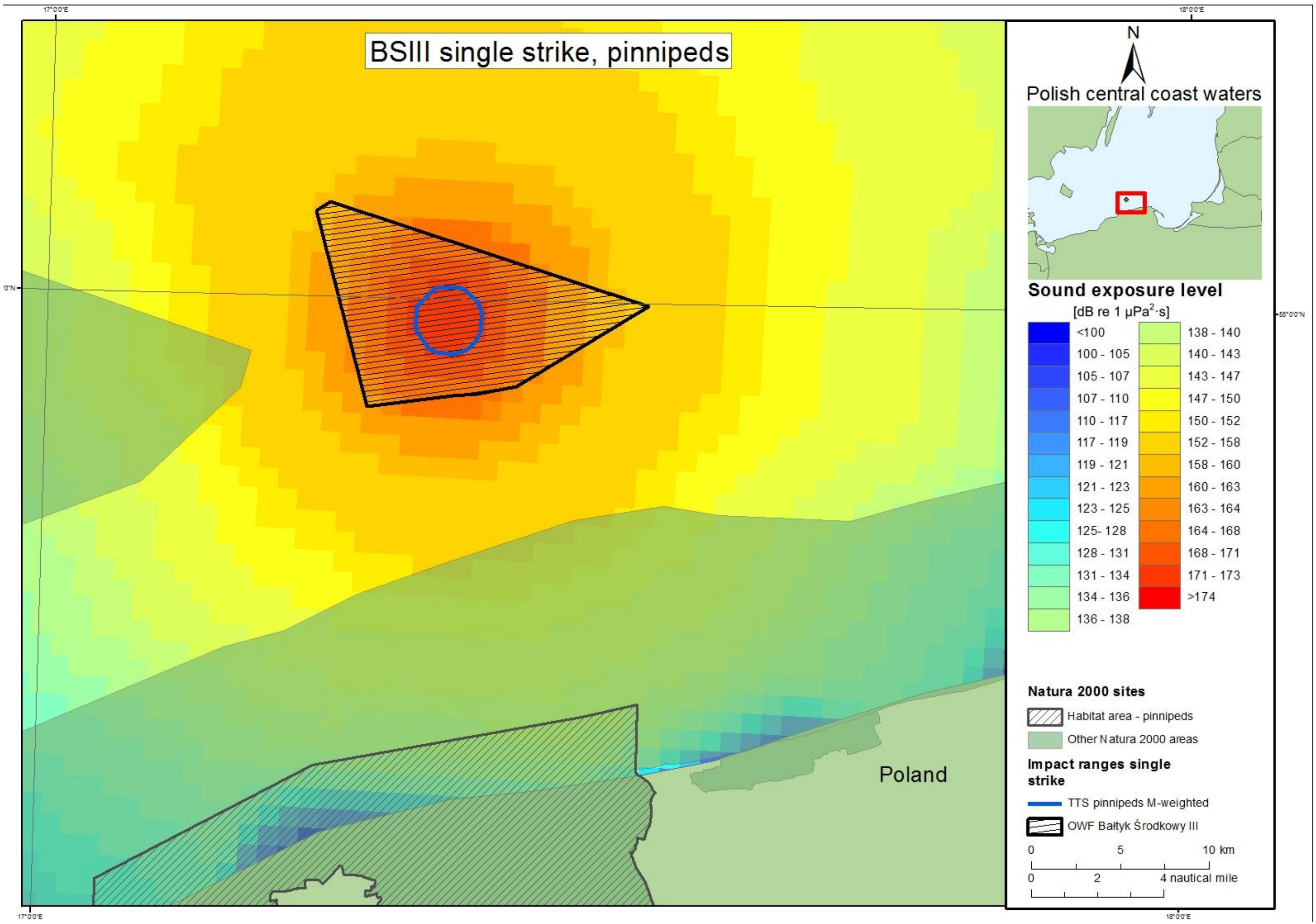

Figure 36 Noise map of the single strike sound exposure levels with associated impact ranges for harbour and grey seals zoomed in including Nature2000 areas (note that TTS and behavioural impact range are identical).

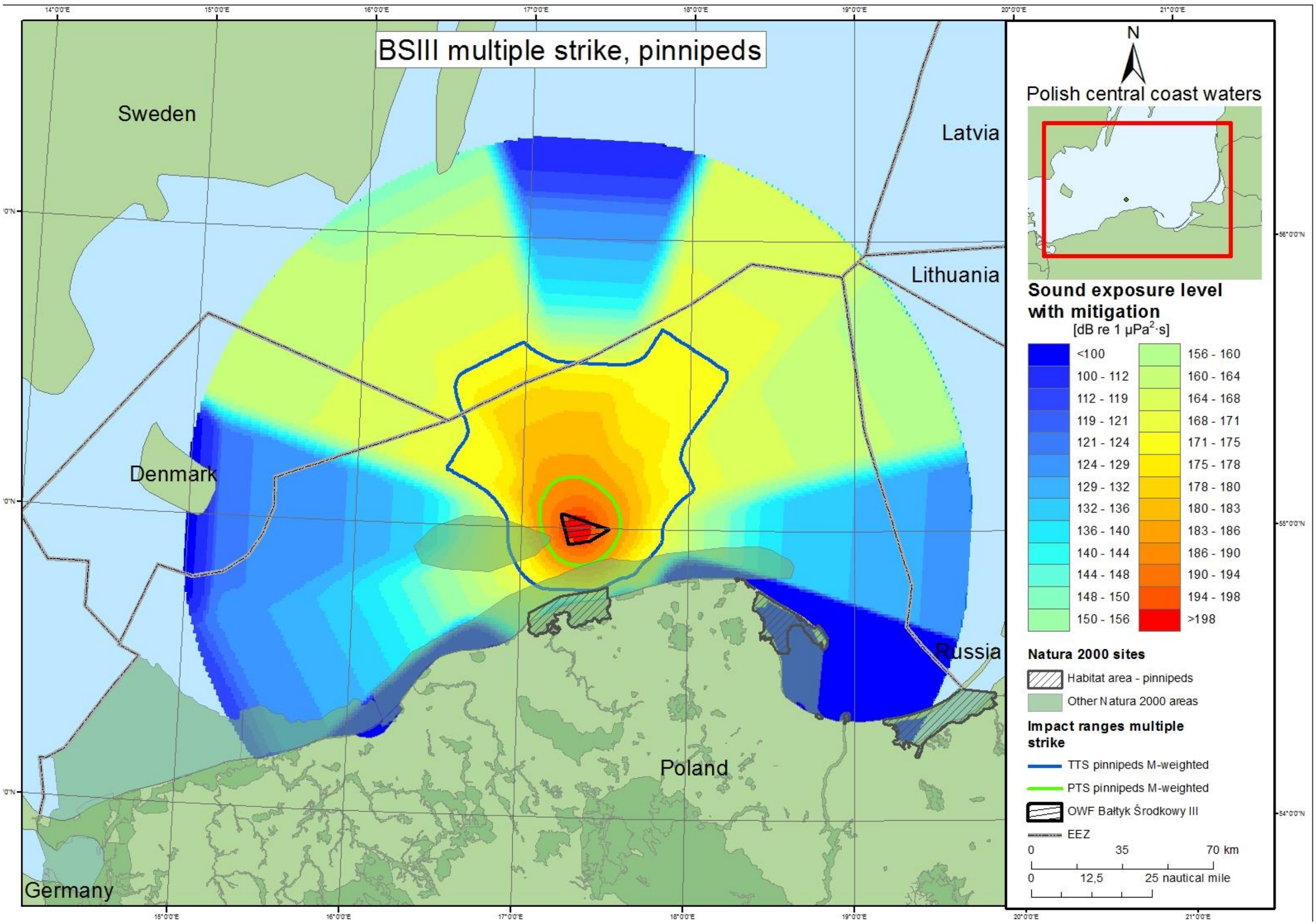

Figure 37 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour and grey seals including Nature2000 areas.

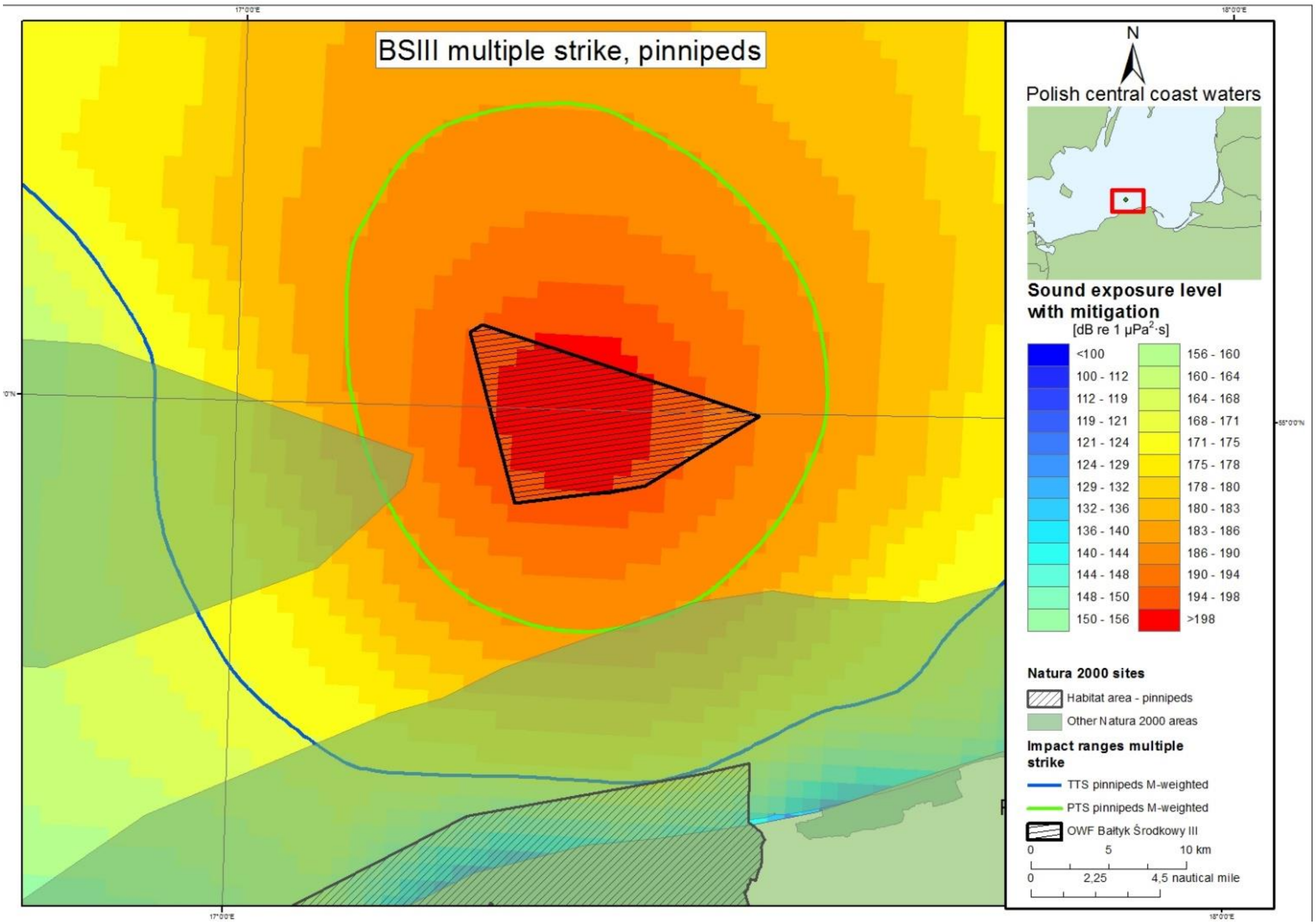

Figure 38 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour and grey seal (zoomed in including Nature2000 areas).

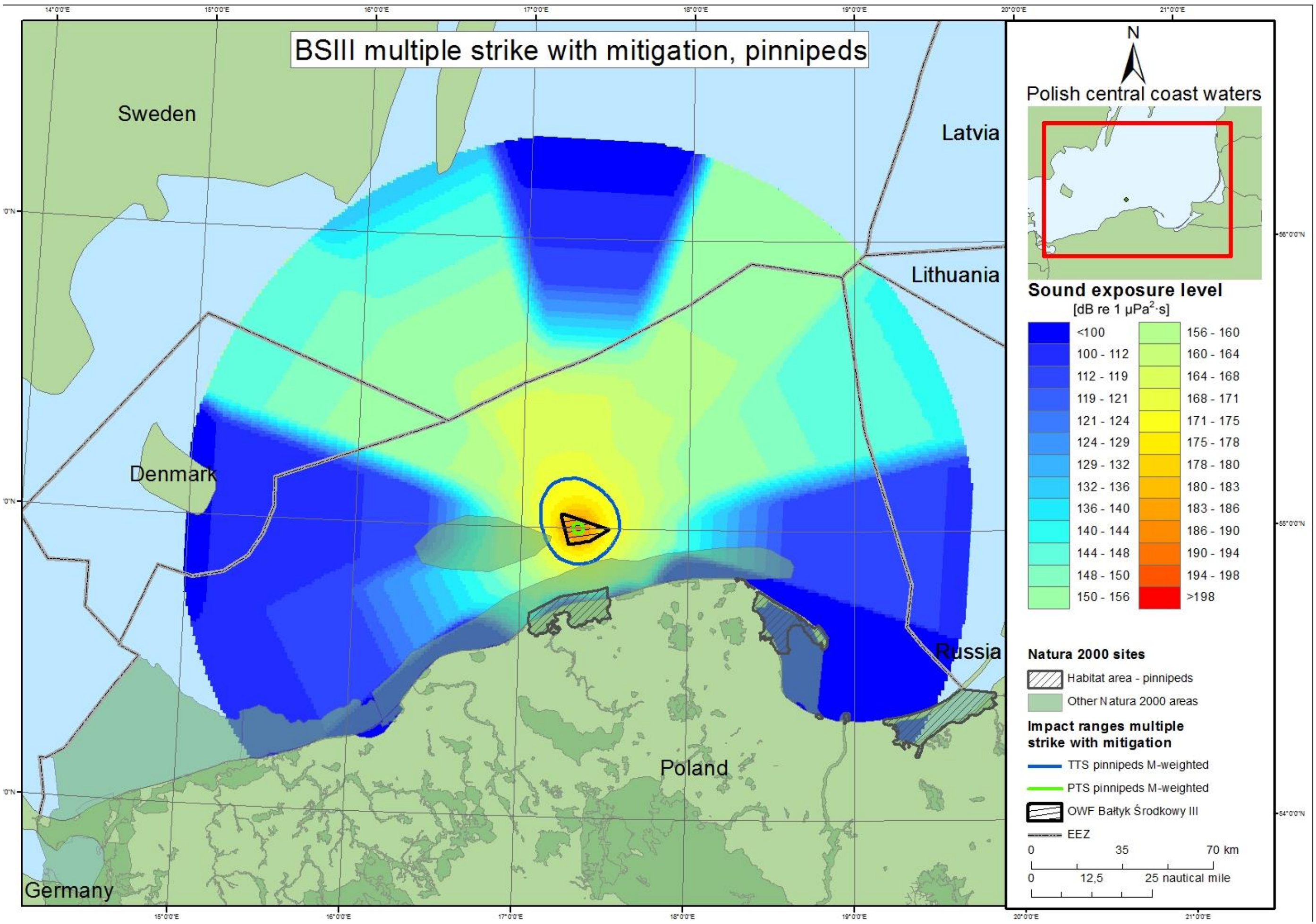

Figure 39 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour and grey seal with bubble curtain mitigation.

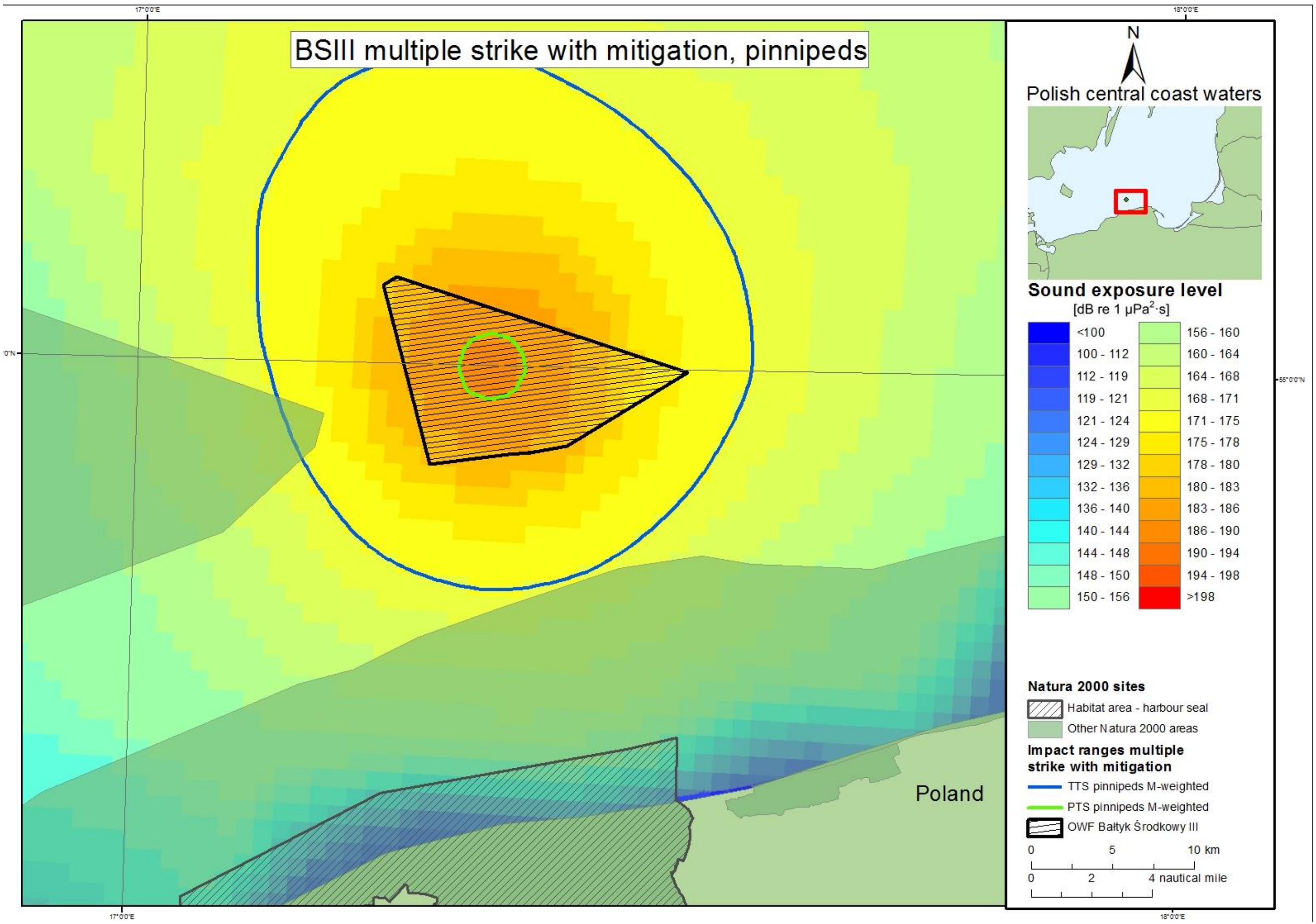

Figure 40 Noise map of the multiple strike sound exposure level with associated impact ranges for harbour and grey seal with bubble curtain mitigation (zoomed in including Nature2000 areas).

