East Anglia ONE North and East Anglia TWO Offshore Windfarms

Underwater Noise Modelling Update

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Applicable to East Anglia ONE North and East Anglia TWO

Project title	Underwater noise modelling at EA2/1N – multiple pile installations
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Introduction

The proposed East Anglia TWO and ONE North (EA2/EA1N) offshore wind farms are proposed to consist of a wind turbine array, with the turbines installed on foundations using either a single monopile or multi-leg jacket driven into the seabed. The pile driving proposed for this will generate noise, which has the potential to adversely affect marine life in the vicinity of the activity.

To identify the extent of the impact of this noise on marine mammals in the North Sea, underwater noise modelling was undertaken as part of the Environmental Impact Assessment. This uses the pile diameter, piling hammer blow energy and other environmental factors relevant to the wind turbine location to predict the extent of the subsea noise propagation, and how the exposure to this noise would affect marine mammals (as per guidance in NMFS, 2018[1]). This is generally expressed in terms of an adverse effect on the hearing of a receptor, either permanent (known as a permanent threshold shift, PTS) or short-term (a temporary threshold shift, TTS).

Modelling was originally based on a marine mammal receptor exposed to the high noise levels produced by installation of a pile. However, there is the potential that multiple piles could be driven in a day (the timescale over which the guidance recommends assessment) and the MMO has raised a concern that this could affect the ranges of impact that represent the extent of adverse effects on marine mammals.

It should be noted that no concurrent piling, that is multiple rigs on site each driving foundation piles simultaneously, is proposed and so concerns stem from multiple piles installed sequentially from a single location.

Acoustic background and principles

The potential effect of underwater noise exposure on marine mammals is assessed using NMFS (2018) methodology. The pile driving generates a succession of discrete pulses in the water, which diminish in noise level as the pulse moves away from the source. At some point this pulse will reach a marine mammal receptor, where it will have a specific noise level, to which the receptor is exposed. It is assumed that under these conditions the receptor will move away from the noise source, and thus, in principle, each successive subsea pulse reaching the receptor will be slightly quieter than the previous one[2]. This will continue for the duration of the piling activity. The exposure to each pulse accumulates to an overall exposure that the receptor reaches at the end of the event.

Although the strikes tend to get louder as the blow energy increases over the pile installation, this is normally more than offset by the increasing distance of the receptor from the pile. The consequence of this is that the majority of the noise exposure occurs at the start of the piling event.

Where multiple piles must be considered, the model applies a second pulse sequence to the receptor on completion of the first, adding to the overall exposure. However, at the start of this subsequent period

[1] National Marine Fisheries Service (NMFS) (2018). *Revisions to: Technical guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts.* U.S. Dept of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59.
[2] The modelling assumes a flee speed of 3.25 ms^{-1} for LF cetaceans and a flee speed of 1.5 ms^{-1} for MF cetaceans, HF cetaceans and PW pinnipeds.

of piling, the receptor is already a significant distance from the pile and this limits the additional exposure; any further piling periods will mean that the receptor will start further and further away.

NMFS (2018) defines a series of noise exposure thresholds, which define the point at which onset of a particular effect – PTS or TTS – could occur to a particular species group. These species groups categorise species by their hearing capabilities, effectively a frequency range to which species in the group are sensitive. Four species groups are considered in the EA2/1N subsea noise impact assessment: “low frequency cetacean” (LF) species, generally baleen whales, “mid frequency cetacean” species (MF), e.g. common dolphins, “high frequency cetacean” species (HF), e.g. harbour porpoise, and pinnipeds (in water) (PW), e.g. seals.

The model outputs an exposure contour. If an individual is inside this contour at the start of piling, then the exposure has been modelled to exceed the threshold relevant to that particular criterion.

NMFS guidelines propose criteria based on the SPL_{peak} and SEL_{cum} metrics for each species group. SPL_{peak} criteria use an effectively instantaneous noise level and so are unsuitable for a comparison using an exposure over time. Therefore, only the SEL_{cum} thresholds will be investigated herein.

