Rampion 2 Wind Farm

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Underwater Noise Study for Sea Bream Disturbance

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Author	**Matt Burlington** **Tim Mason**
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1. Introduction

There is continuing concern regarding the potential for materially significant disturbance to black seabream (*Spondyliosoma cantharus*) during their nesting season, caused by underwater noise produced during impact piling for turbine foundations at the Rampion 2 OWF.

Acoustic disturbance can only occur to an individual of a species when it is audible. At a minimum, an introduced noise must be:

a) above the individual's hearing threshold, and

b) exceeding the existing background noise.

Other context-dependent conditions will also apply.

It is recognised that noise from piling during the installation of foundations at Rampion 2 will create noise in the surrounding water and this could lead to disturbance. Background underwater noise monitoring was undertaken at the Kingmere MCZ, a known habitat for black seabream nesting. The establishment of a baseline, the typical ambient noise levels from existing noise sources, and the application of known and modelled pile driving noise together, combined with data from relevant noise impact articles in the literature, is intended to help identify an appropriate disturbance threshold

2. Black seabream and fish reactions

Black seabream hearing sensitivity

No known audiogram is available for black seabream. However, red seabream (*Pagrus major*) is in the same family, *Sparidae*. An audiogram (using Auditory Evoked Potential (AEP) and behavioural techniques) was measured by Kojima *et al.* (2010) for this species and provides the best available proxy. It is believed that this species would be in Group 3 of the hearing categories for fishes identified by Popper *et al.* (2014), fishes with swim bladders that are close, but not intimately connected, to the ear. These fishes are sensitive to both particle motion and sound pressure, but will be less sensitive to noise than those in Group 4. No particle motion audiogram is available for either species.

Behavioural audiograms tend to provide the best indication of the noise to which a fish is sensitive in practice. Seabream appear to have peak hearing sensitivity in the 300-500 Hz bands.

Fish reaction to noise

Studies over the last five to ten years have looked at reactions of fish to noise stimulus. Generally speaking these have shown reactions to a specific, controlled-level noise source but rarely with appropriate consideration of the stimulus noise level above the ambient noise present.