19 Appendix 2 Cumulative noise maps for the variant chosen for realisation and rational alternative variant

19.1 Simultaneous piling at two sites - BŚIII

19.1.1 Harbour porpoise

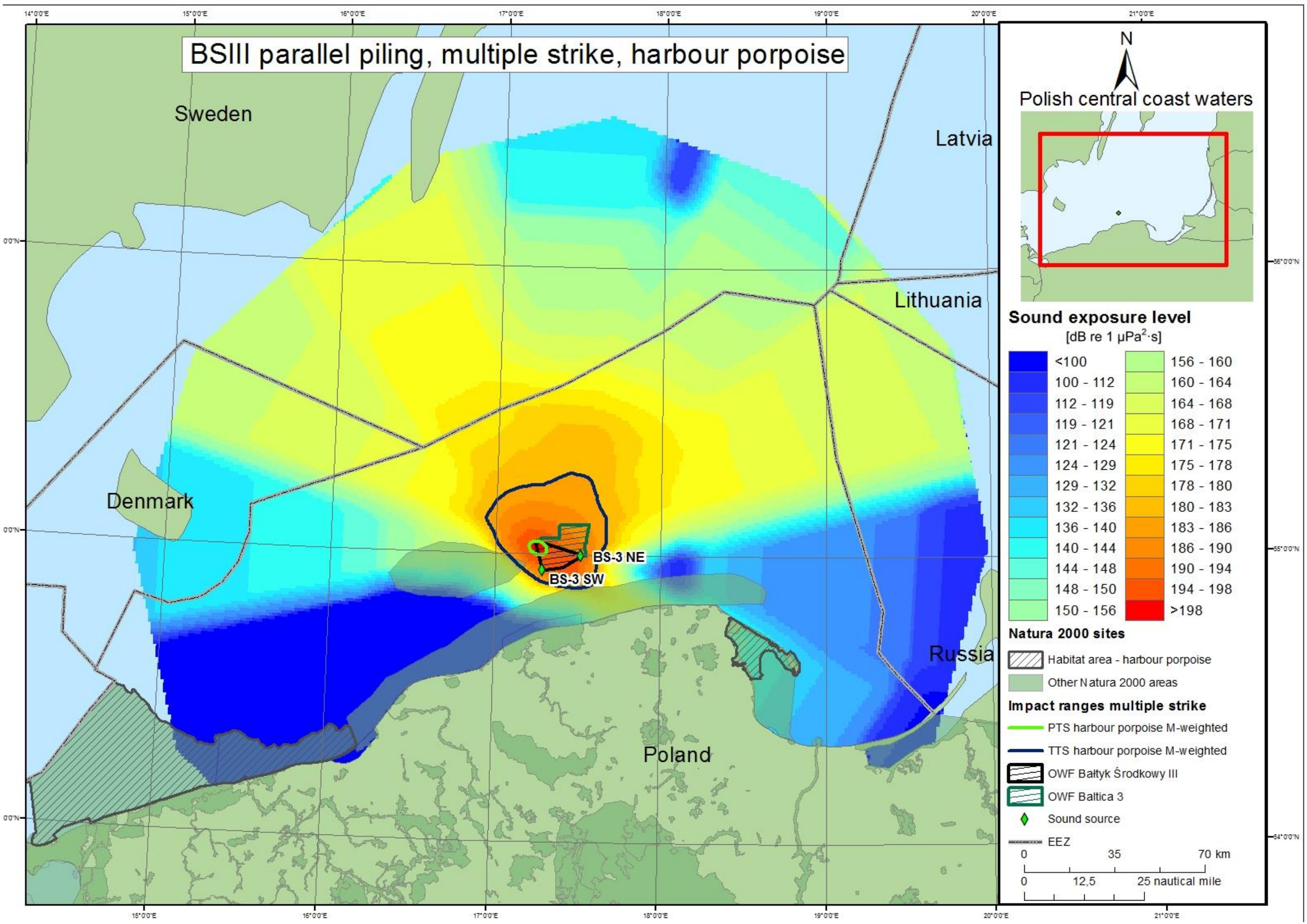

Figure 41 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for harbour porpoises.

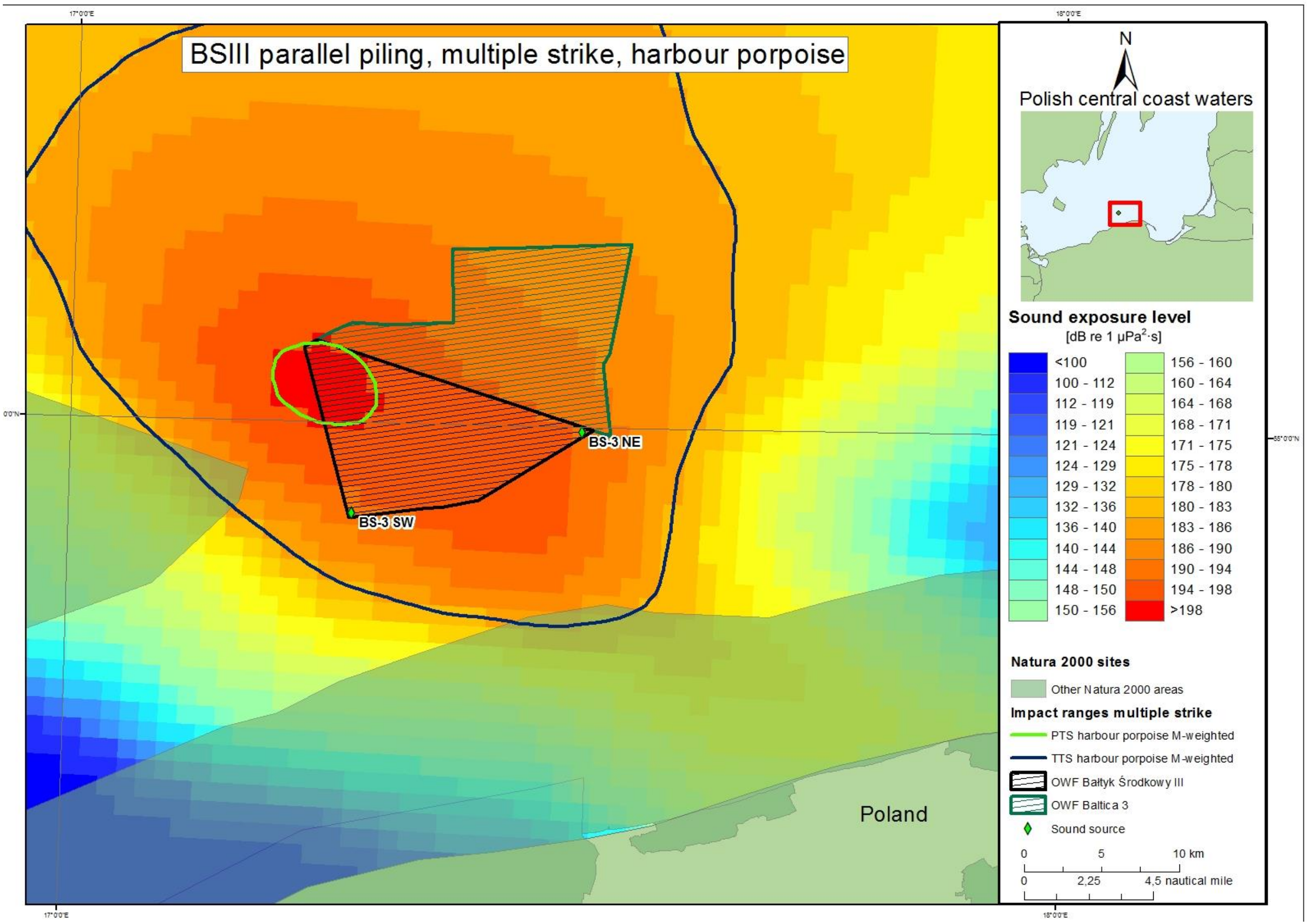

Figure 42 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for harbour porpoises (zoomed in including Nature2000 areas).

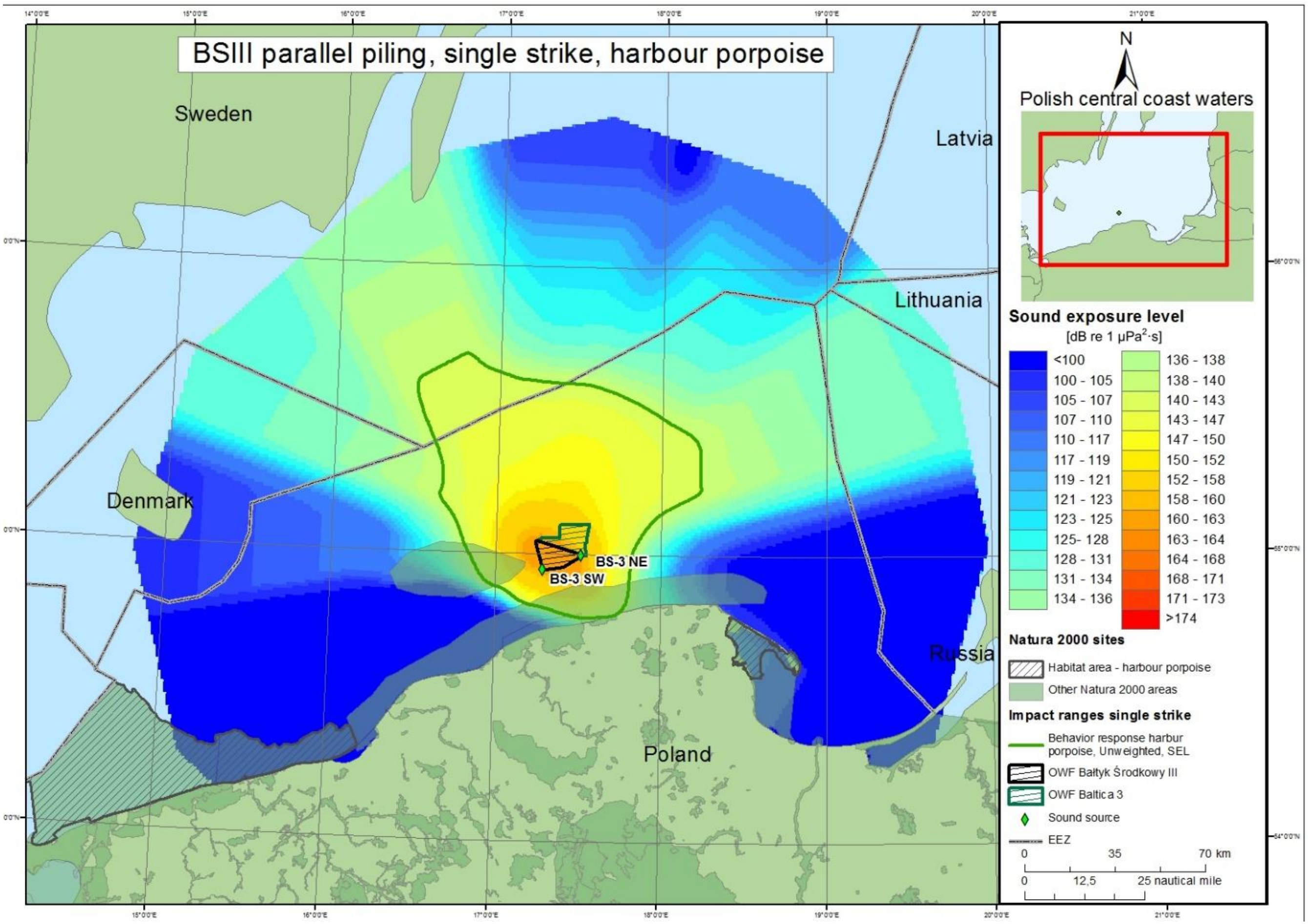

Figure 43 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for harbour porpoises.

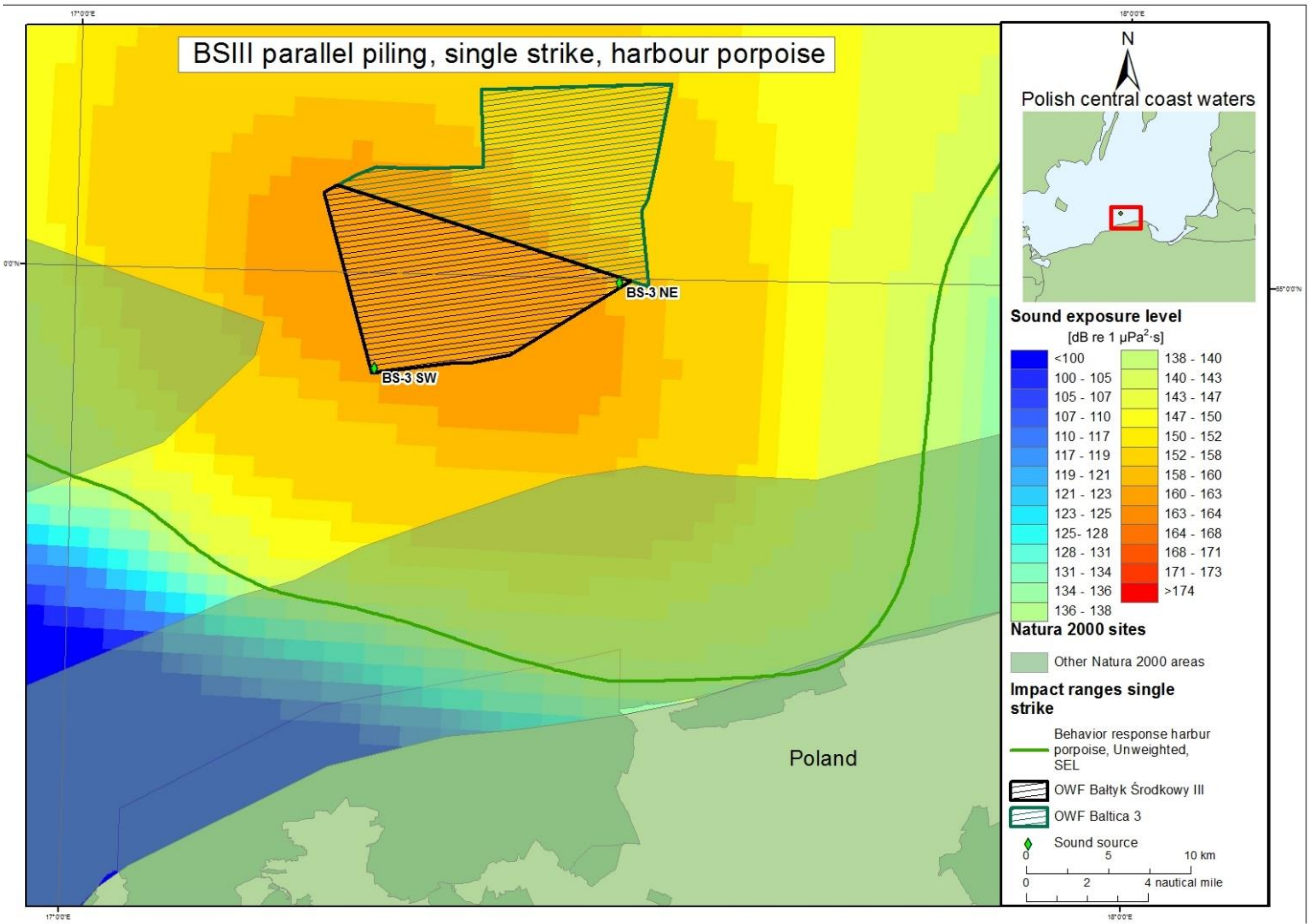

Figure 44 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for harbour porpoises (zoomed in including Nature2000 areas).

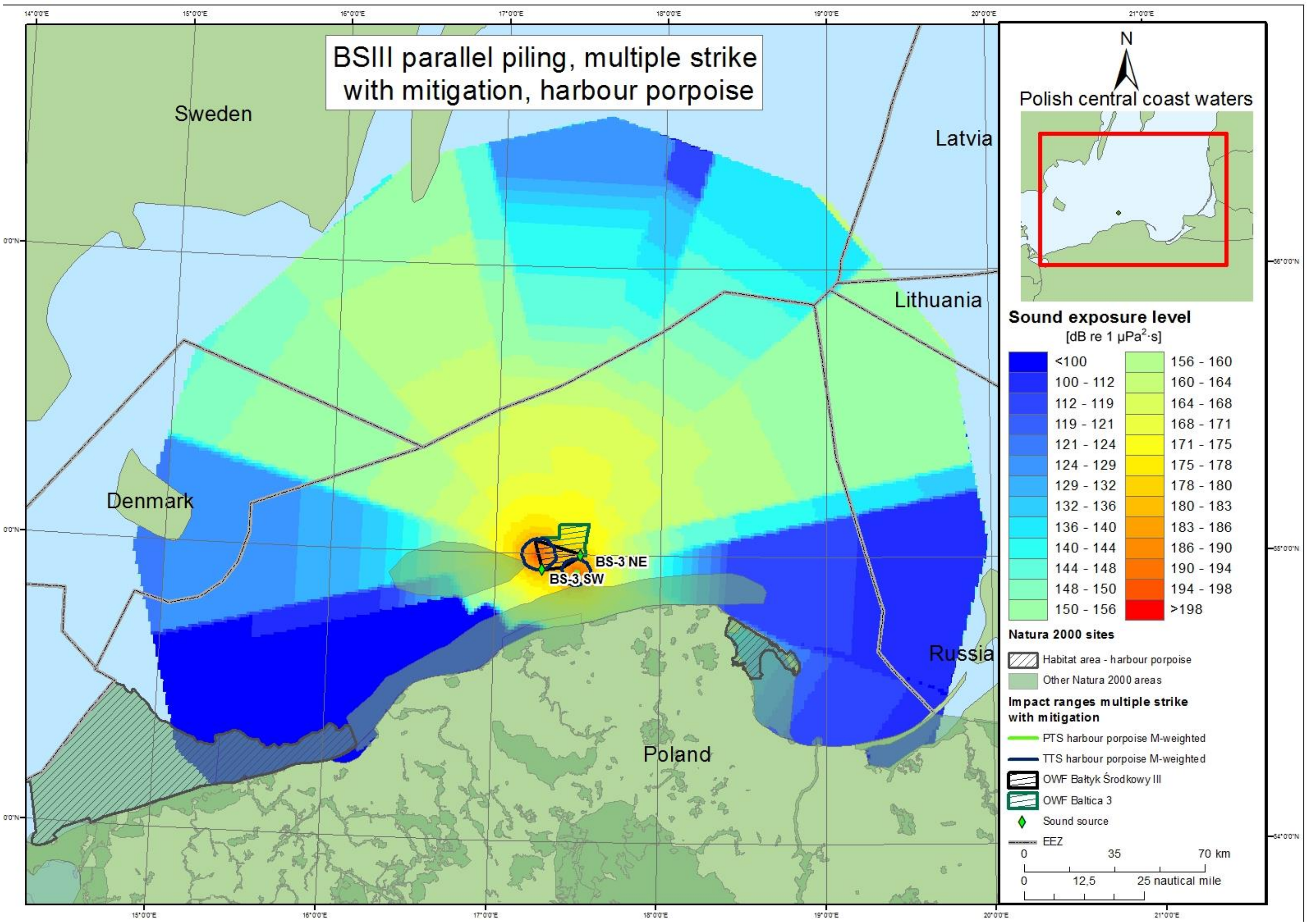

Figure 45 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously with bubble curtain. Impact ranges are for harbour porpoises.

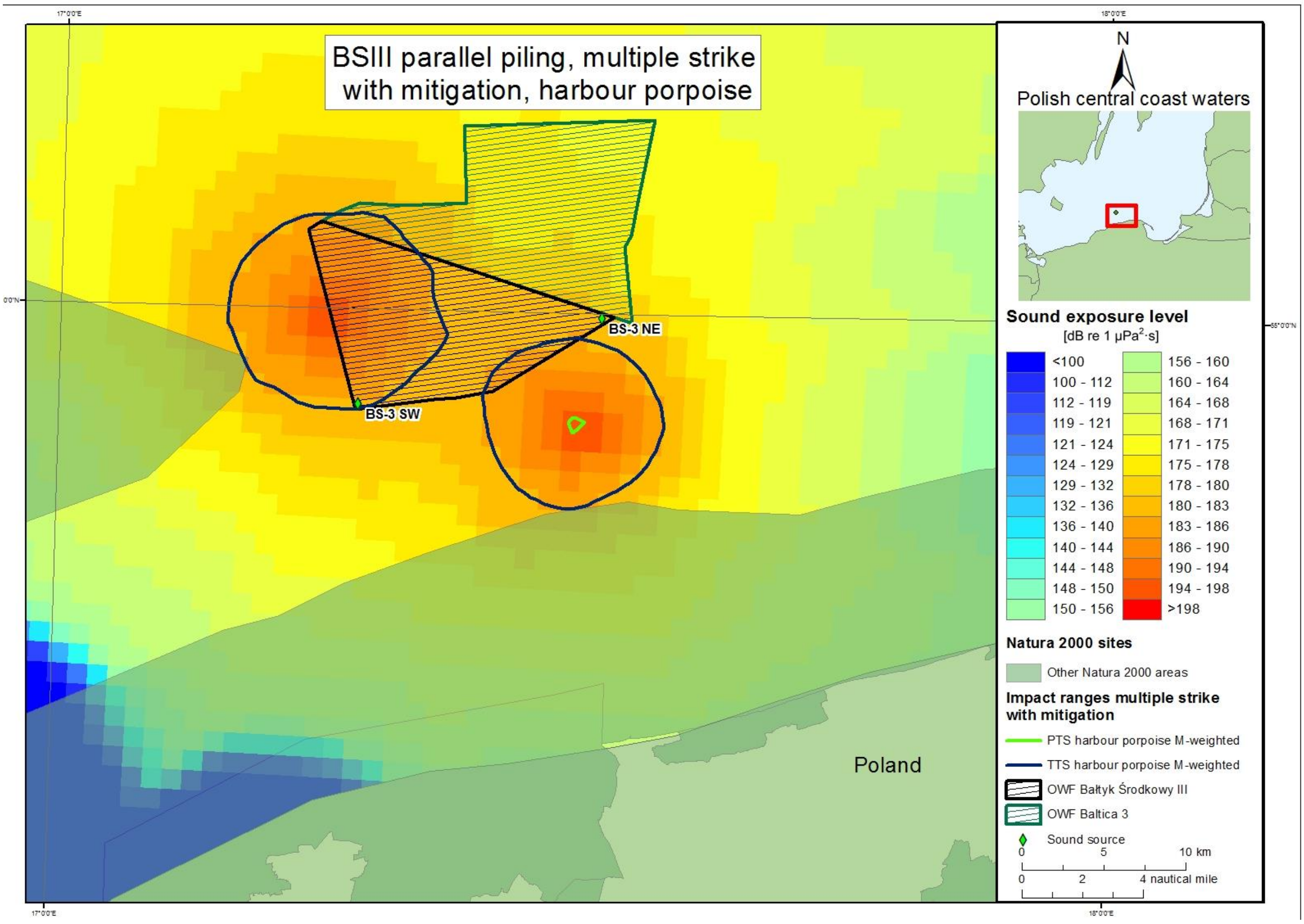

Figure 46 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously with bubble curtain. Impact ranges are for harbour porpoises (zoomed in including Nature2000 areas).