Underwater noise modelling

Modelling has been undertaken to predict the noise exposure from the installation of four sequential piles for a wind turbine generator (WTG) multi-leg jacket foundation to marine mammal receptors, in comparison to the single driven foundation pile presented in the EA2/EA1N Environmental Statement. Based on the PTS thresholds defined in NMFS, 2018, the new contour has been overlaid on the original contour presented in the EA2/1N environmental statement. For the purposes of this demonstrative study, only PTS has been remodelled.

One location in EA2 and one location in EA1N have been chosen as a representative example to demonstrate the effect on contour size of installation of four sequential piles in comparison to a single pile. It should be noted that the location in EA1N is the same as used in the original impact assessment modelling to enable a direct comparison for the purposes of this study, although the latest EA1N boundaries have moved slightly. This small change in position will have little effect on the modelled contours, and no effect on the principle of identifying relative changes in contours from one pile installation to four sequentially.

Piling parameters are unchanged from those used in the EA2/1N Environmental Statement.

Results

The tables below present the modelling SEL_{cum} impact ranges for the noise from a single pile installation and for the noise from four piles, installed sequentially. All ranges are given to two significant figures.

NMFS (2018) – PTS, weighted SEL_{cum}			1 pile (from ES)		4 piles, sequential	
			Maximum	**Mean**	**Maximum**	**Mean**
EA2	LF Cetacean	183 dB	20 km	16 km	20 km	16 km
	MF Cetacean	185 dB	< 10 m	< 10 m	< 10 m	< 10 m
	HF Cetacean	155 dB	21 km	18 km	21 km	18 km
	PW Pinniped	185 dB	6.9 km	5.9 km	7.1 km	6.0 km

Table 1 – PTS ranges comparison at East Anglia TWO (EA2) Offshore Wind Farm

NMFS (2018) – PTS, weighted SEL_{cum}			1 pile (from ES)		4 piles, sequential	
			Maximum	**Mean**	**Maximum**	**Mean**
EA1N	LF Cetacean	183 dB	21 km	17 km	21 km	17 km
	MF Cetacean	185 dB	< 10 m	< 10 m	< 10 m	< 10 m
	HF Cetacean	155 dB	21 km	18 km	21 km	18 km
	PW Pinniped	185 dB	7.0 km	5.8 km	7.2 km	5.9 km

Table 2 – PTS ranges comparison at East Anglia ONE North (EA1N) Offshore Wind Farm

Figures showing the effect on ranges are presented for the HF cetacean and PW pinniped species groups, as defined in NMFS (2018), are given at the end of the report (Figure 1 to Figure 4). For each figure, the yellow contour represents the SEL_{cum} impact ranges for one pile, and the red contour represents the SEL_{cum} contour for four piles installed sequentially.

LF and MF cetacean plots have not been presented. The faster flee speed for LF cetaceans (3.25 m/s vs 1.5 m/s for the other species groups) meant that the receptor has travelled much further from the noise source than the other species groups in the same time period, and the impact ranges for four piles were negligibly larger than for a single pile. The small impact ranges predicted for MF cetaceans would not be visible on a chart at this scale.

These results represent the effect of installation of multiple piles for a jacket foundation in a 24-hour period. It is understood that the monopile option for turbine foundations could potentially include up to two pile installations in a day. The results for monopiles are unlikely to be significantly different to those provided for the pin piles above: while the overall noise level produced by a driven monopile might be slightly greater than from the smaller multi-leg jackets, fewer piles driven in a day will lead to less energy introduced overall.

Conclusions

Remodelling of the underwater noise exposure for marine mammals at EA2 and EA1N has shown that there is a small increase in the PTS ranges when considering four sequential driven pile installations compared to a single installation. This is up to a 3% increase in range for the pinnipeds (in water) species hearing group, at most. The duration in time over which a pile is installed is sufficient for an individual to be able to move a sufficient distance from the noise source such that any additional exposure to noise does not contribute significantly to the animal's overall exposure in a day.