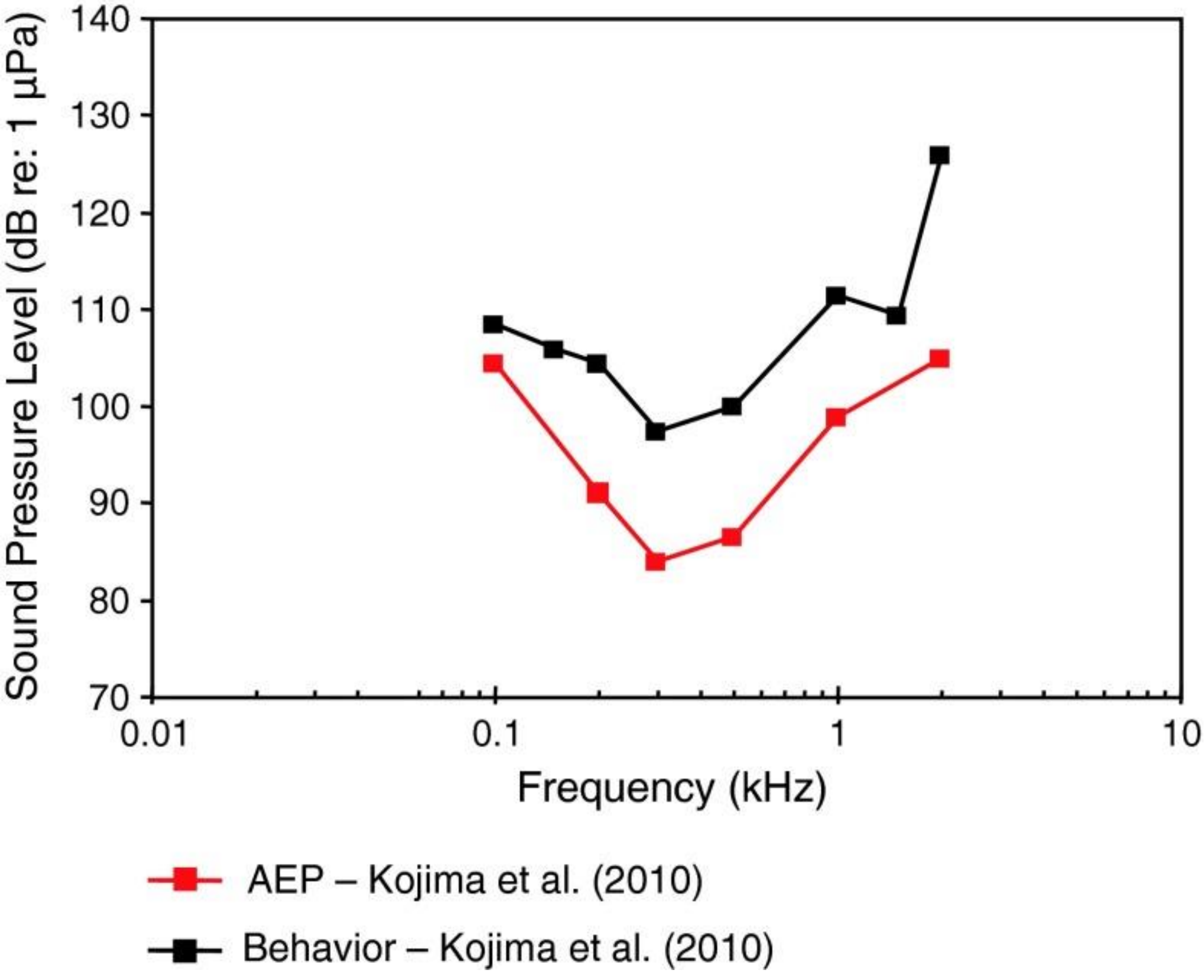

Figure 1- Red seabream audiograms, after Kojima et al (2010)

3. Ambient underwater noise at Kingmere MCZ

A 15-day continuous background noise survey was undertaken at the nearest edge of the Kingmere MCZ to the Rampion 2 boundary, representing the conditions at the point where in theory the noise from piling could be greatest. The survey was undertaken between 4th July 2022 and 19th July 2022 and captured the full range of high tides and low tides from springs to neeps. The location of the hydrophone for the survey is shown in **Figure 2**.

The purpose of this survey was to demonstrate the background noise levels to which resident seabream are already exposed, and to establish a baseline for any new noise (such as from impact piling).