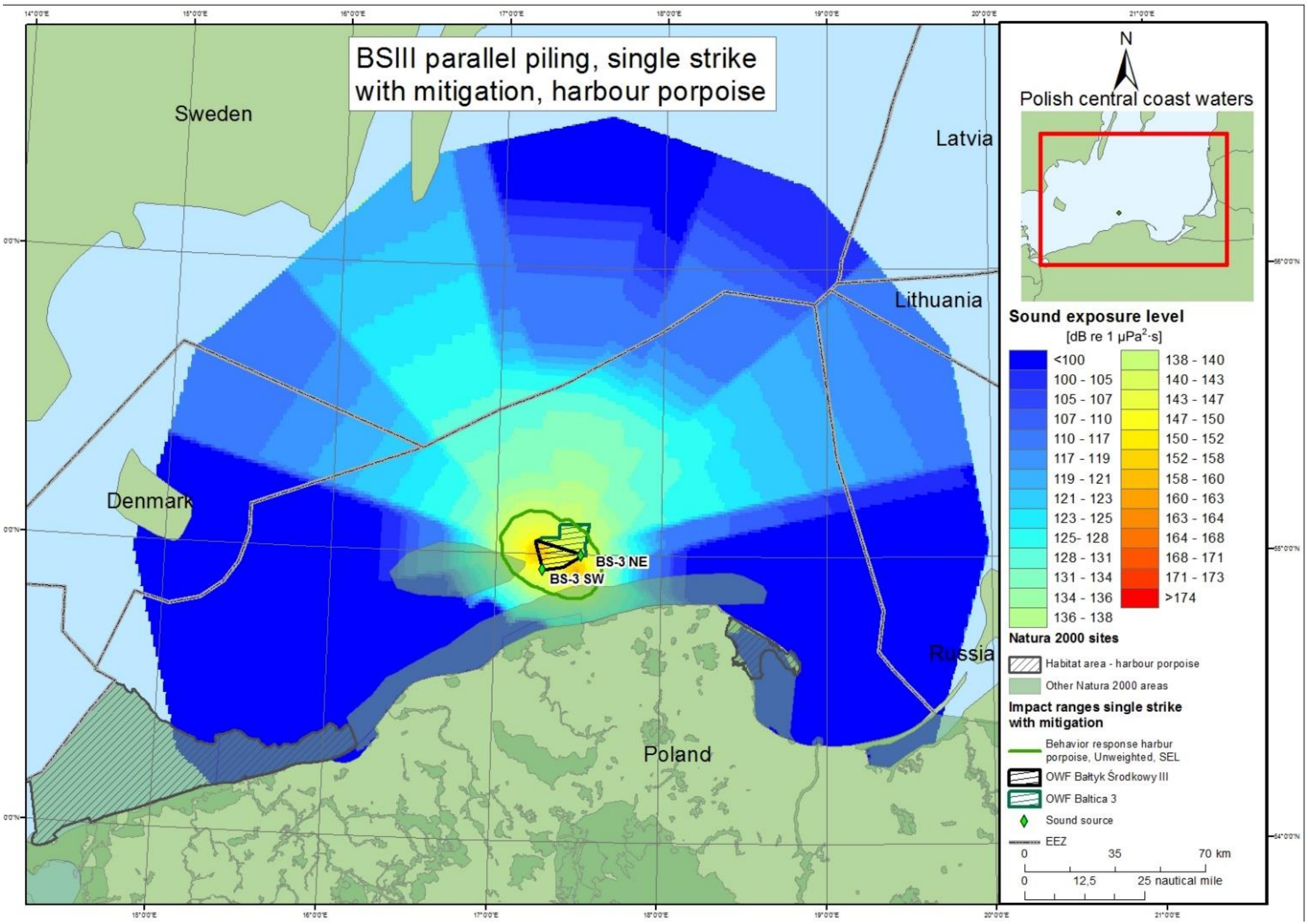

Figure 47 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously with bubble curtain. Impact ranges are for harbour porpoise.

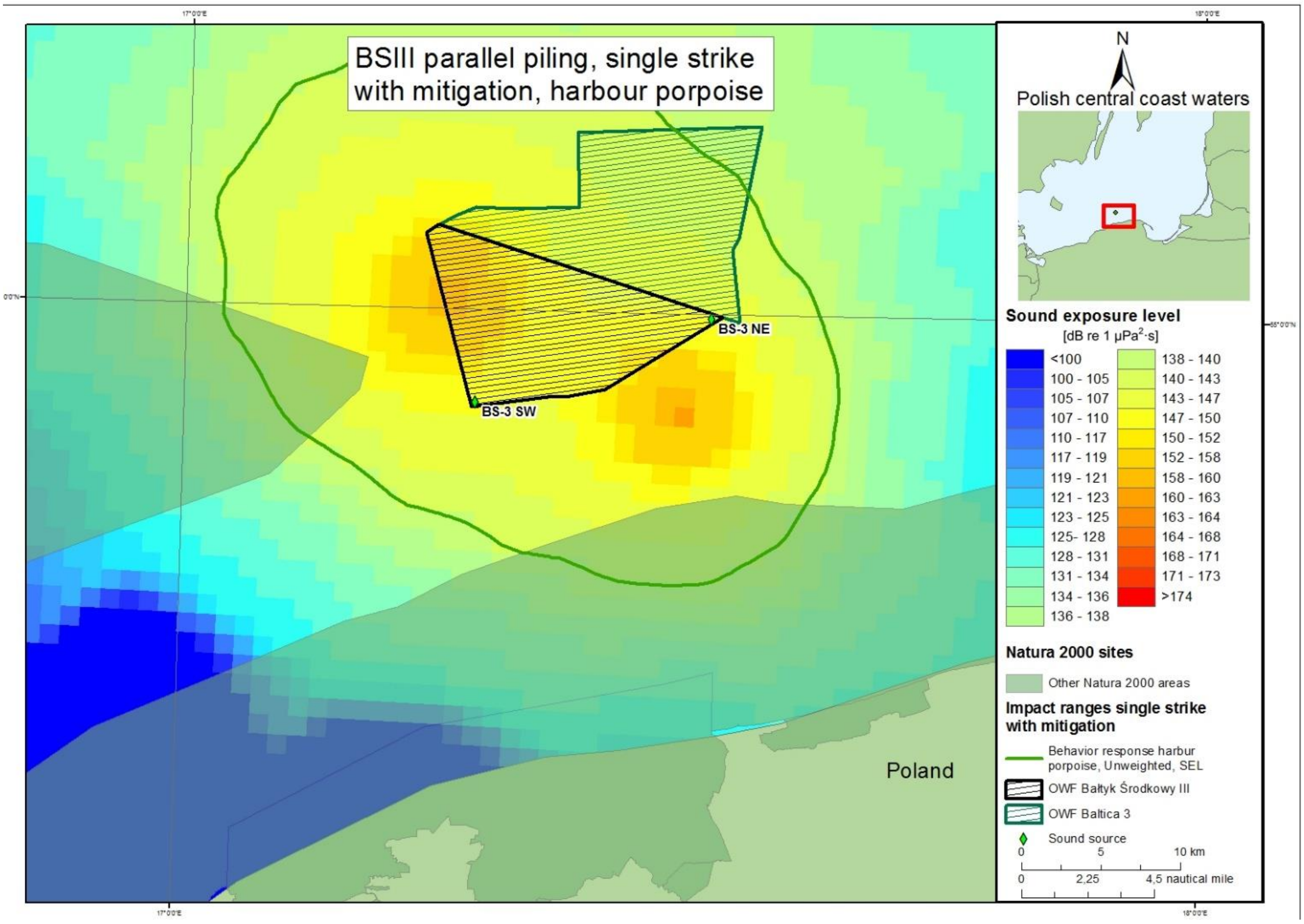

Figure 48 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously with bubble curtain. Impact ranges are for harbour porpoise (zoomed in including Nature2000 areas).

19.1.2 Harbour and grey seal

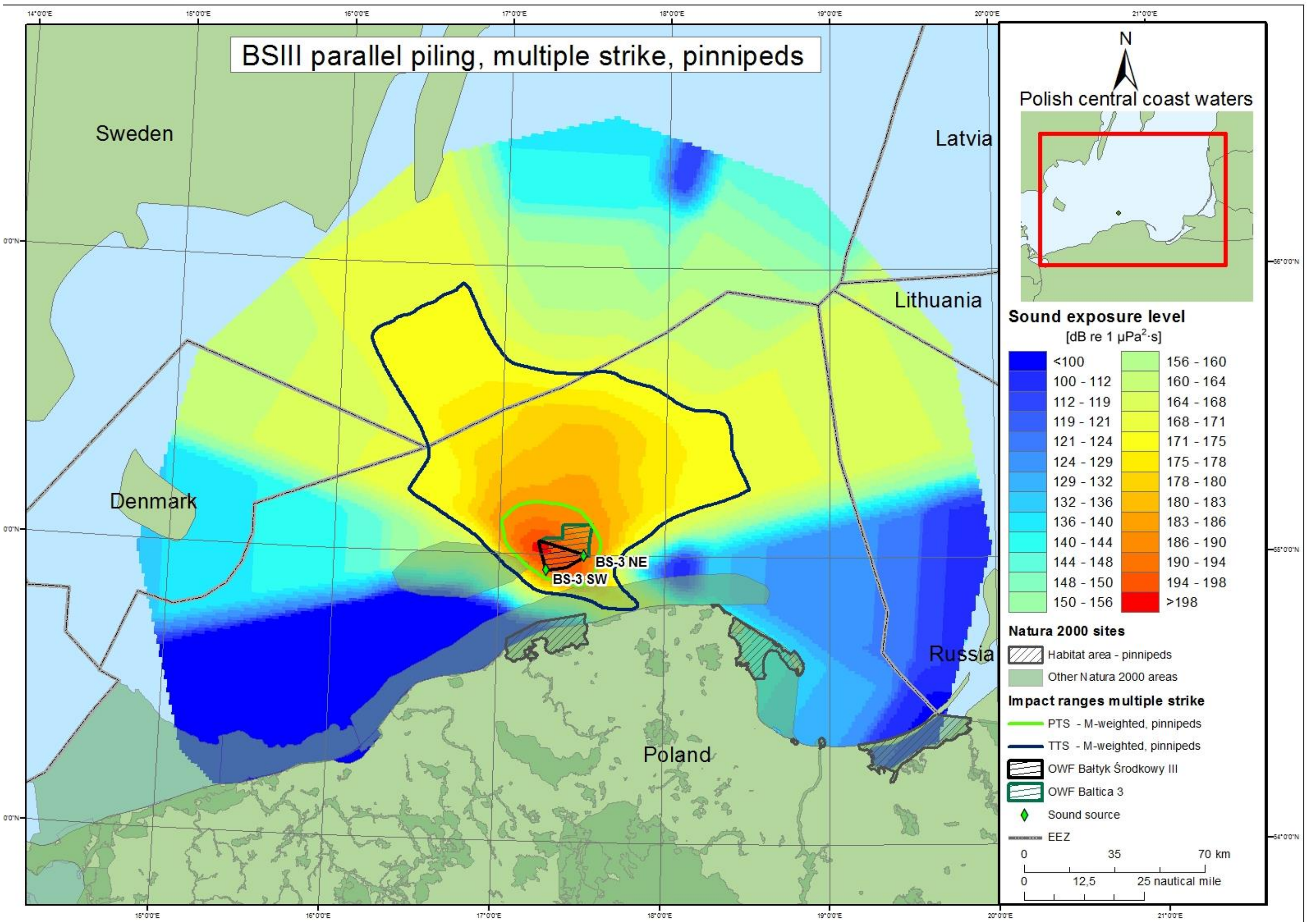

Figure 49 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for pinnipeds.

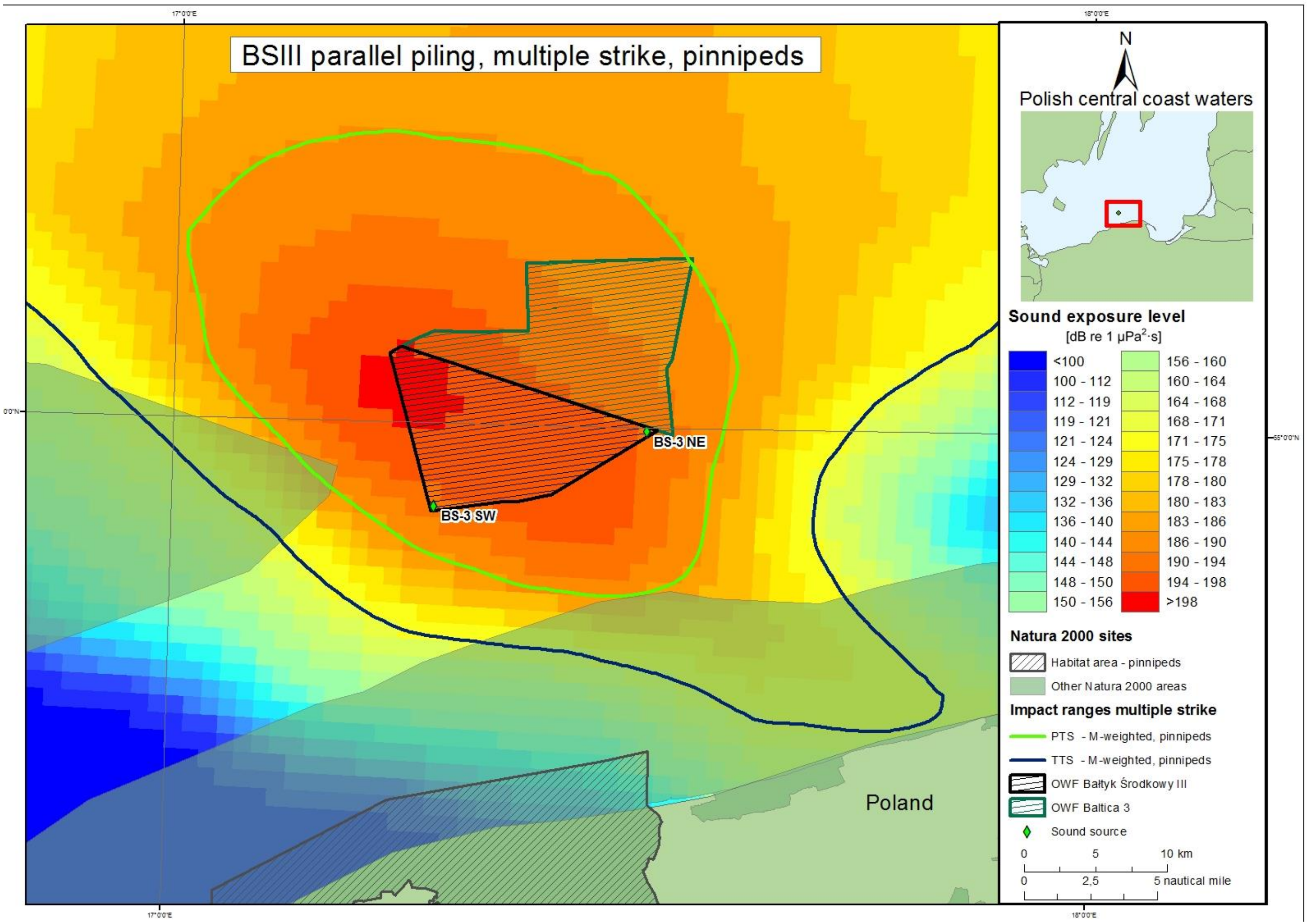

Figure 50 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for pinnipeds seals (zoomed in including Nature2000 areas).

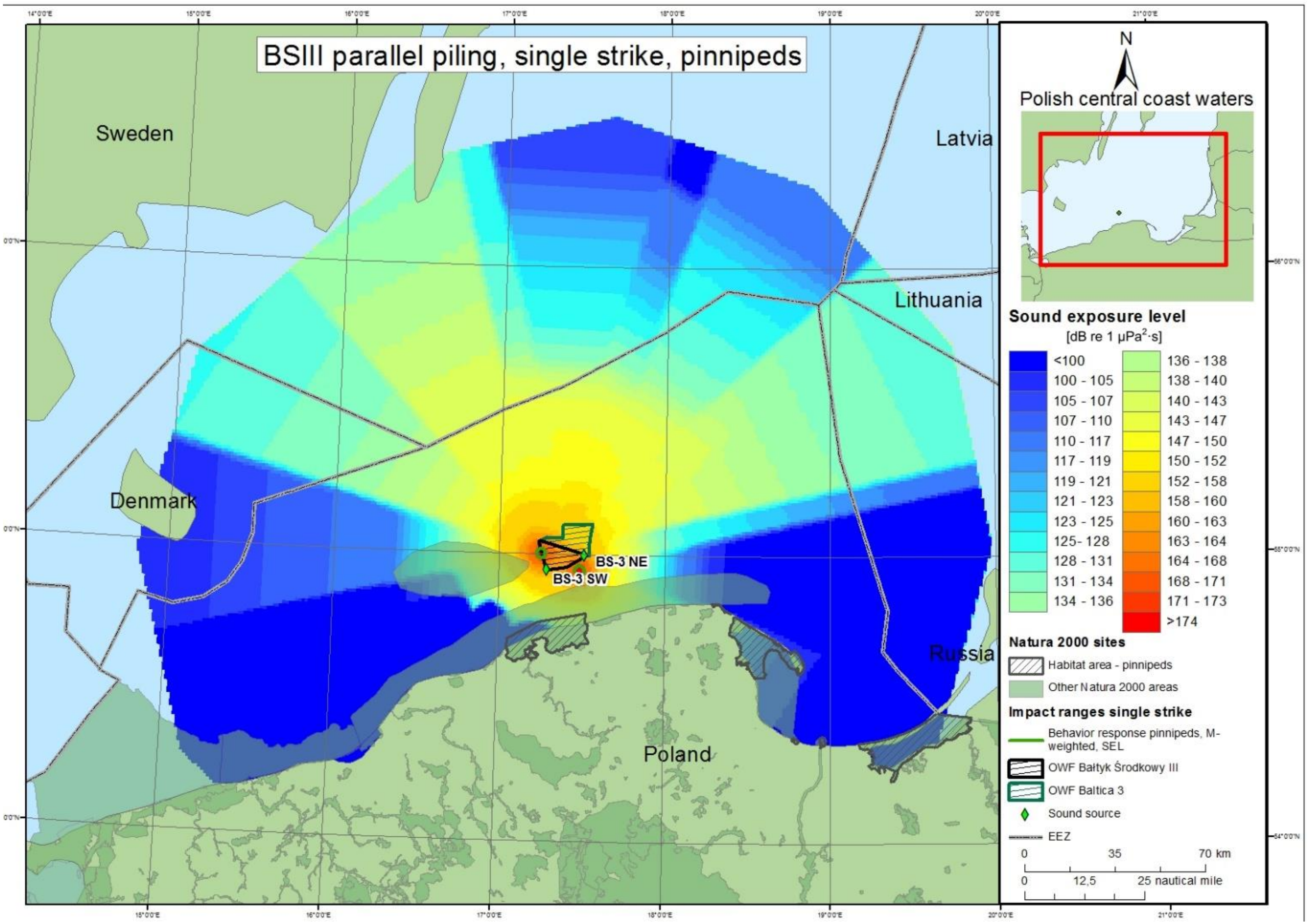

Figure 51 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for pinnipeds.