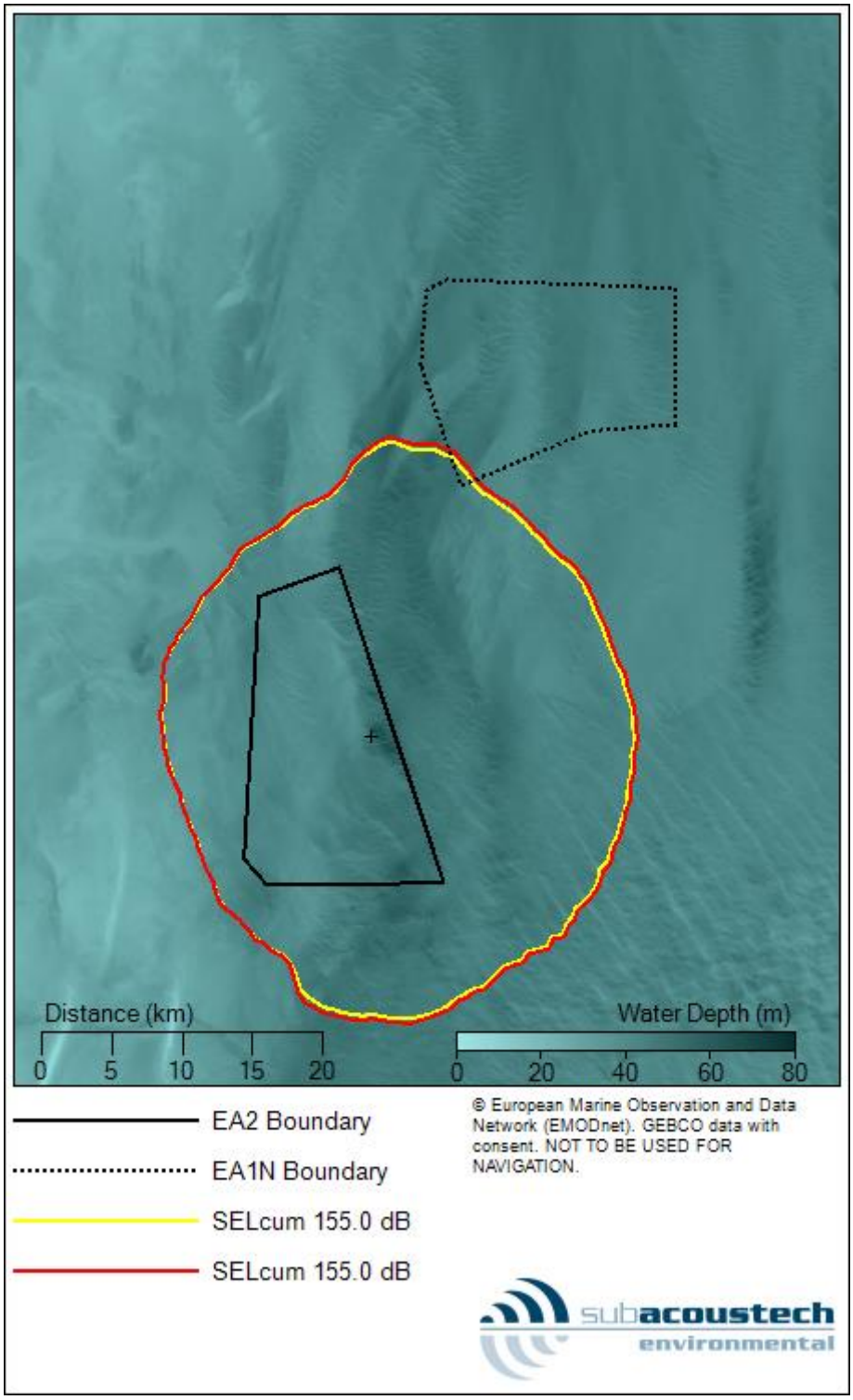

Figure 1 Contour plot showing the PTS ranges for High Frequency Cetaceans (HF) at EA2. The yellow contour represents the noise from a single pile installation, and the red contour represents the noise from four piles, installed sequentially.