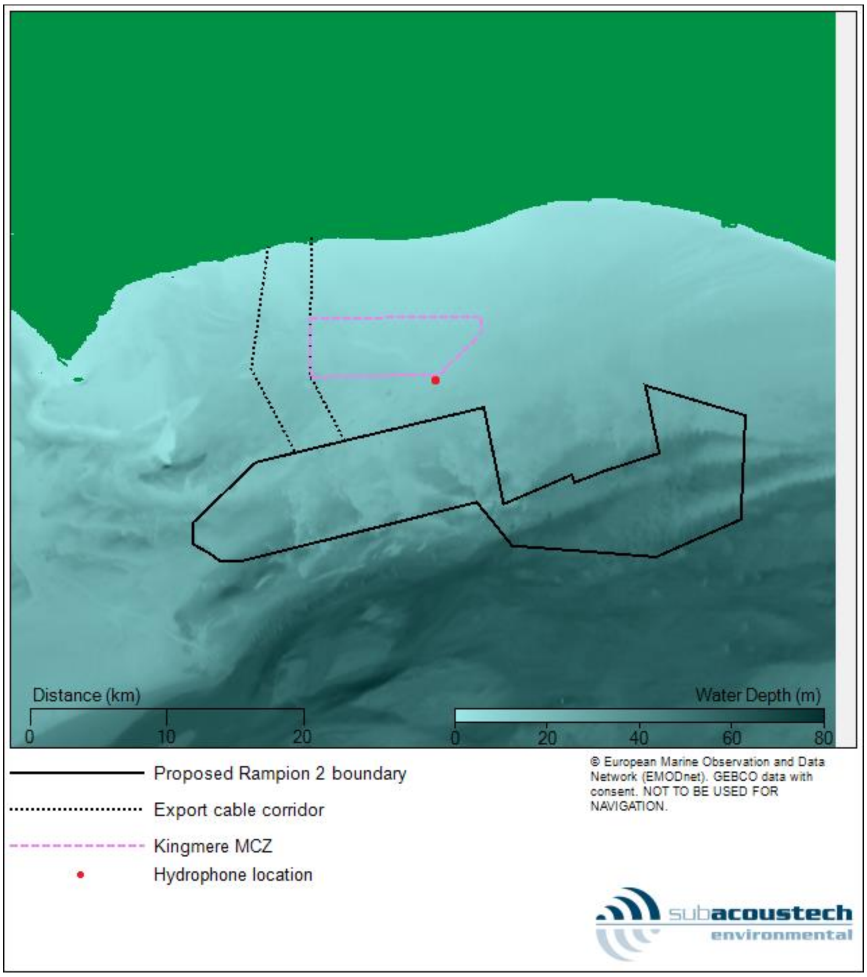

Figure 2 – Kingmere MCZ boundary and recorded hydrophone location

Figure 3 presents the background noise levels sampled over the 15-day period, with a 1-minute resolution. This includes the SPL_{RMS} (underlying noise level) and SPL_{peak} (highest noise level within sample period).

Clear cyclical variations can be seen in the data, driven by tides: the periods of high tidal flow lead to the highest background noise in a day. It is acknowledged that this will include some contribution from the currents acting on the mooring, the data was subjected to a 20 Hz high-pass filter to reduce this effect. A typical minimum background noise level during low tidal flow periods was 103 dB SPL_{RMS}, whereas during periods of high tidal flow the background level commonly exceeded 120 dB SPL_{RMS}.

As no underwater noise data has been previously collected at Rampion 2, a spot measurement taken during the Rampion 1 met mast installation of 117 dB SPL_{RMS} had been presented to the SNCBs as an estimated background noise level. This survey shows that the estimated noise level was a reasonable estimate.

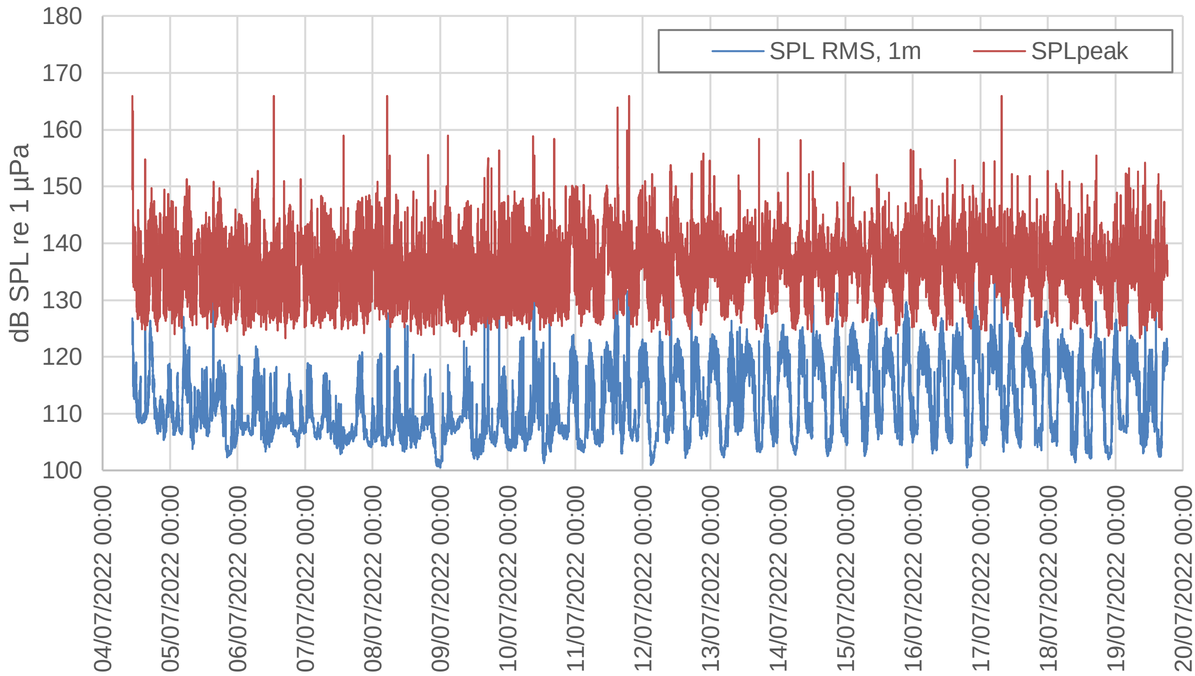

Figure 3- Baseline underwater noise levels

The peak noise levels naturally occurring were normally in excess of 140 dB SPL_{peak}, and exceeded 160 dB SPL_{peak} at multiple times on any given day.