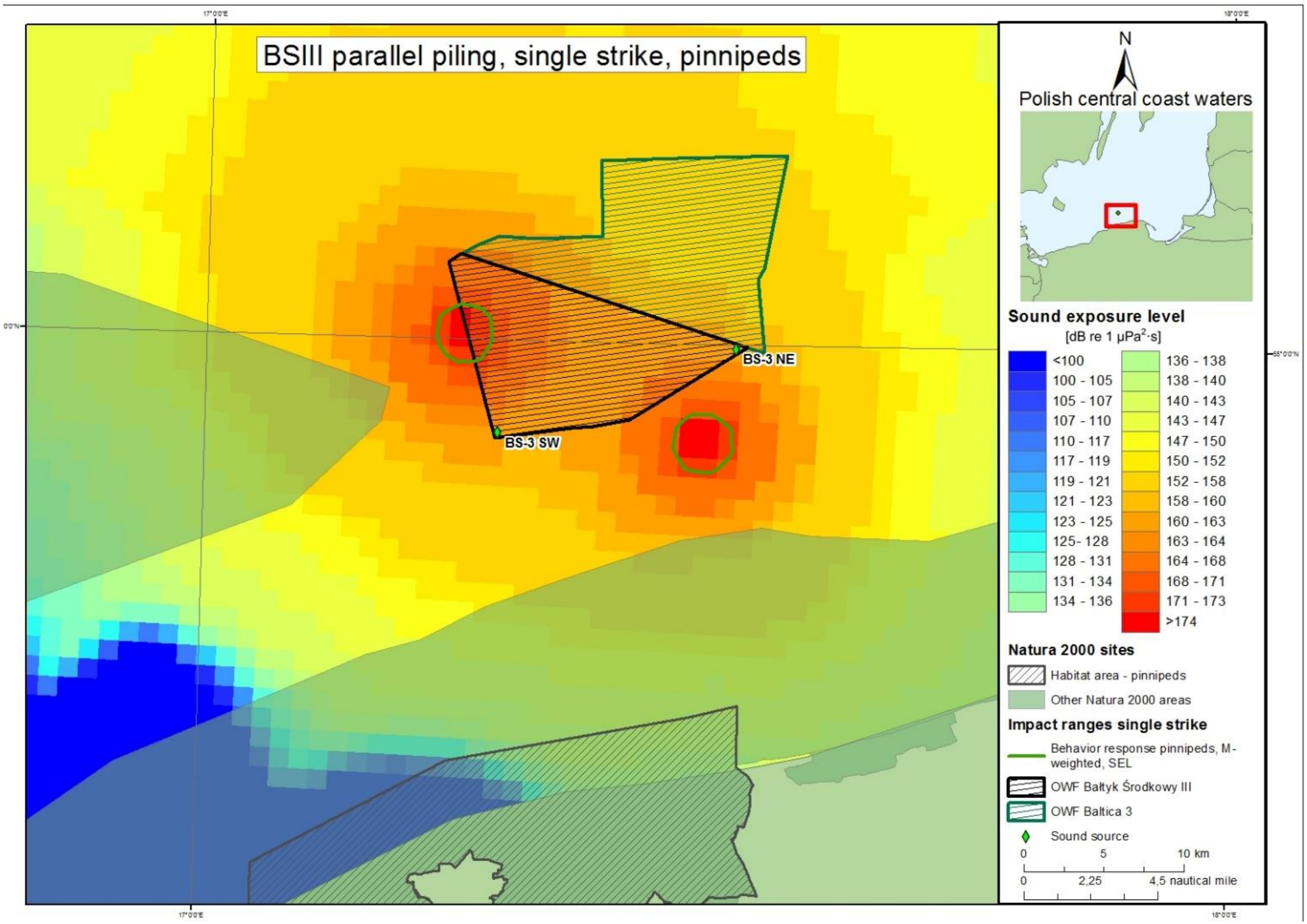

Figure 52 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously. Impact ranges are for pinnipeds (zoomed in including Nature2000 areas).

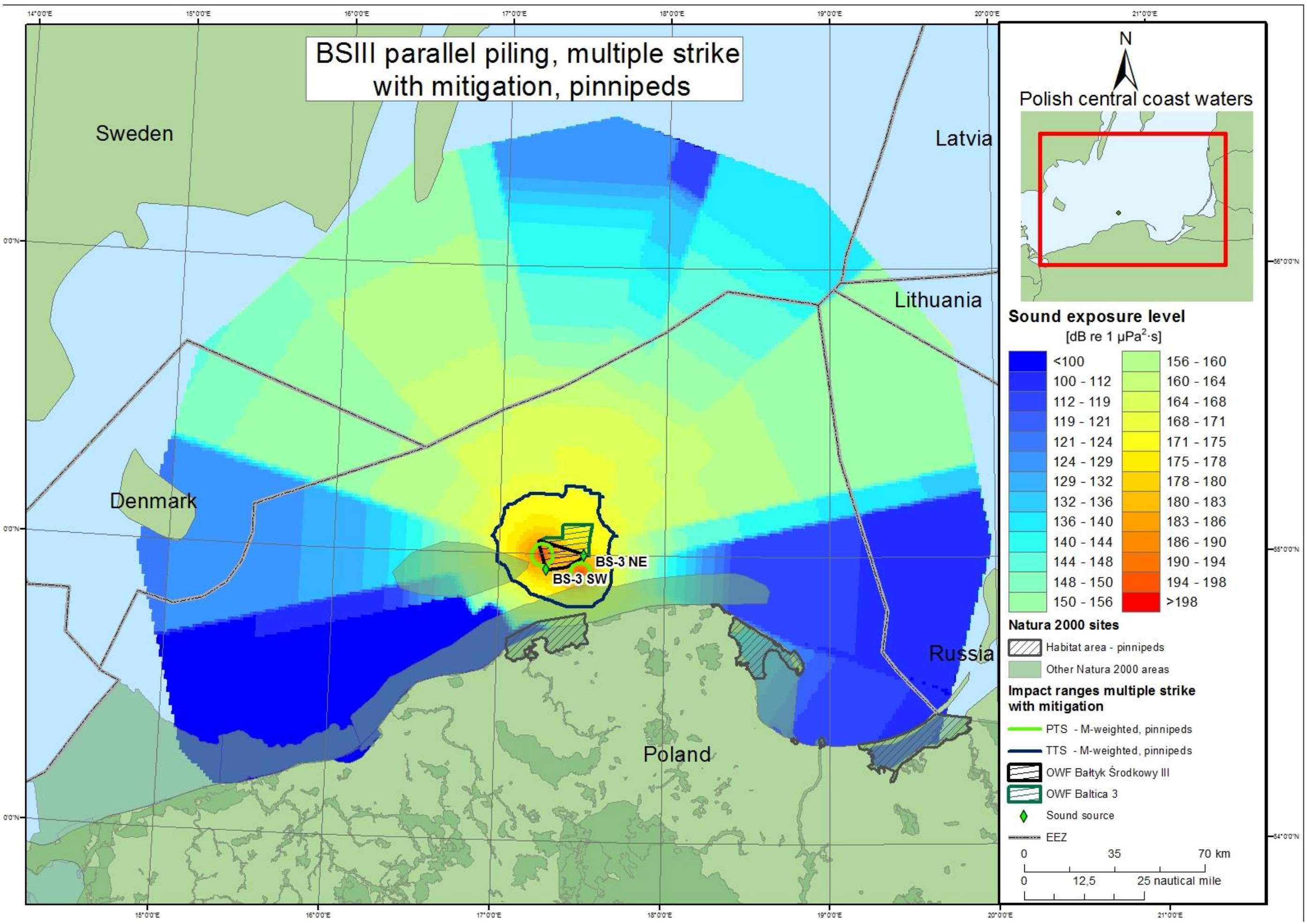

Figure 53 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of cumulative noise from 1 hrs of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously with bubble curtain. Impact ranges are for pinnipeds.

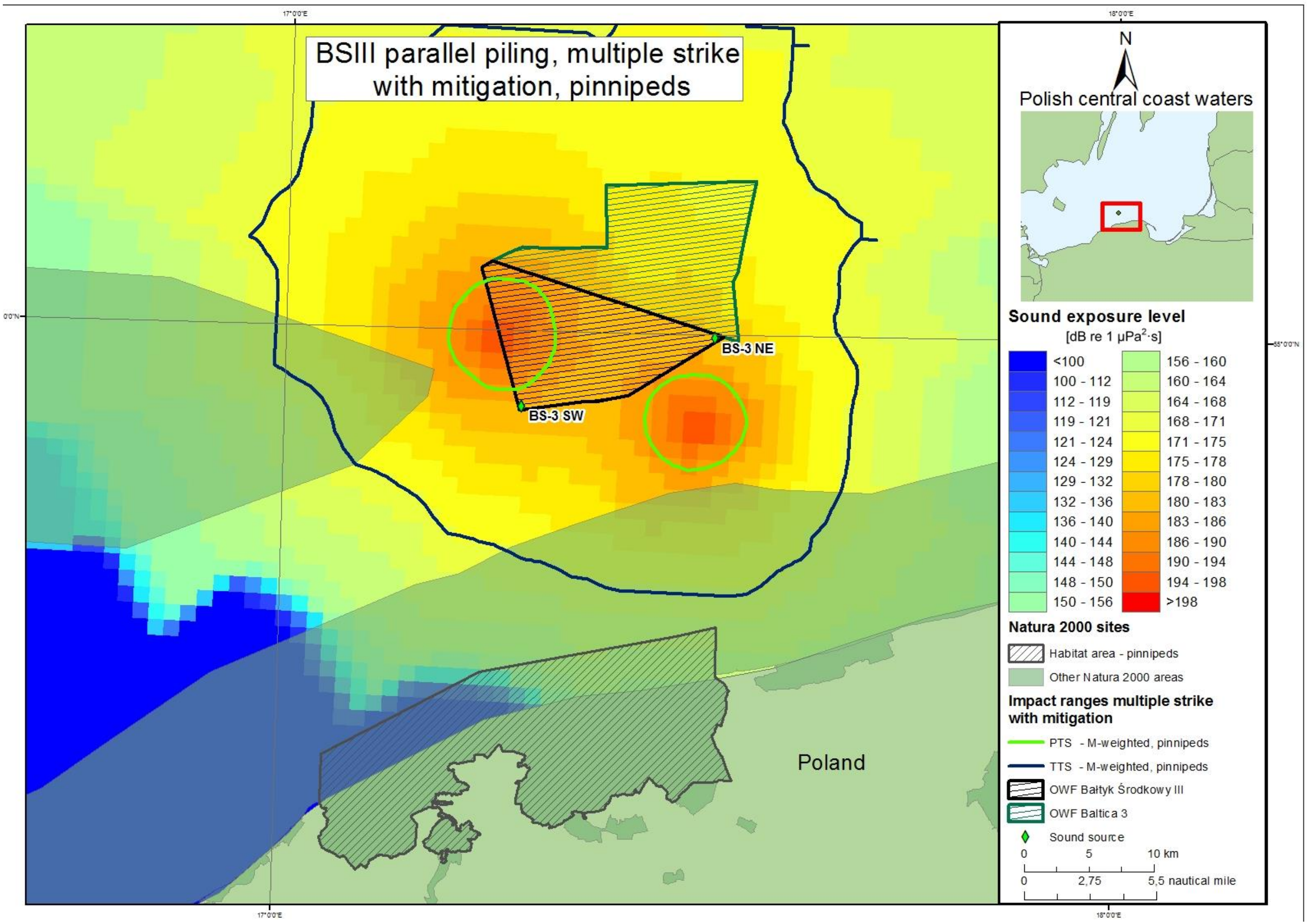

Figure 54 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations within a project area simultaneously with bubble curtain). Impact ranges are for pinnipeds (zoomed in including Nature2000 areas).

19.2 Simultaneous piling at two sites – BŚIII and Baltica 3

19.2.1 Harbour porpoise

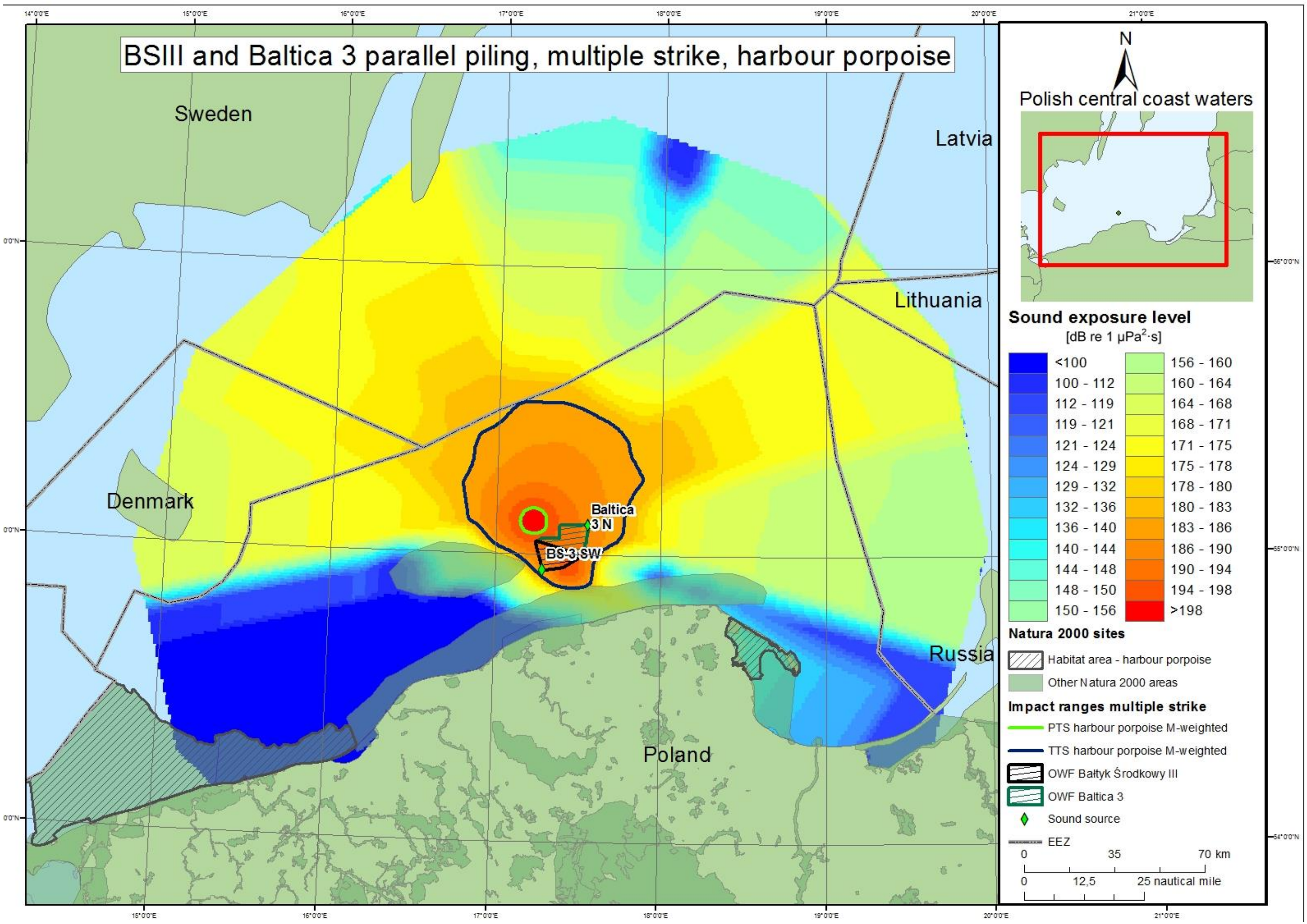

Figure 55 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour porpoises.

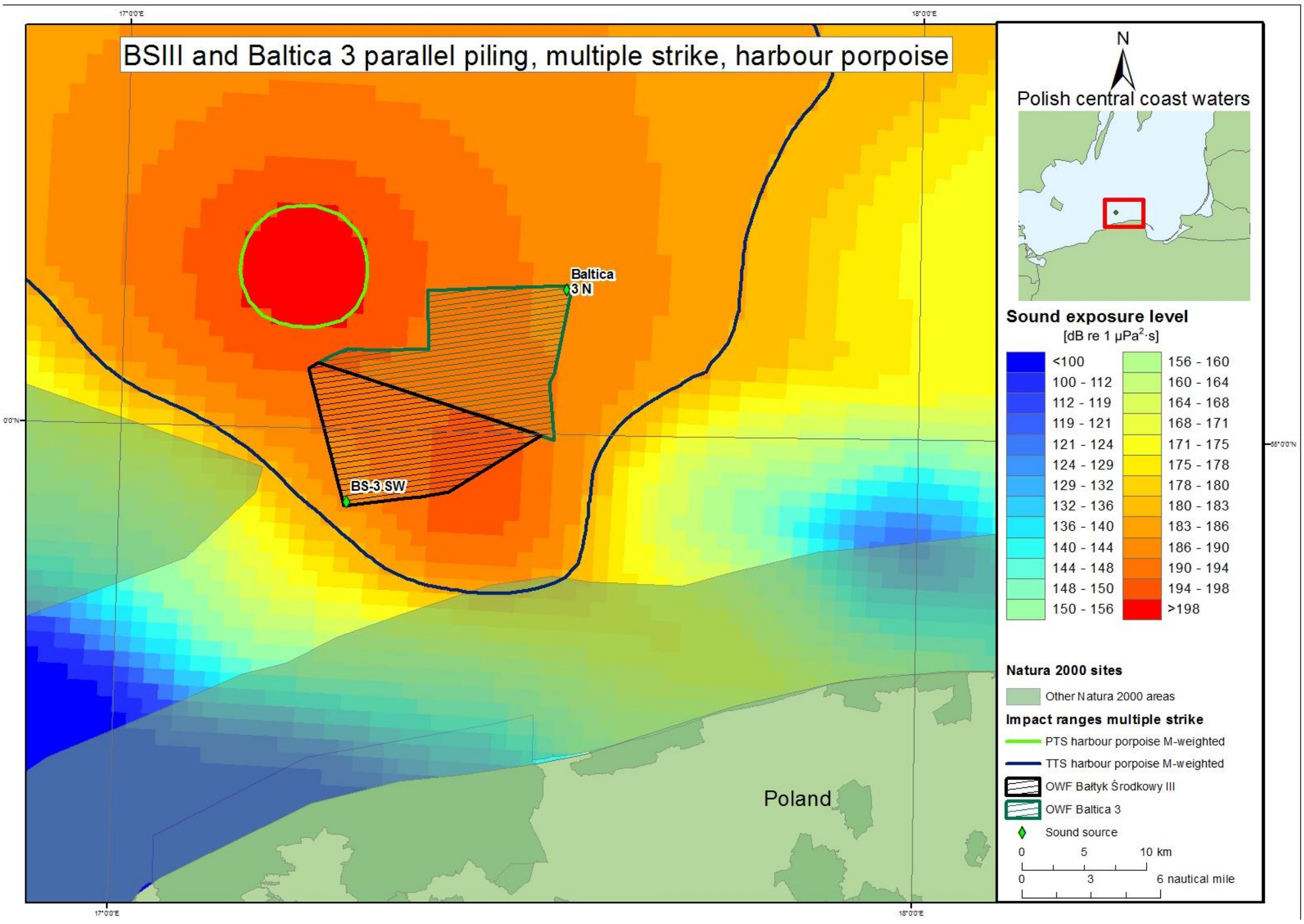

Figure 56 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour porpoises (zoomed in including Nature2000 areas).

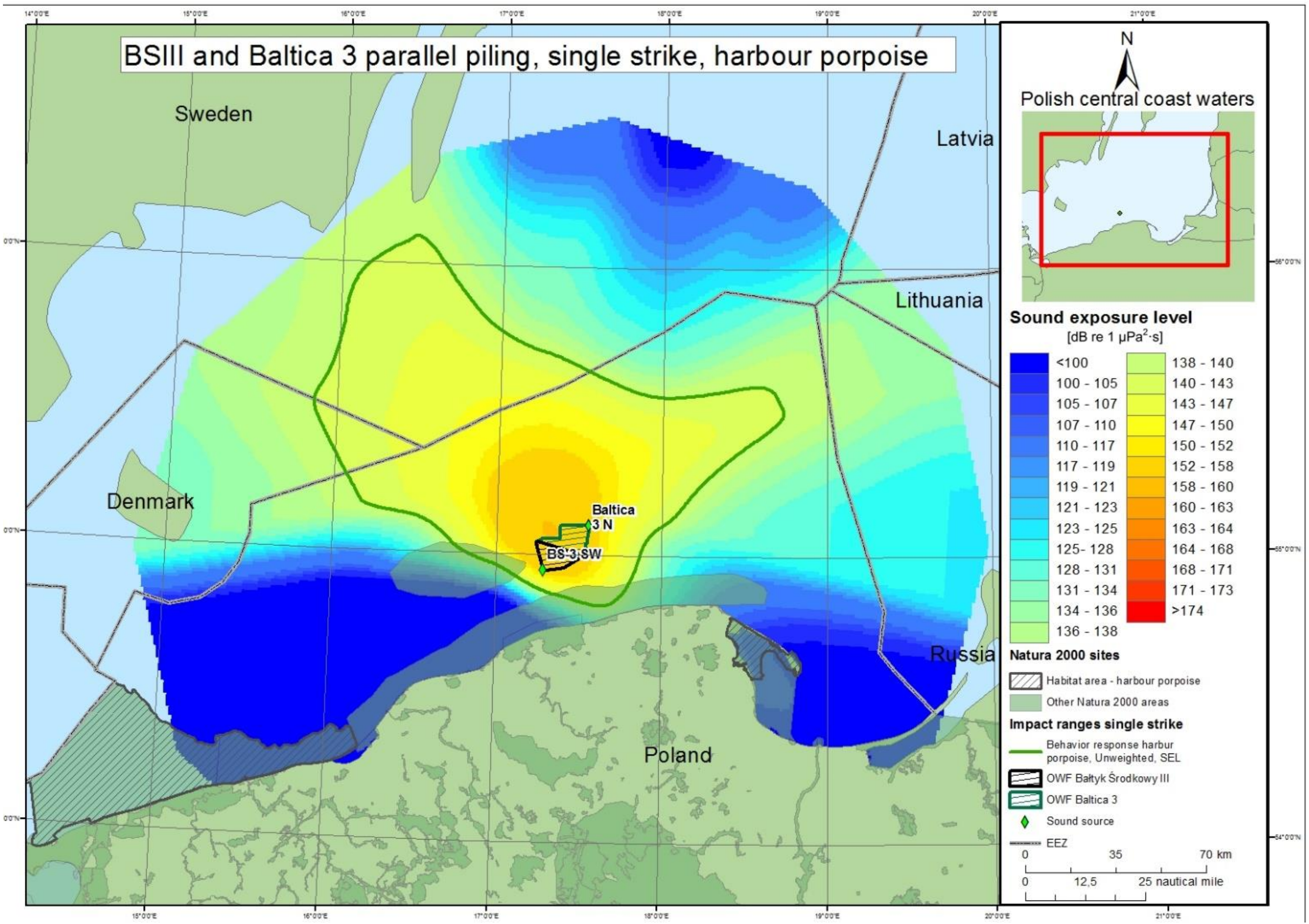

Figure 57 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour porpoises.