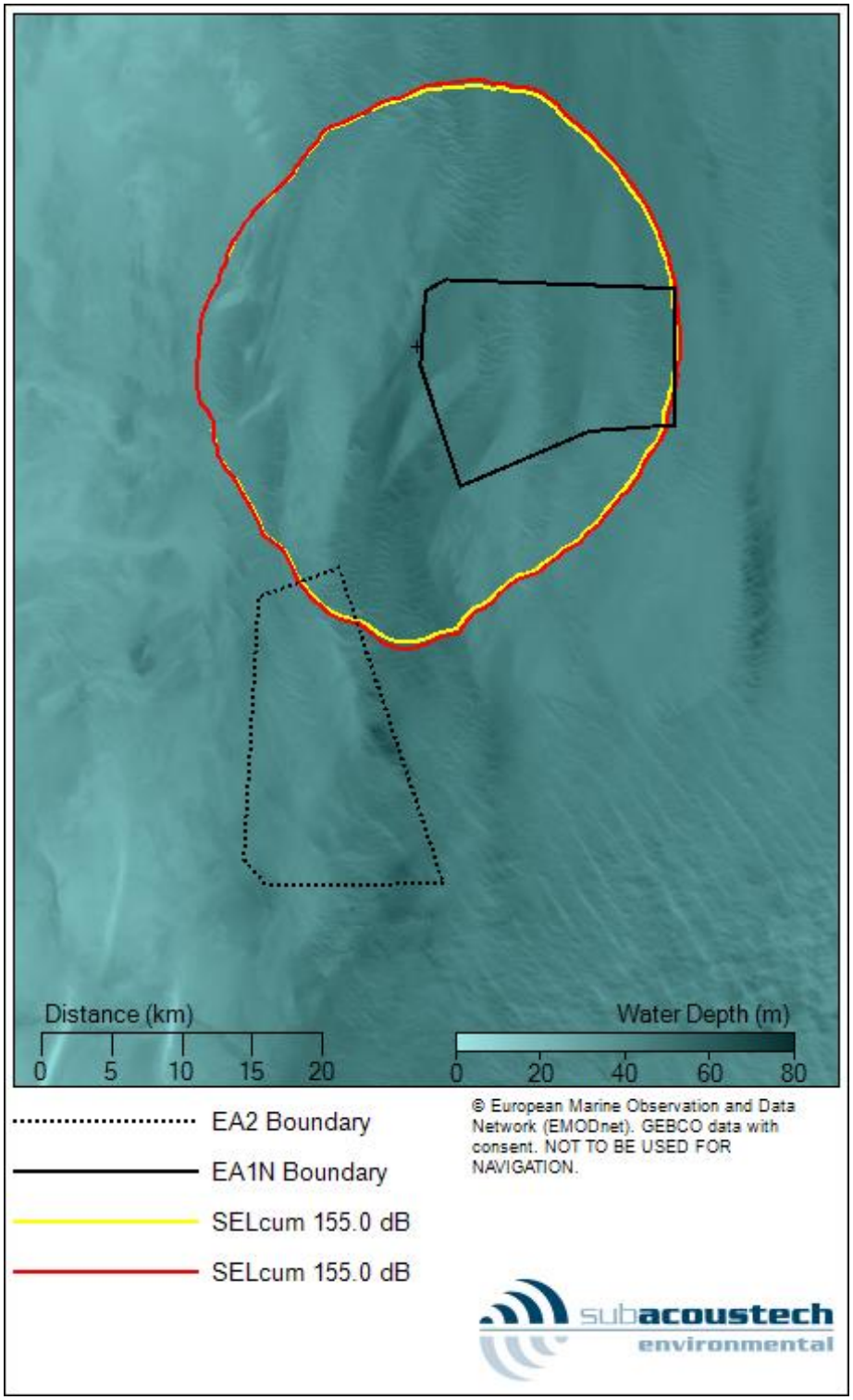

Figure 2 Contour plot showing the PTS ranges for High Frequency Cetaceans (HF) at EA1N. The yellow contour represents the noise from a single pile installation, and the red contour represents the noise from four piles, installed sequentially.