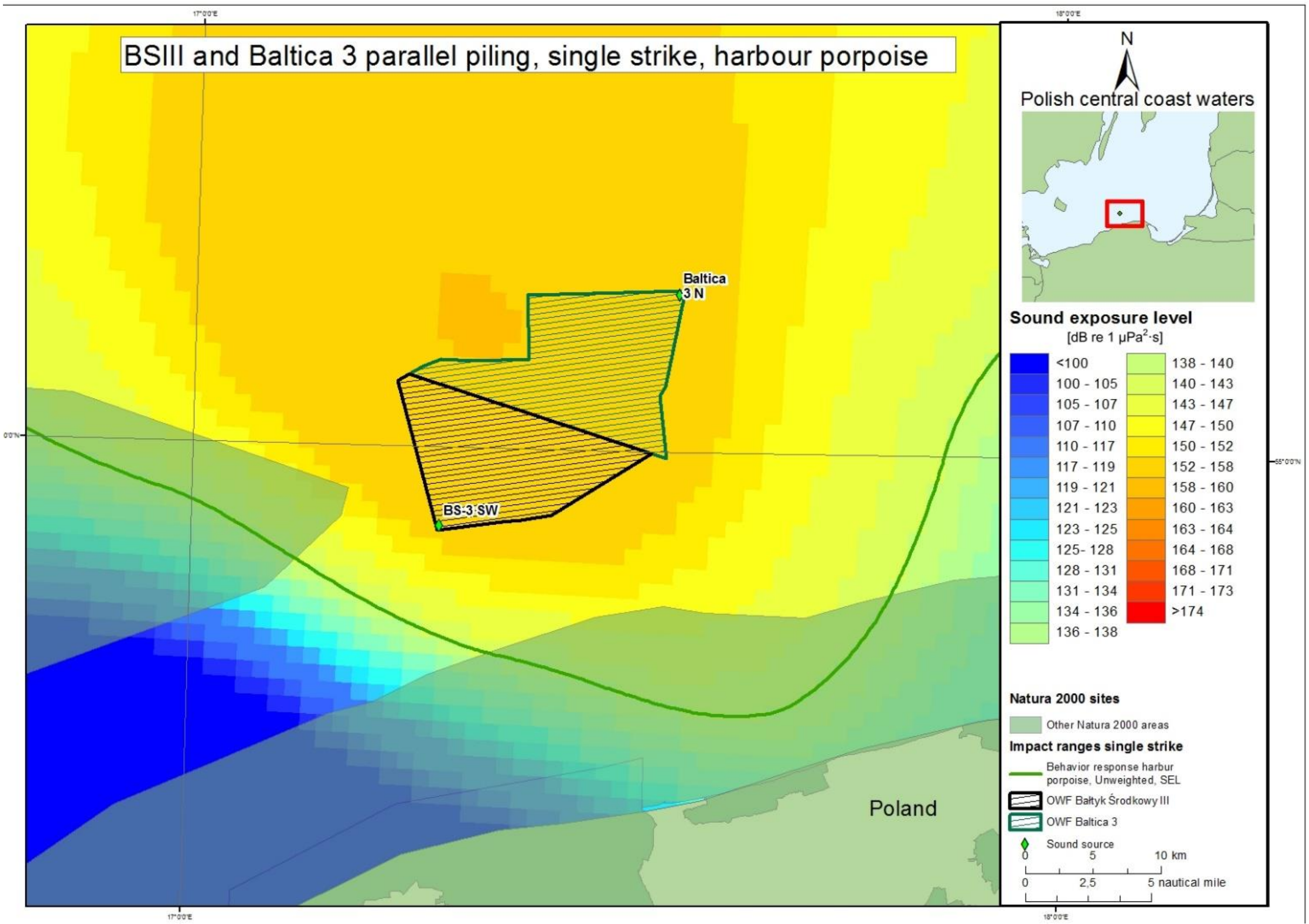

Figure 58 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour porpoises (zoomed in including Nature2000 areas).

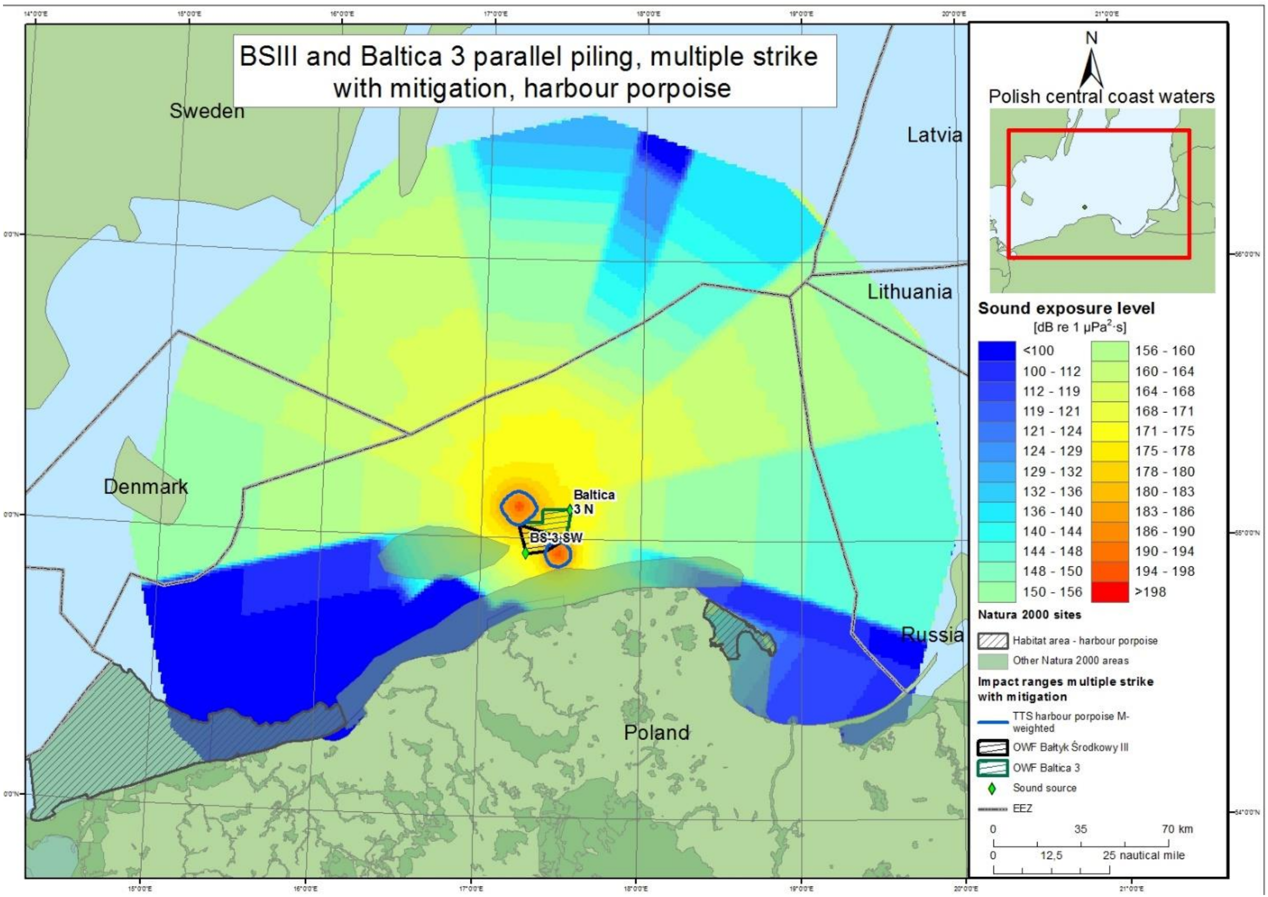

Figure 59 Sound map in SEL (= dB re 1μPa2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour porpoises.

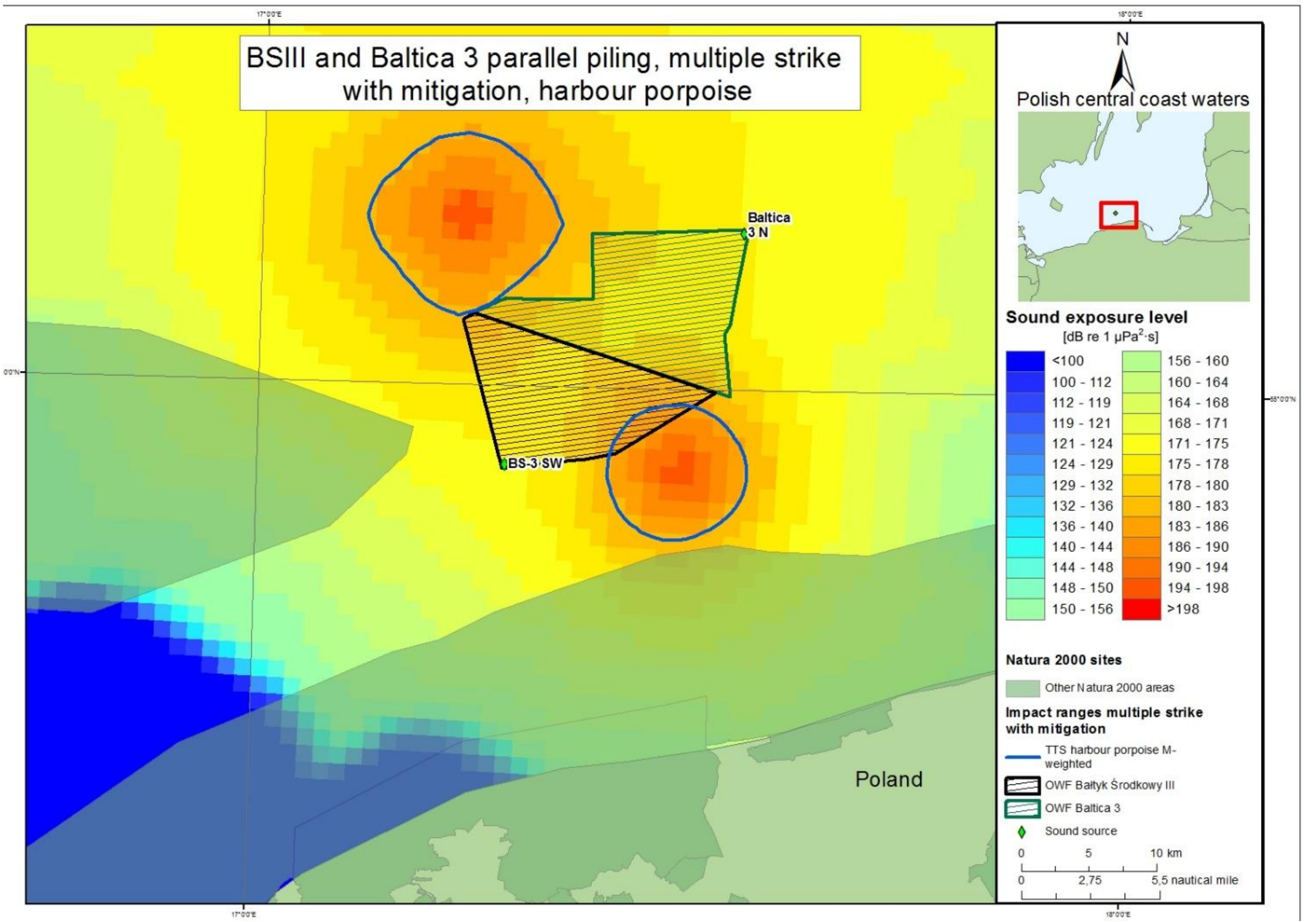

Figure 60 Sound map in SEL (= dB re 1μPa2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour porpoises (zoomed in including Nature 2000 areas).

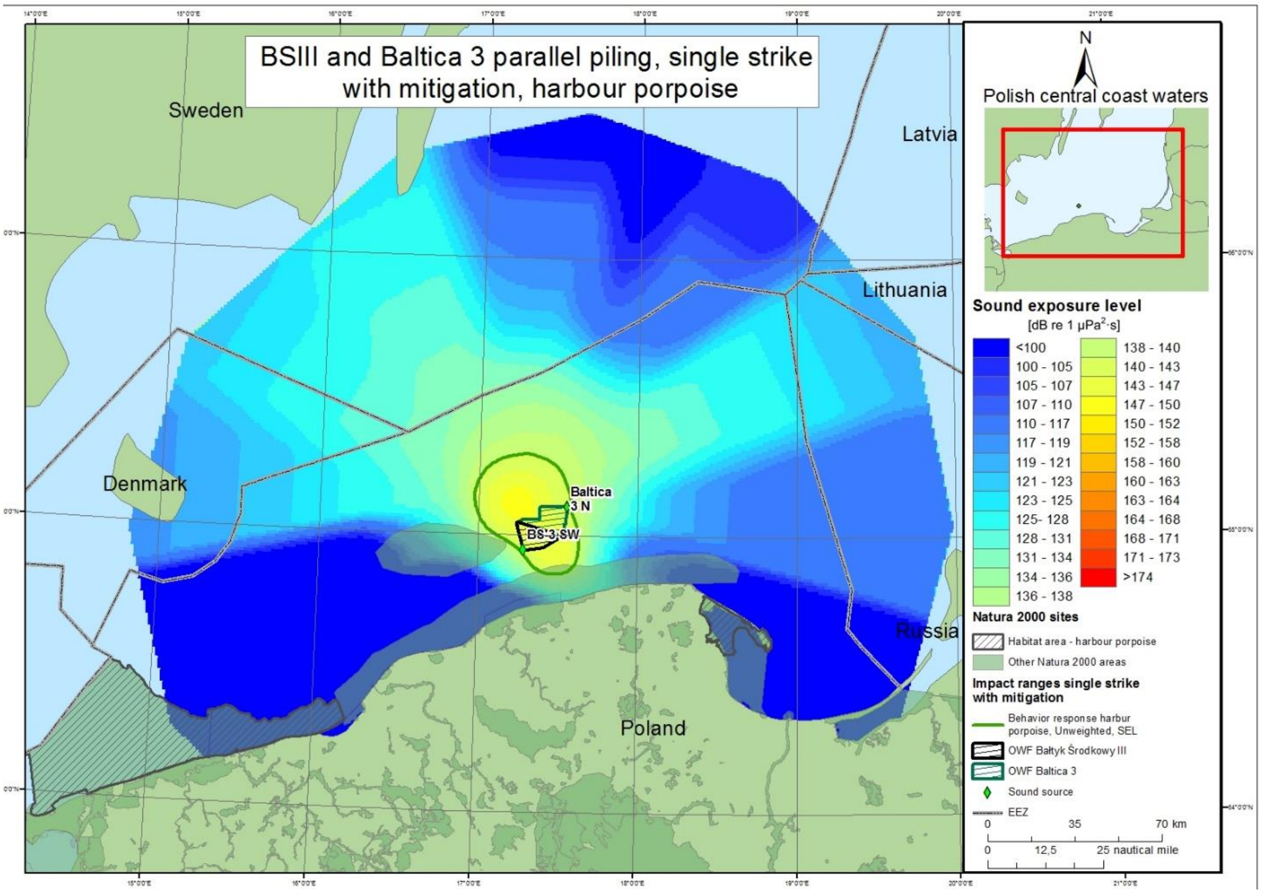

Figure 61 Sound map in SEL (= dB re 1µPa2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour porpoises.

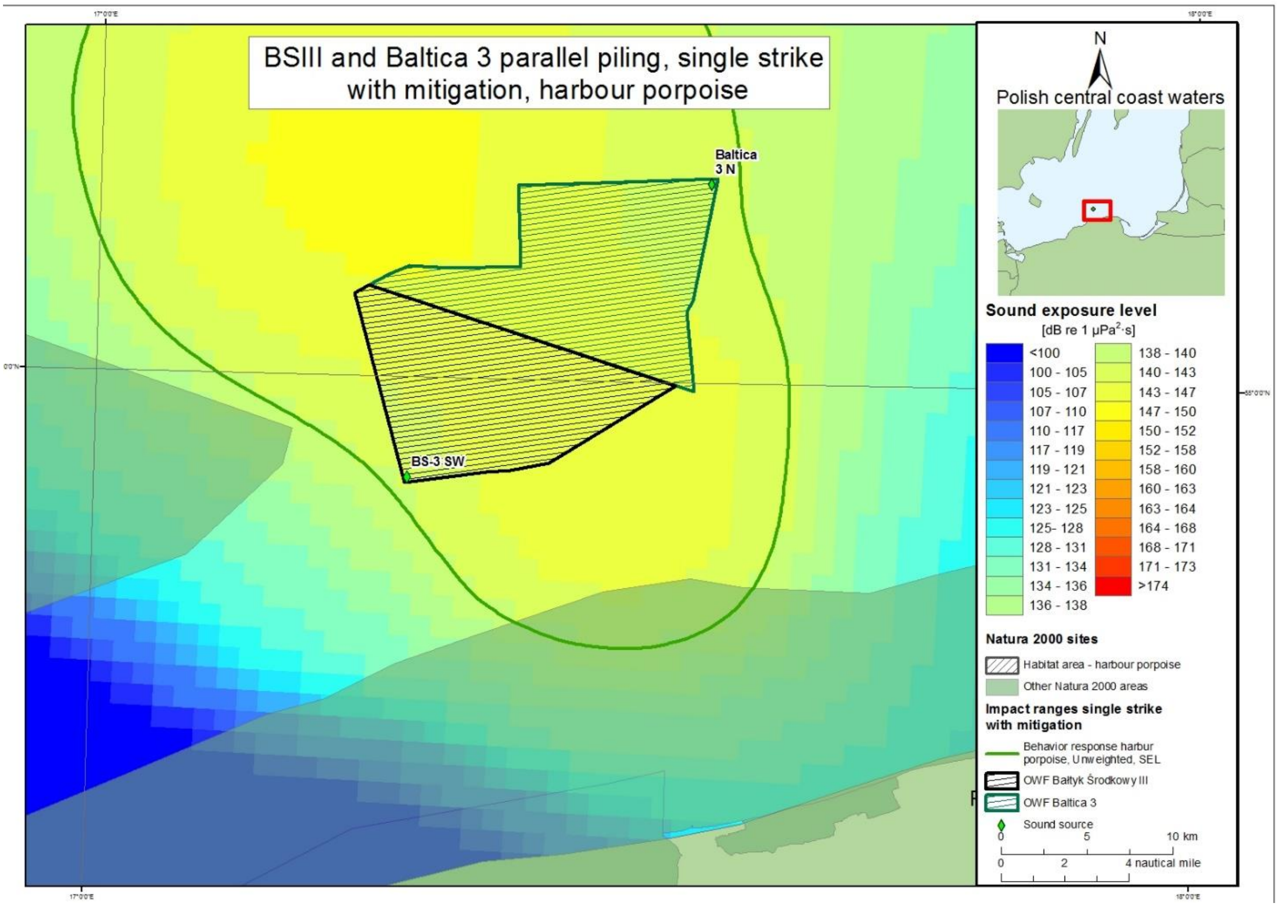

Figure 62 Sound map in SEL (= dB re 1μPa2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour porpoises (zoomed in including Nature2000 areas).