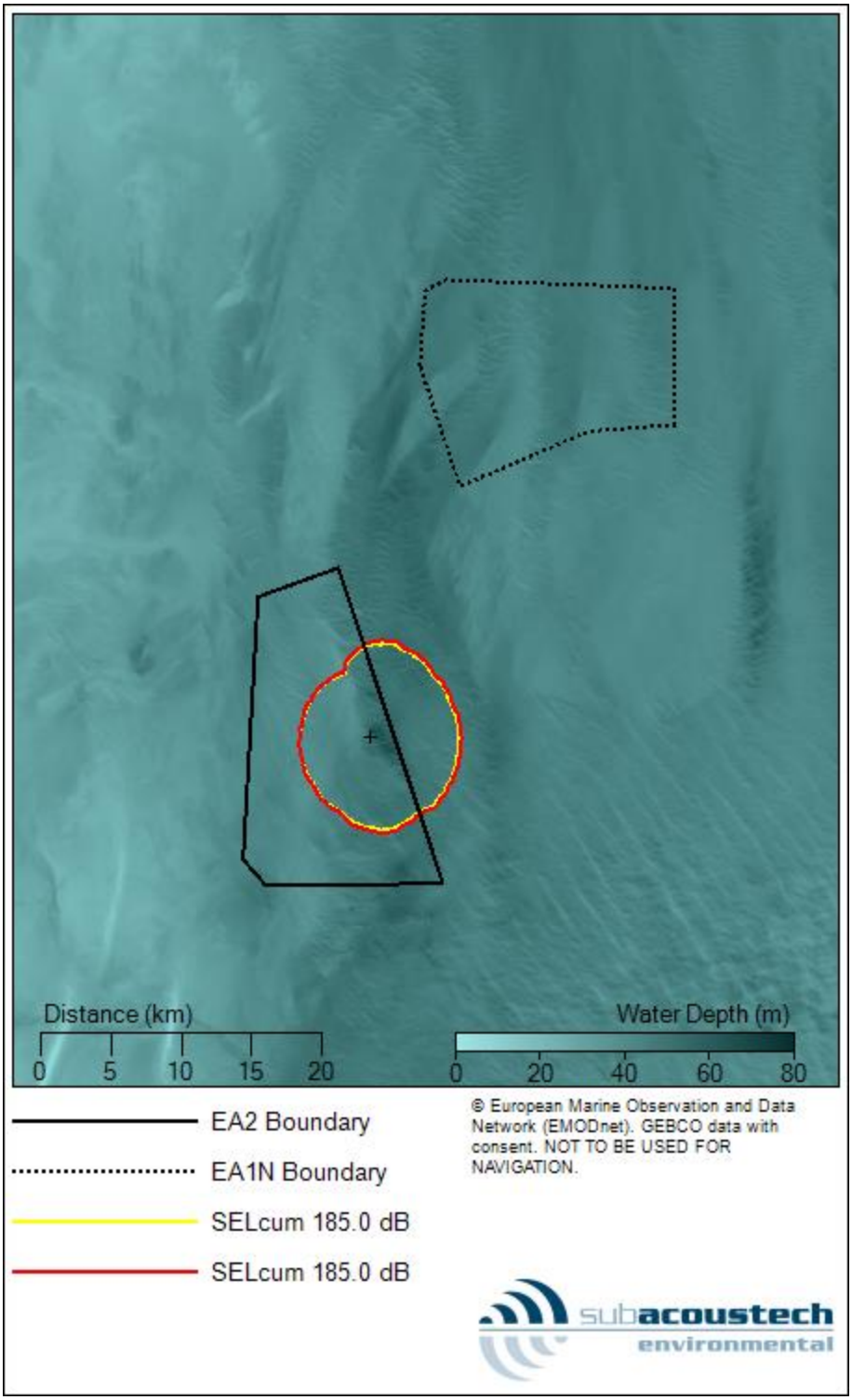

Figure 3 Contour plot showing the PTS ranges for Pinnipeds (in water) (PW) at EA2. The yellow contour represents the noise from a single pile installation, and the red contour represents the noise from four piles, installed sequentially.