19.2.2 Harbour and grey seal

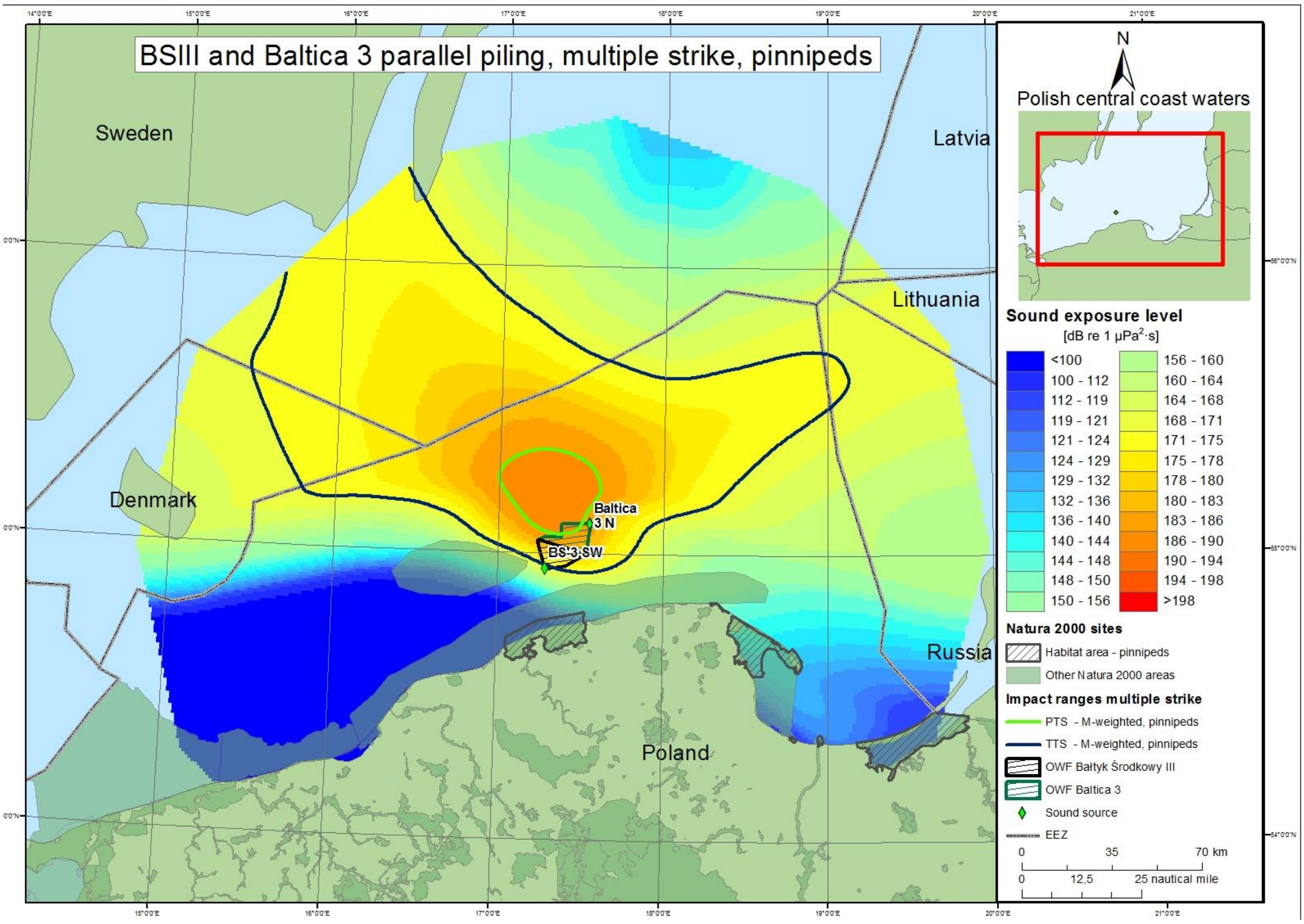

Figure 63 Sound map in SEL (= dB re $1\mu Pa^2 \cdot s$) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour seals and grey seals.

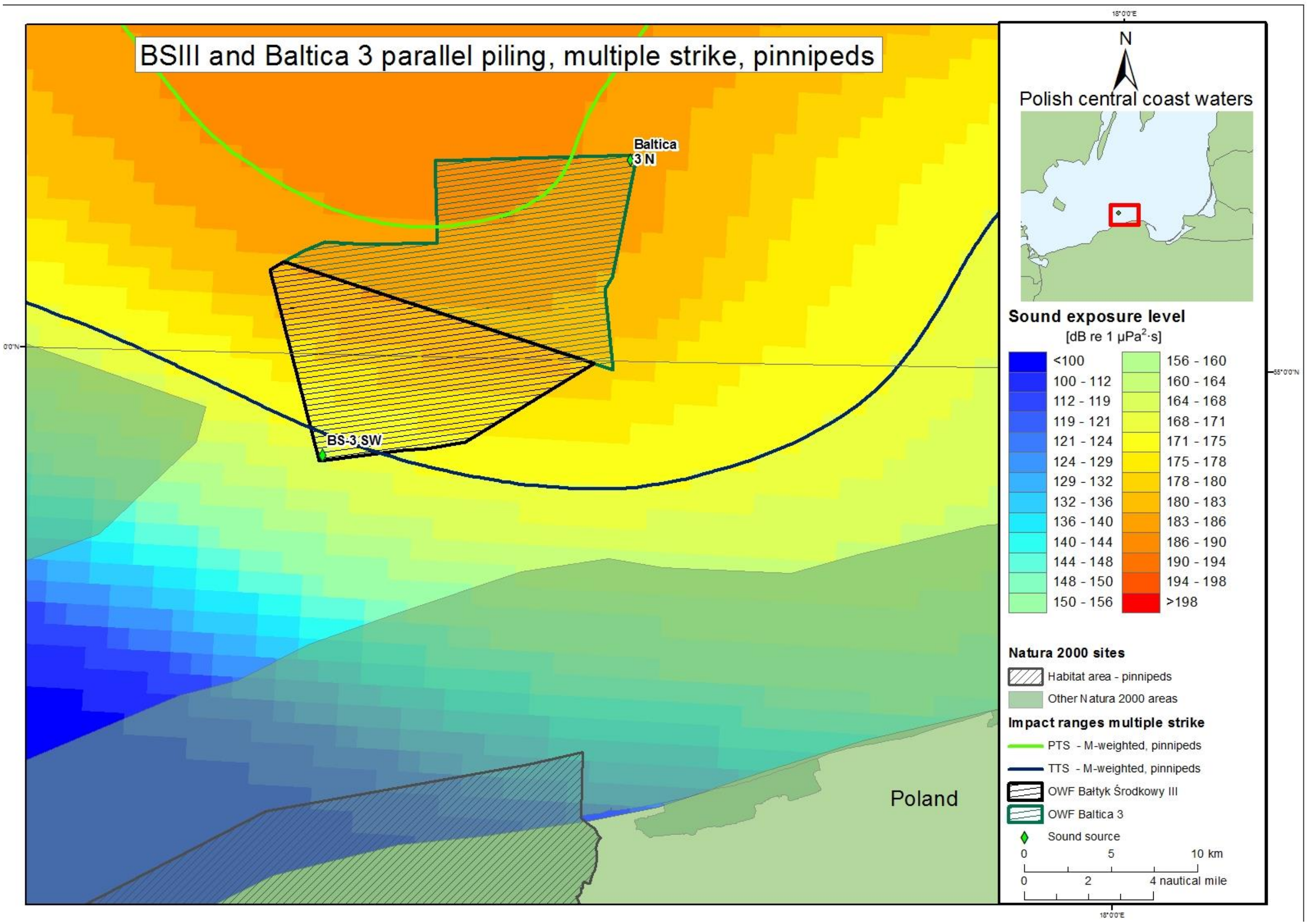

Figure 64 Sound map in SEL (= dB re 1μPa^2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour seals and grey seals (zoomed in including Nature2000 areas).

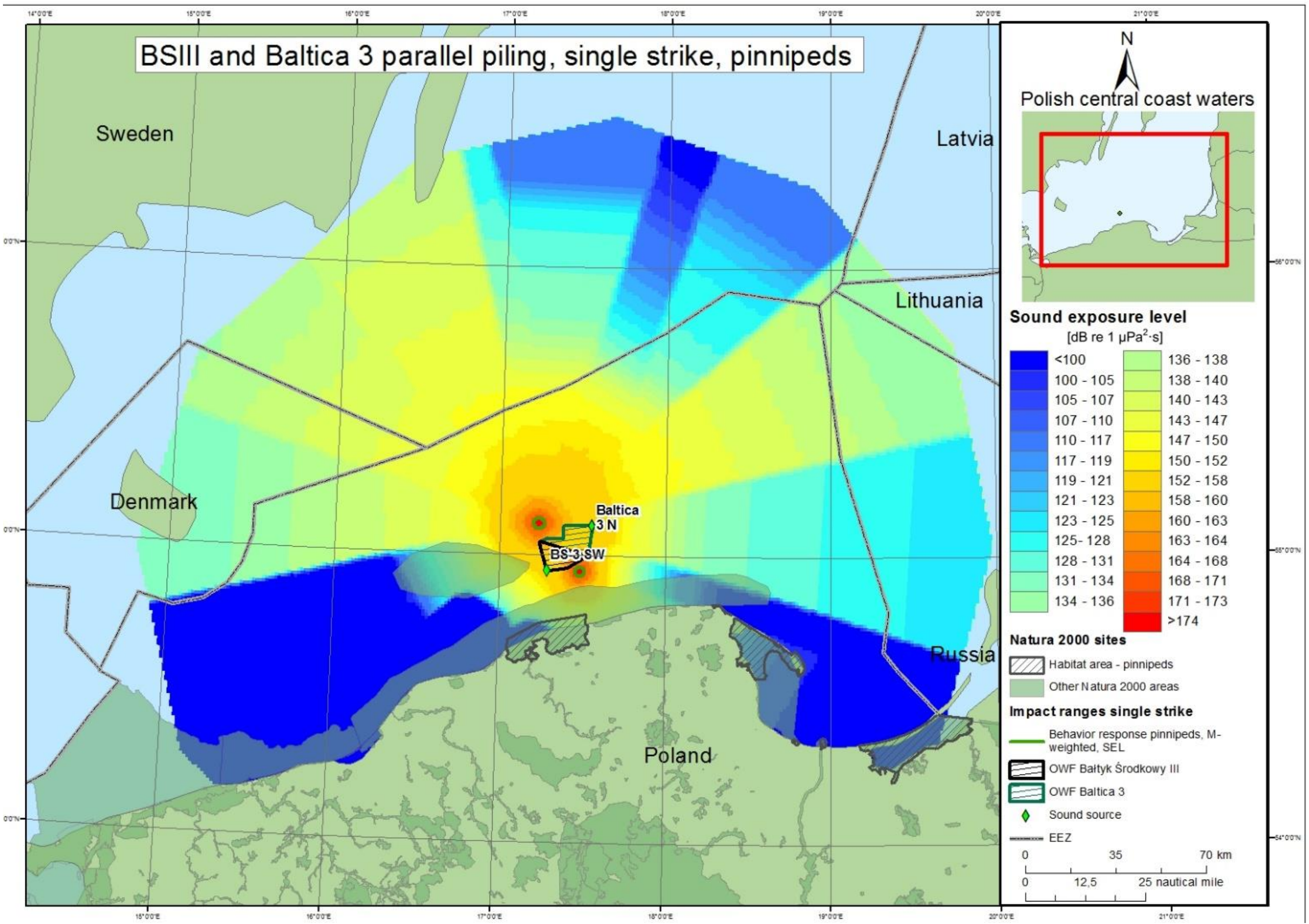

Figure 65 Sound map in SEL (= dB re 1µPa^2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour seals and grey seals.

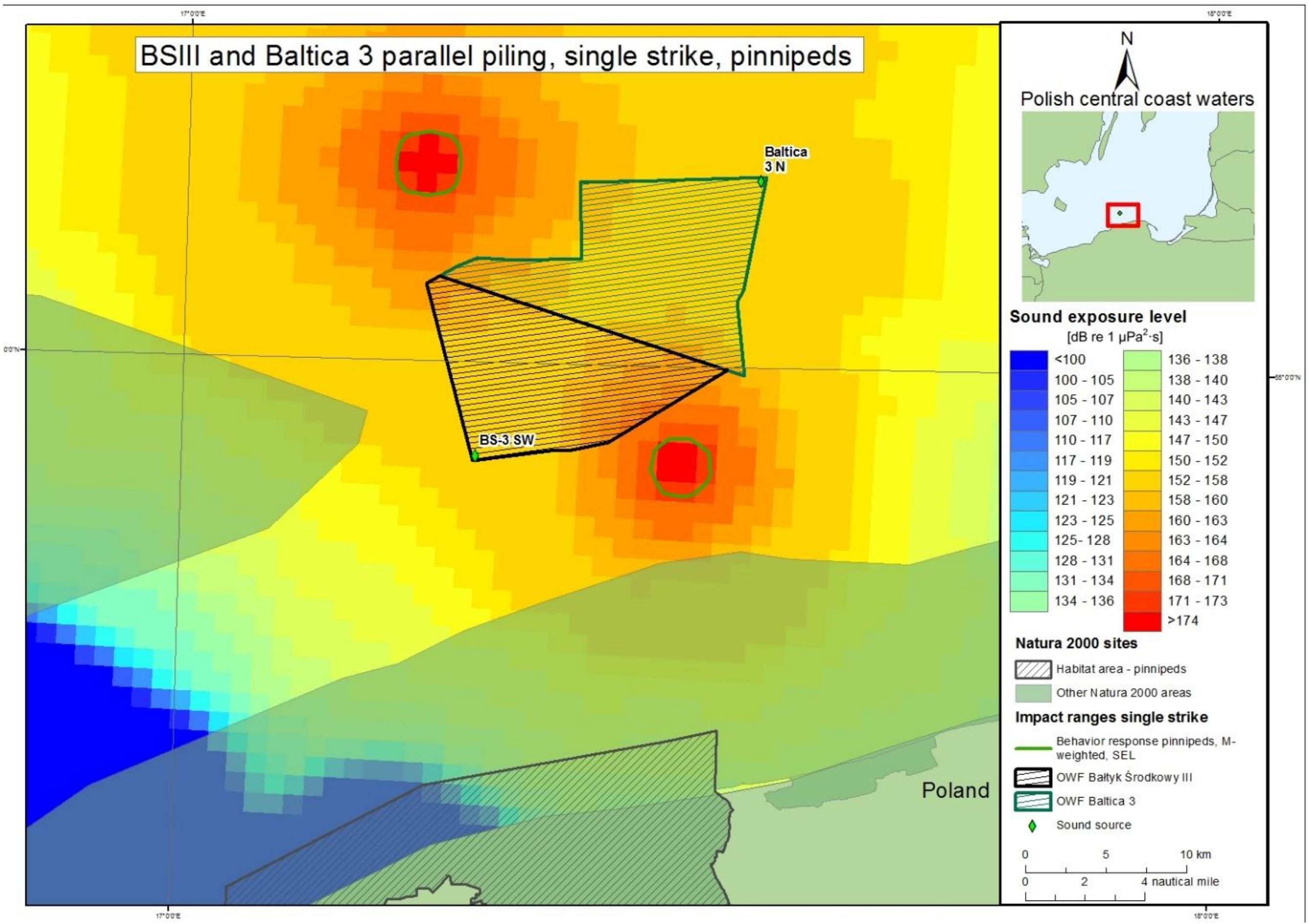

Figure 66 Sound map in SEL (= dB re 1µPa²•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously. Impact ranges are for harbour seals and grey seals (zoomed in including Nature2000 areas).

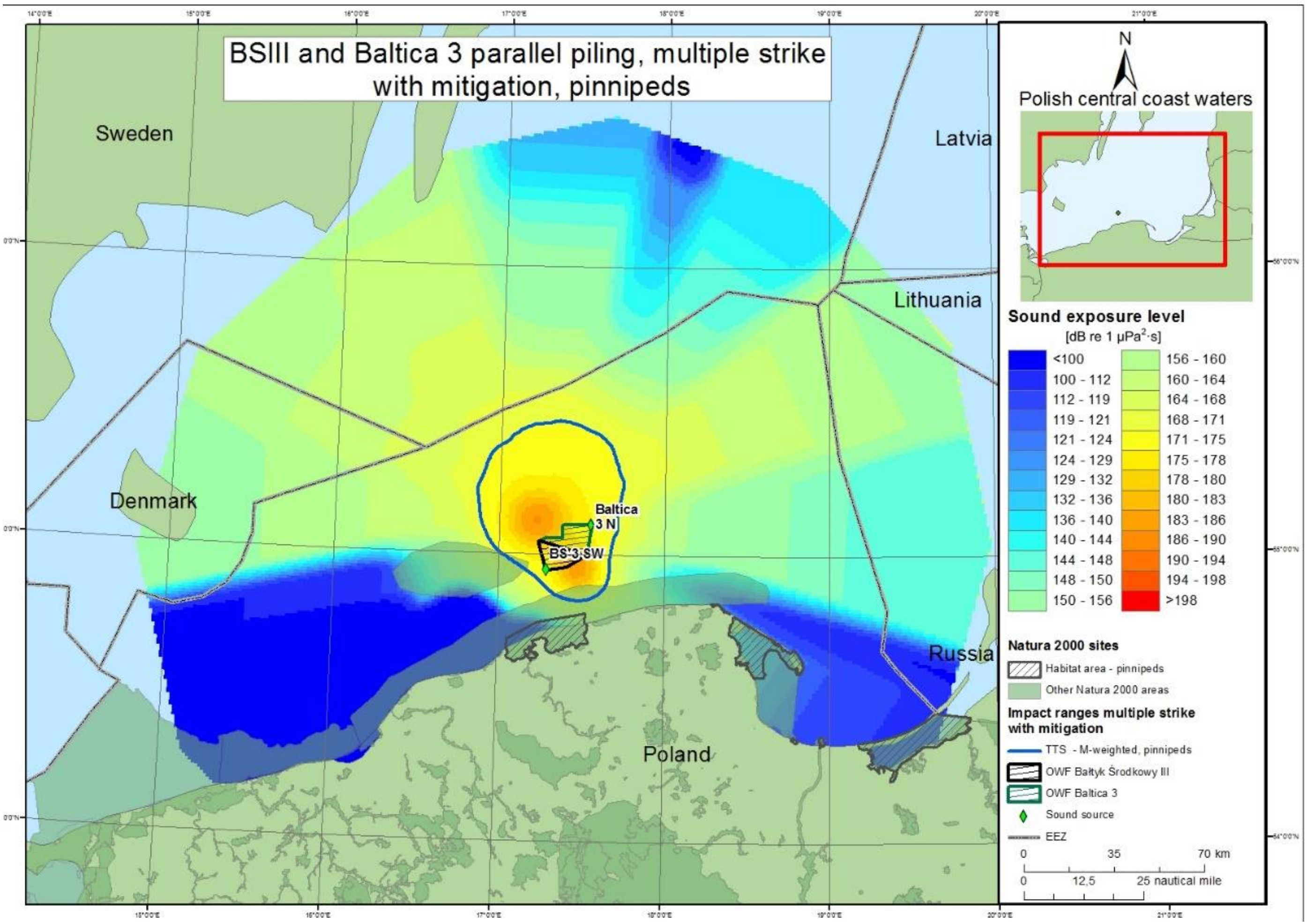

Figure 67 Sound map in SEL (= dB re 1µPa2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour seals and grey seals.

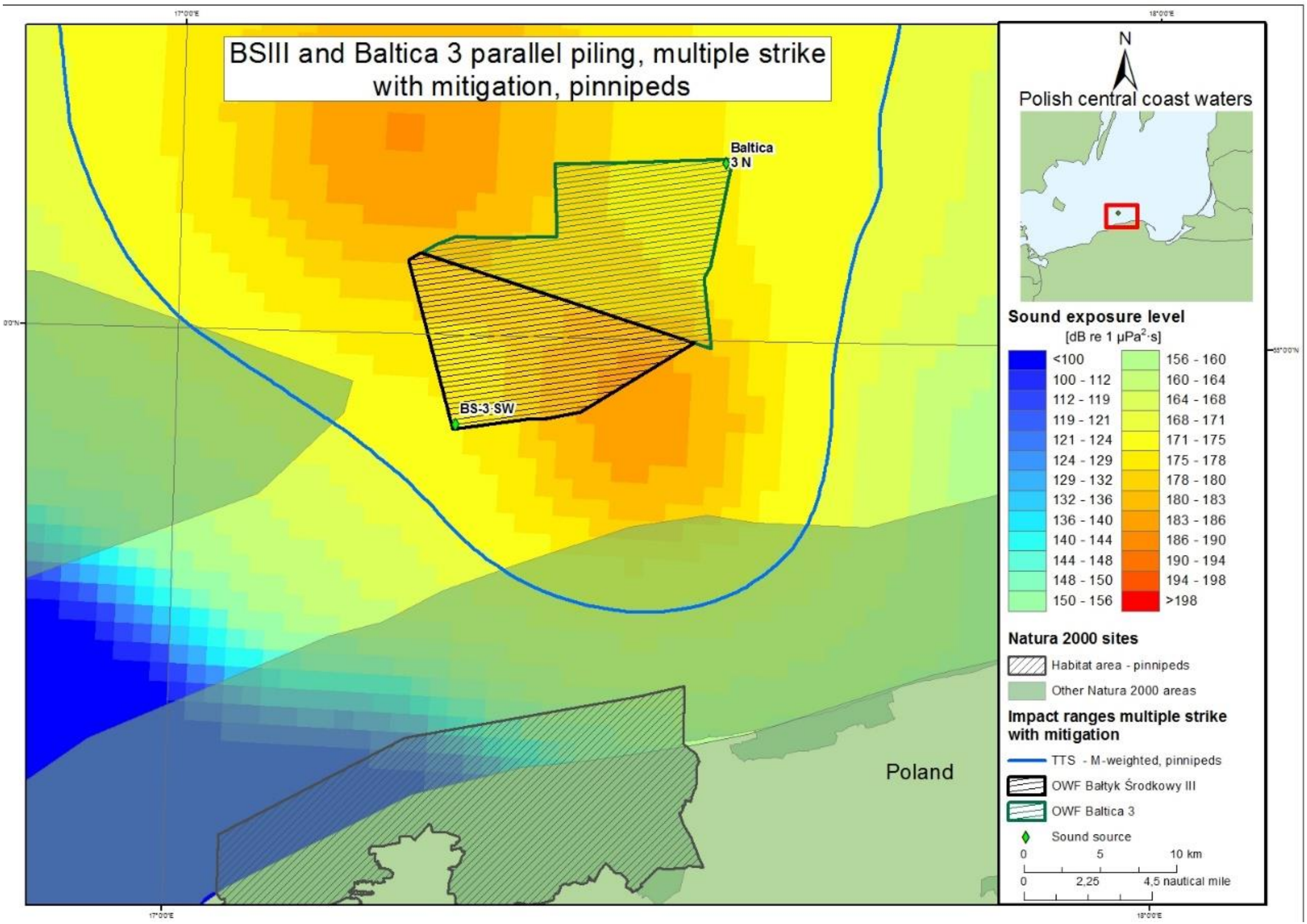

Figure 68 Sound map in SEL (= dB re 1μPa2•s) of the sound transmission of cumulative noise from 1 hour of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour seals and grey seals (zoomed in including Nature2000 areas).

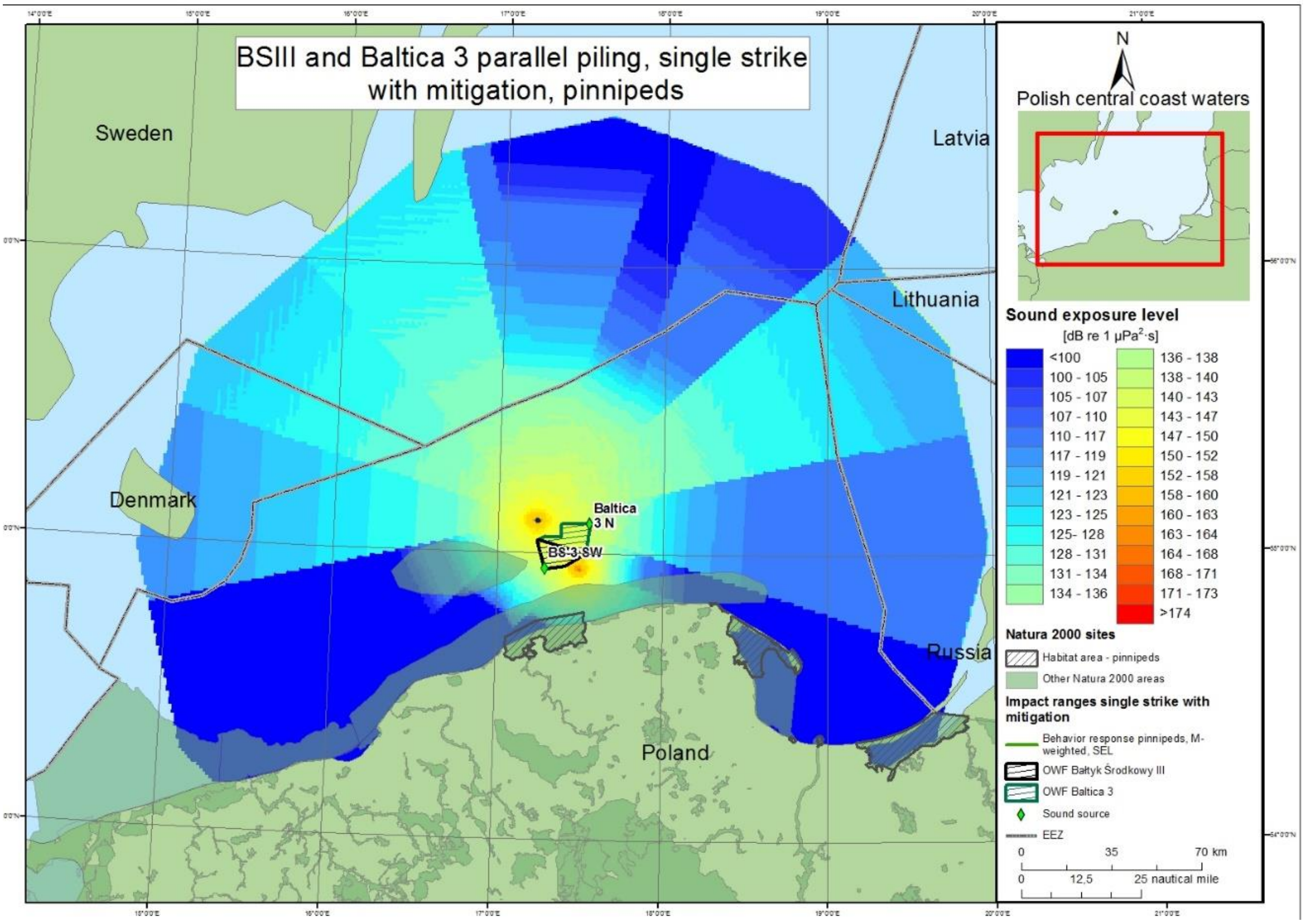

Figure 69 Sound map in SEL (= dB re 1µPa2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour seals and grey seals.

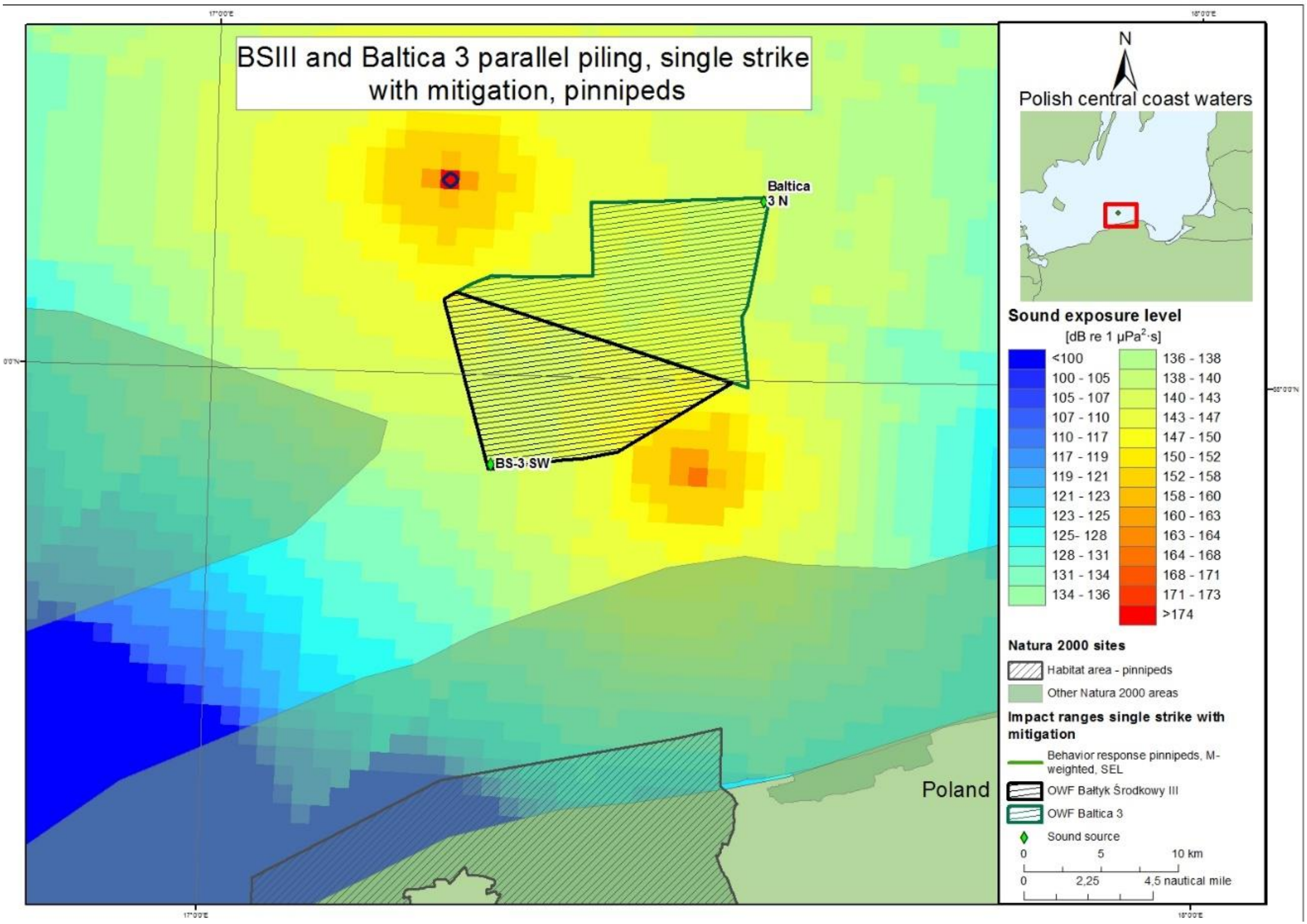

Figure 70 Sound map in SEL (= dB re 1μPa2•s) of the sound transmission of a single strike of a simulated pile driving activity for the variant chosen for realisation and rational alternative variant at two locations in two adjacent project areas simultaneously (with bubble curtain). Impact ranges are for harbour seals and grey seals (zoomed in including Nature2000 areas).

20 Appendix 3 Modelled propagation maps of cumulative piling at BŚIII and Baltica 3 wind farm

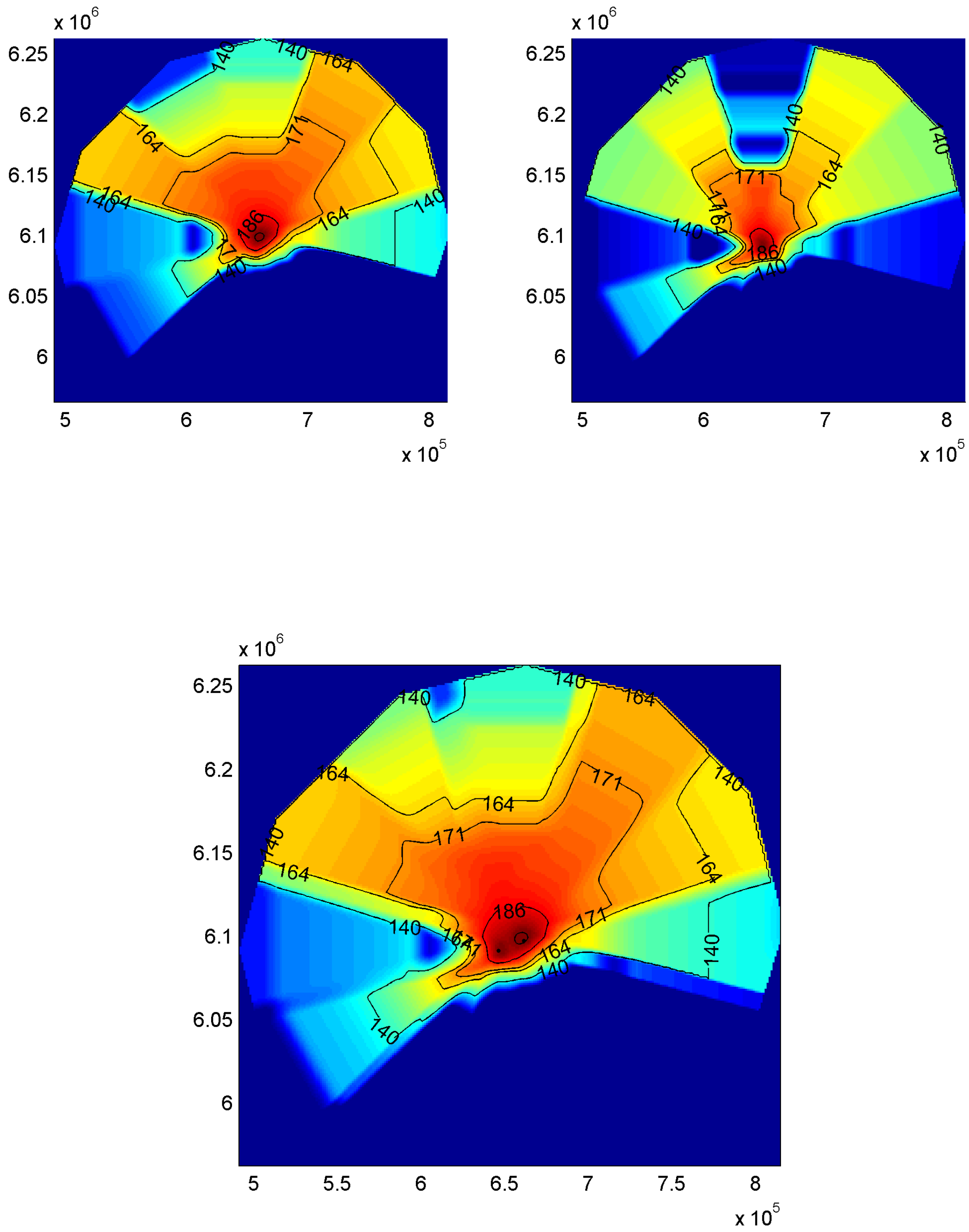

Figure 71 Modelled propagation of cumulative noise from 1 hour of pile-driving for the variant chosen for realisation and rational alternative variant for scenario 1 - unweighted. The upper left panel shows sound propagation from position BŚ III SW, and the upper right panel shows sound propagation from position BŚ III NE. The lower panel shows the noise propagation in the event of two noise sources.

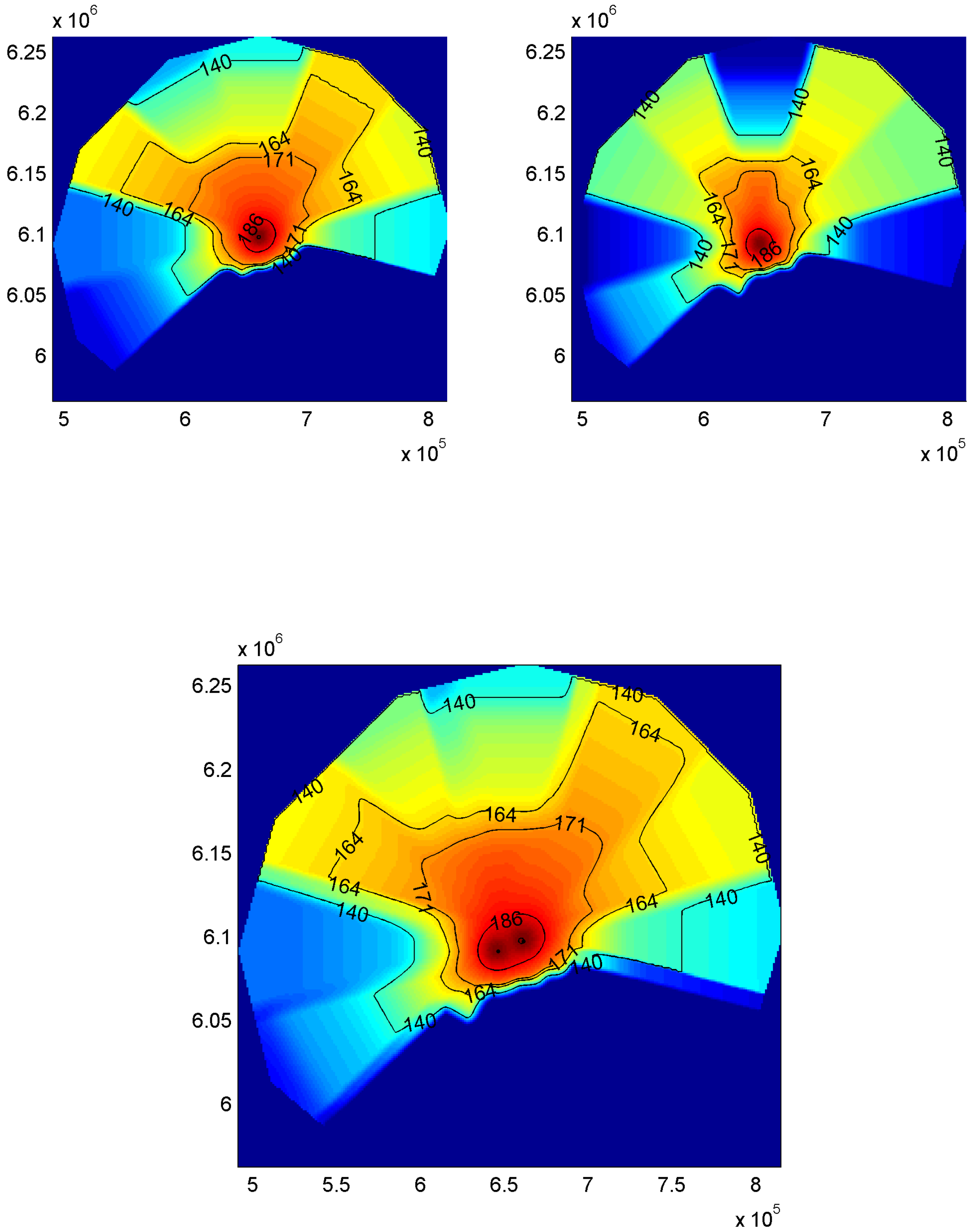

Figure 72 Modelled propagation of cumulative noise from 1 hour of pile-driving for the variant chosen for realisation and rational alternative variant for scenario 1 – M-weighted (High Frequency Cetacean). Upper left panel shows sound propagation from position BŚ III SW, and upper right panel shows sound propagation from position BŚ III NE. The lower panel shows the noise propagation in the event of two noise sources.

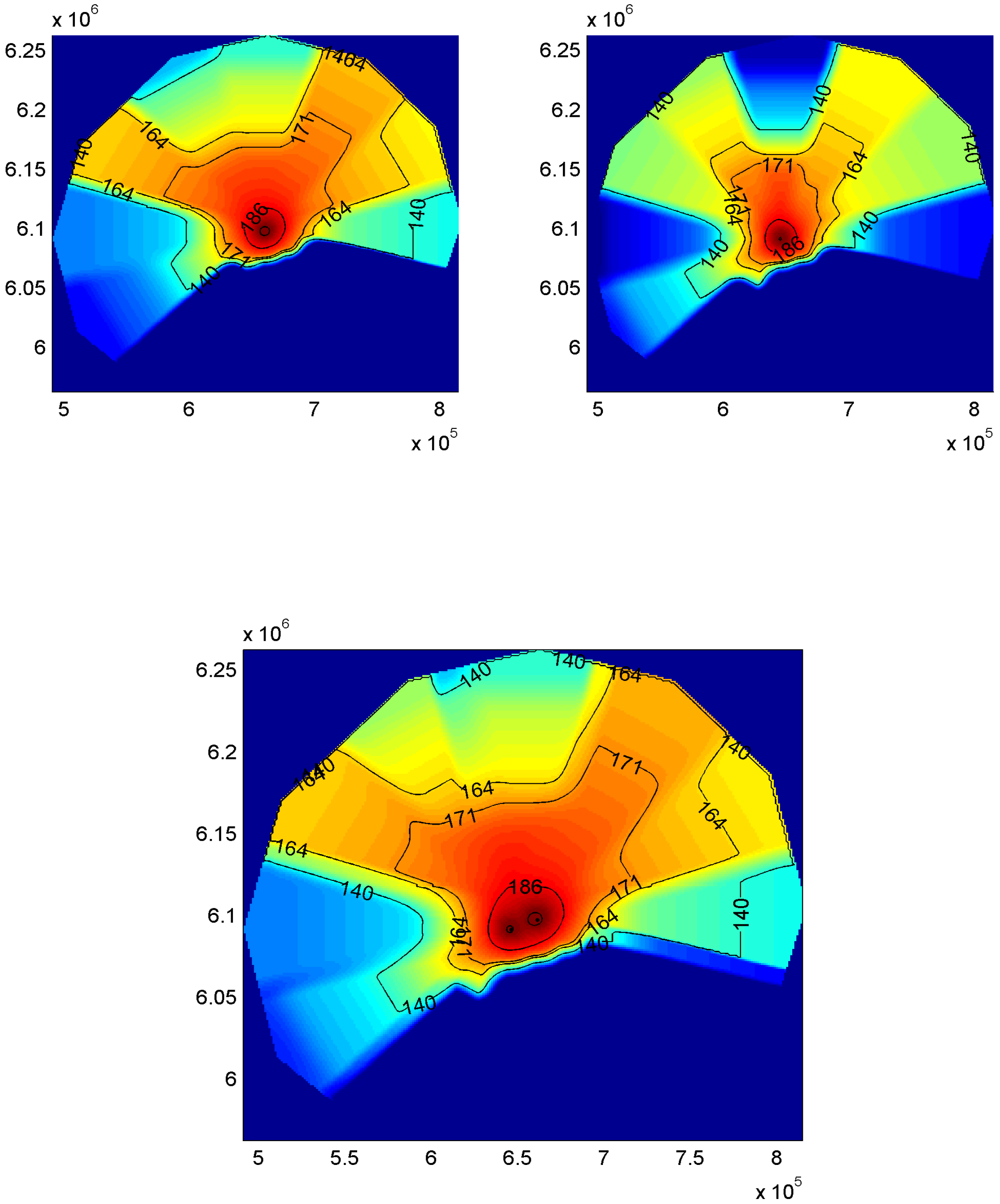

Figure 73 Modelled propagation of cumulative noise from 1 hour of pile-driving for the variant chosen for realisation and rational alternative variant for scenario 1 – M-weighted (Pinniped water). The upper left panel shows sound propagation from position BŚ III SW, and the upper right panel shows sound propagation from position BŚ III NE. The lower panel shows the noise propagation in the event of two noise sources.