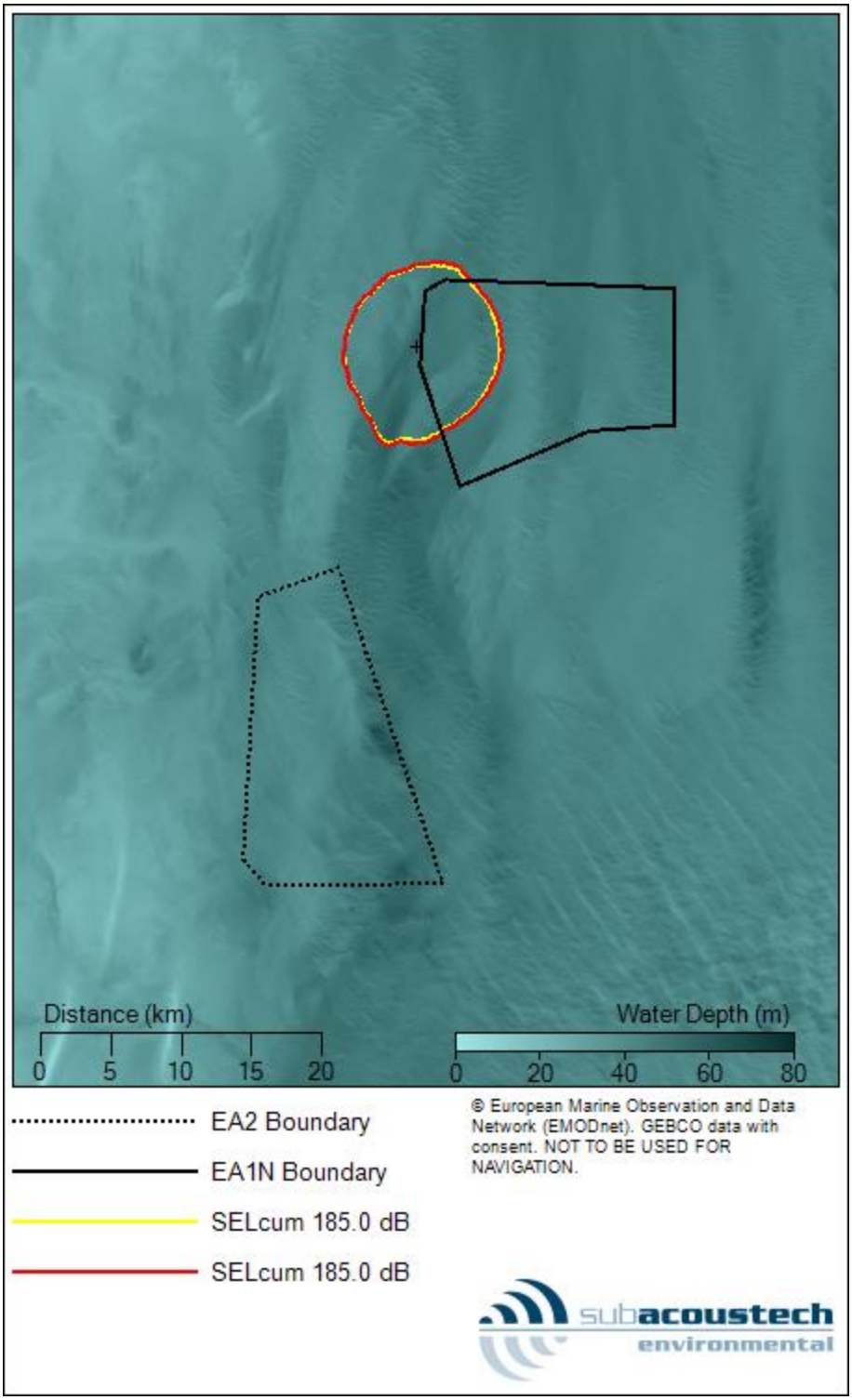

Figure 4 Contour plot showing the PTS ranges for Pinnipeds (in water) (PW) at EA2. The yellow contour represents the noise from a single pile installation, and the red contour represents the noise from four piles, installed sequentially.