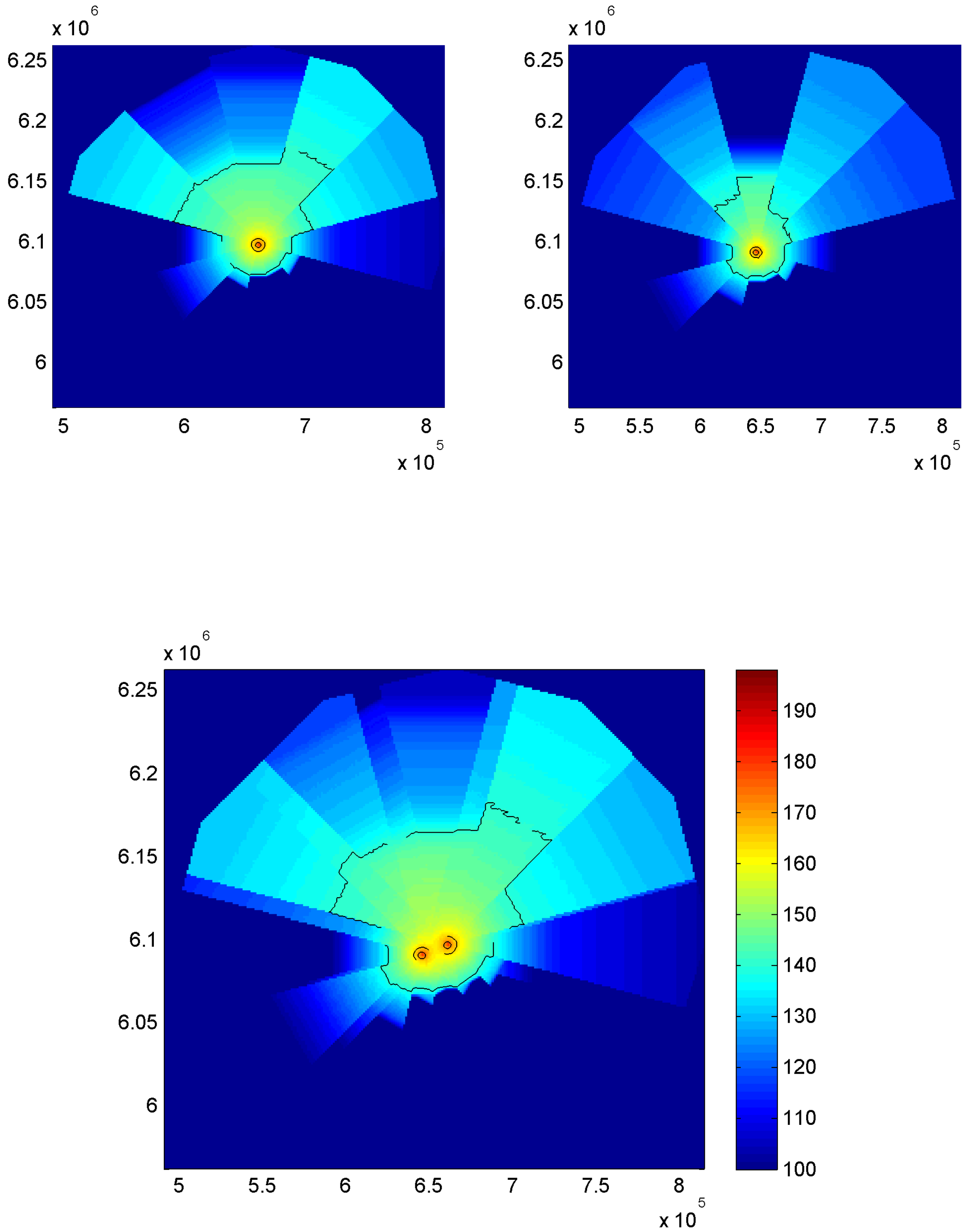

Figure 74 Modelled propagation of cumulative noise from a single strike for the variant chosen for realisation and rational alternative variant for scenario 1 – unweighted. The upper left panel shows sound propagation from position BŚ III SW and the upper right panel shows sound propagation from position BŠ III NE. The lower panel shows the noise propagation in the event of two noise sources.

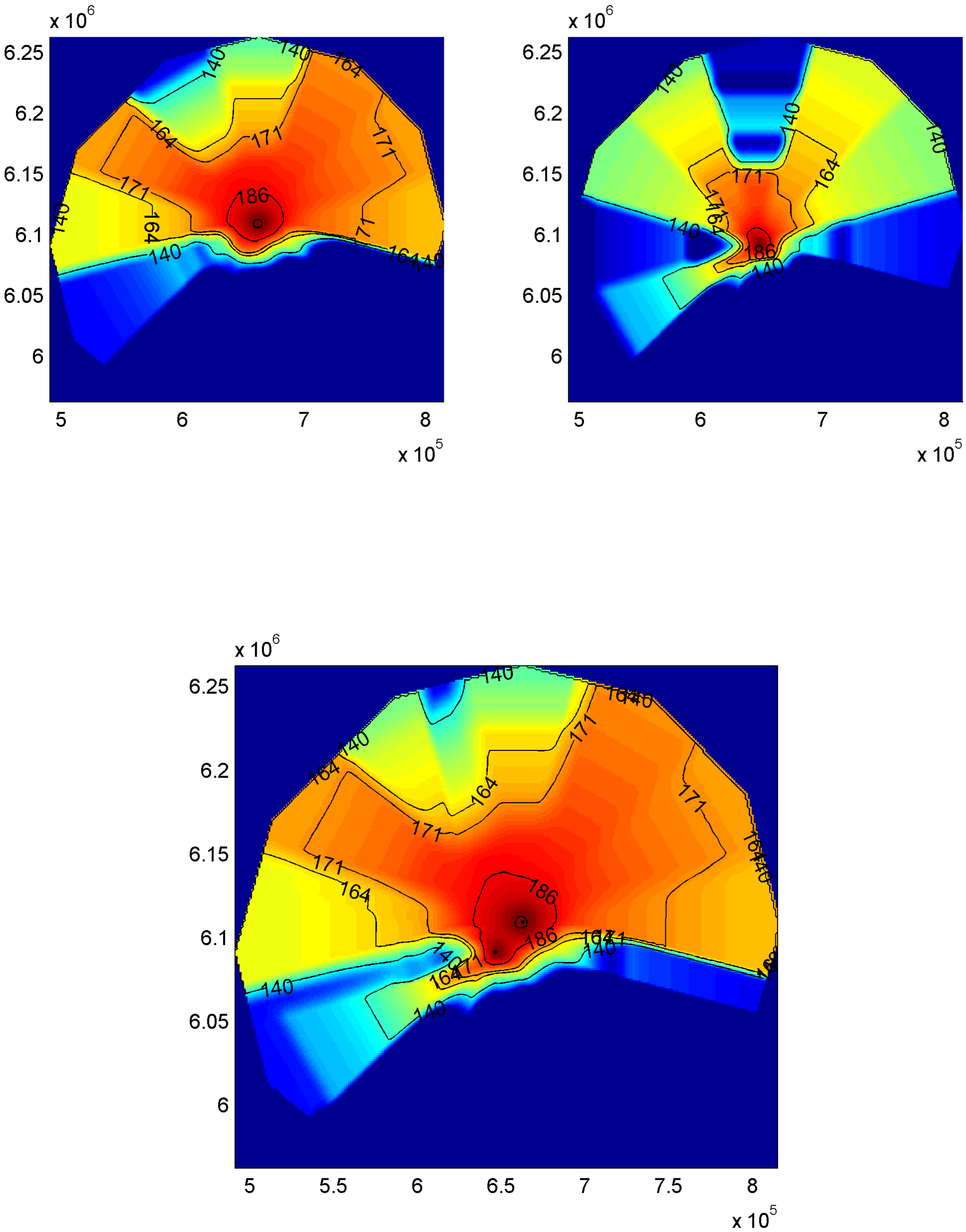

Figure 75 Modelled propagation of cumulative noise from 1 hour of pile-driving for the variant chosen for realisation and rational alternative variant for scenario 2 – unweighted. The upper left panel shows sound propagation from position BŚ III SW, and the upper right panel shows sound propagation from position Baltica 3 N. The lower panel shows the noise propagation in the event of two noise sources.

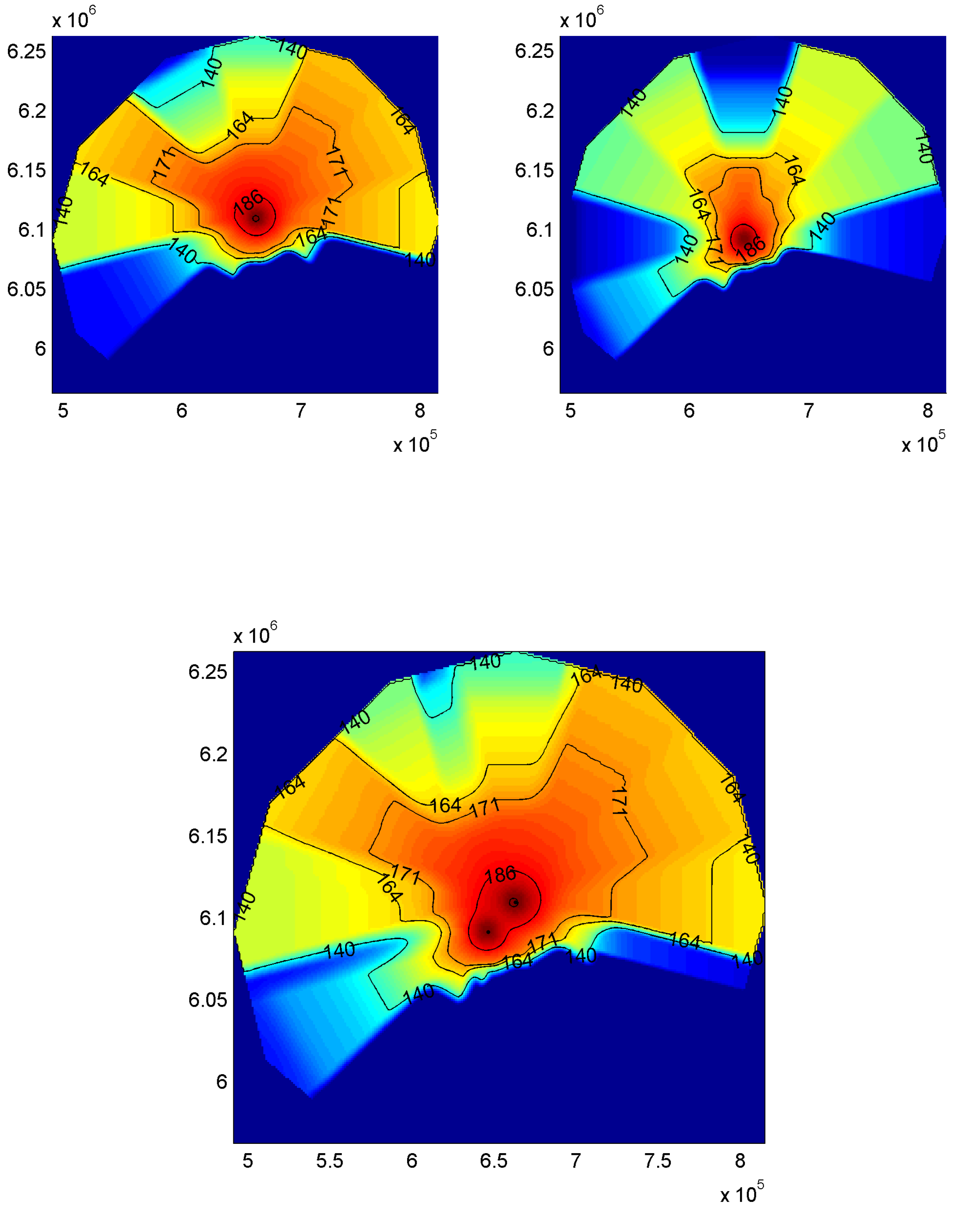

Figure 76 Modelled propagation of cumulative noise from 1 hour of pile-driving for the variant chosen for realisation and rational alternative variant for scenario 2 – M-weighted (High Frequency Cetacean). The upper left panel shows sound propagation from position BŚ III SW, and the upper right panel shows sound propagation from position Baltica 3 N. The lower panel shows the noise propagation in the event of two noise sources.

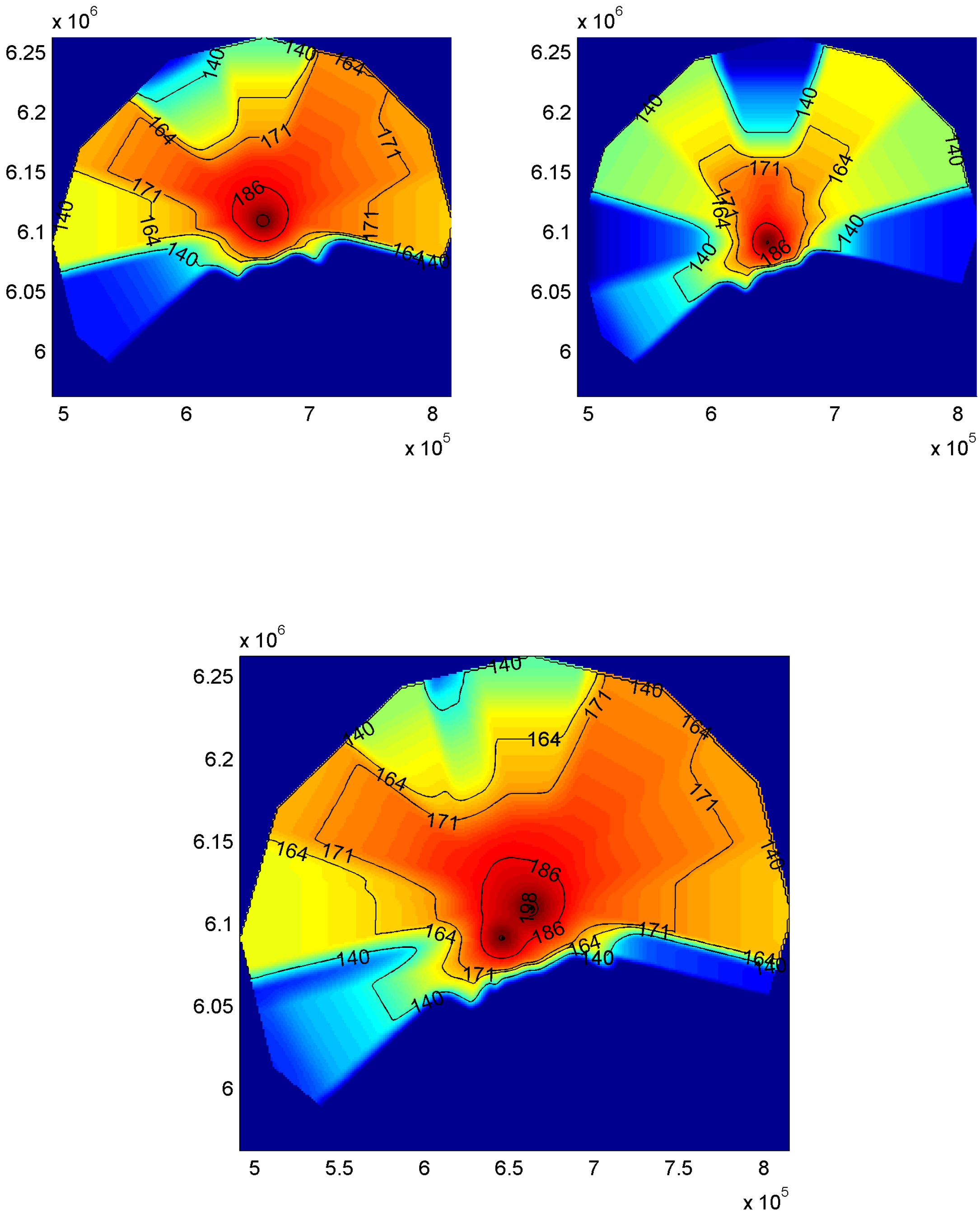

Figure 77 Modelled propagation of cumulative noise from 1 hour of pile-driving for the variant chosen for realisation and rational alternative variant for scenario 2 – M-weighted (Pinniped Water). The upper left panel shows sound propagation from position BŚ III SW, and the upper right panel shows sound propagation from position Baltica 3 N. The lower panel shows the noise propagation in the event of two noise sources.

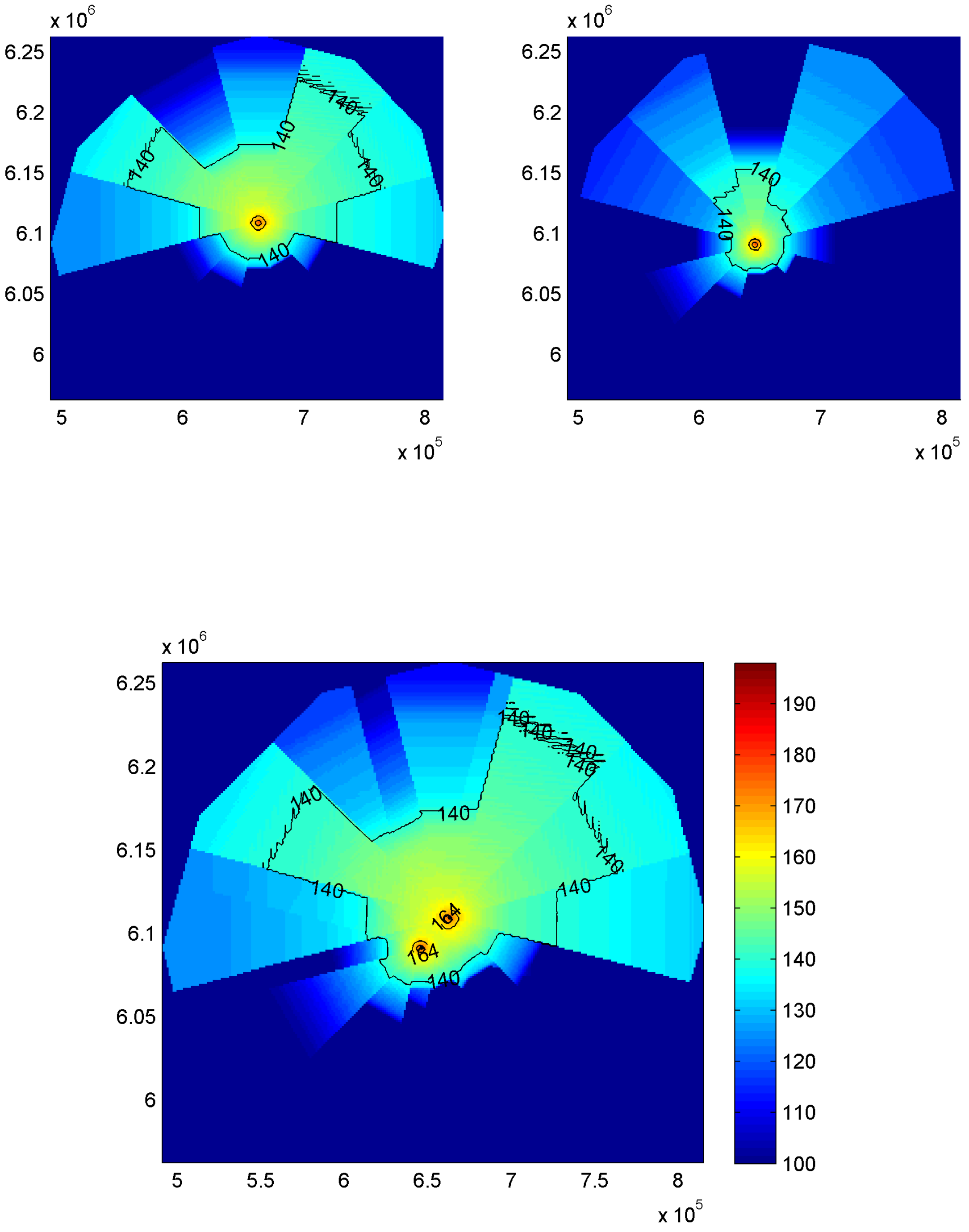

Figure 78 Modelled propagation of cumulative noise from a single strike for the variant chosen for realisation and rational alternative variant for scenario 2 – unweighted. The upper left panel shows sound propagation from position BŚ III SW and the upper right panel shows sound propagation from position Baltica 3 N. The lower panel shows the noise propagation in the event of two noise sources.