4. Soundscape at Kingmere MCZ

The existing noise at the Kingmere MCZ monitoring location was generally either caused by tidal flows or passing vessels. Critical to audible sound is not just overall level, but also frequency, and **Figure 4** shows the spectra derived from events at Kingmere over the sampled period.

It is clear that the effect of the tides is at low frequency <100 Hz. Passing vessels increase noise across the spectrum, to 1000 Hz, and beyond if the source is loud. Three spectra shown are for recorded vessels, likely of different types or distances from the hydrophone: the highest level is from a loud vessel of a sort that was observed passing through the region generating these noise levels once or twice a day on average. The 'typical boat' was seen four or five times a day; 'quiet boats' are frequently in the background. It is not possible to determine any specific information on the boats or their distance from this data.

Also included on this chart is the seabream behavioural audiogram. This shows that the low/high flow background noise in the absence of vessels is below the seabream hearing threshold, and therefore inaudible. More importantly, this means the reference for disturbance should rightly be the seabream hearing threshold rather than the background noise level.

The "loud vessel" is approximately only 25 dB above the seabream hearing threshold. This implies that as a result of the seabream sensitivity, the "loud vessel" would be audible to the fish but is unlikely to be perceived as "loud".

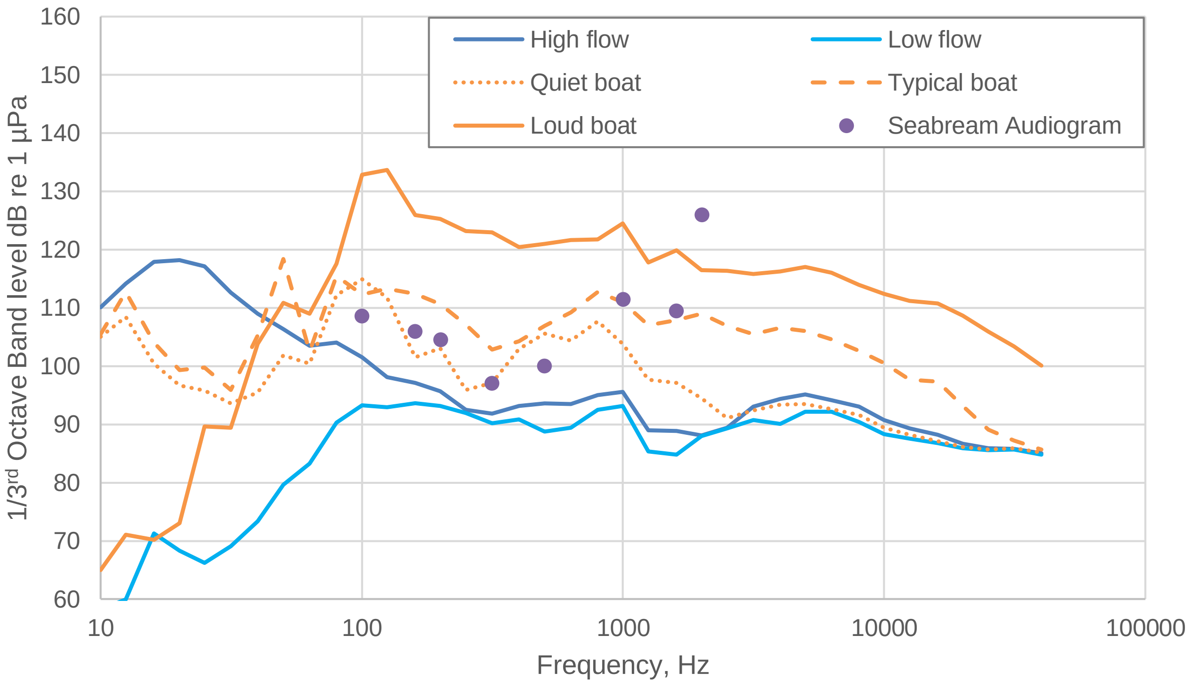

Figure 4- Typical noise spectra for various conditions at Kingmere

5. Impact of piling noise at Kingmere MCZ

In order to understand the potential impacts of noise from piling, the typical ambient noise levels from **Figure 4** and overlayed pile strikes previously measured from monopile installation at the Burbo Bank Extension OWF from 4,100 m and 7,800 m (piling was unmitigated) were used. This is shown in **Figure 5**. 4,100 m was chosen as it represented the measured noise data that was closest to the distance of the actual closest point of the Kingmere MCZ to the Rampion 2 boundary, with 7,800 m close to double that distance. The seabream audiogram is also included.

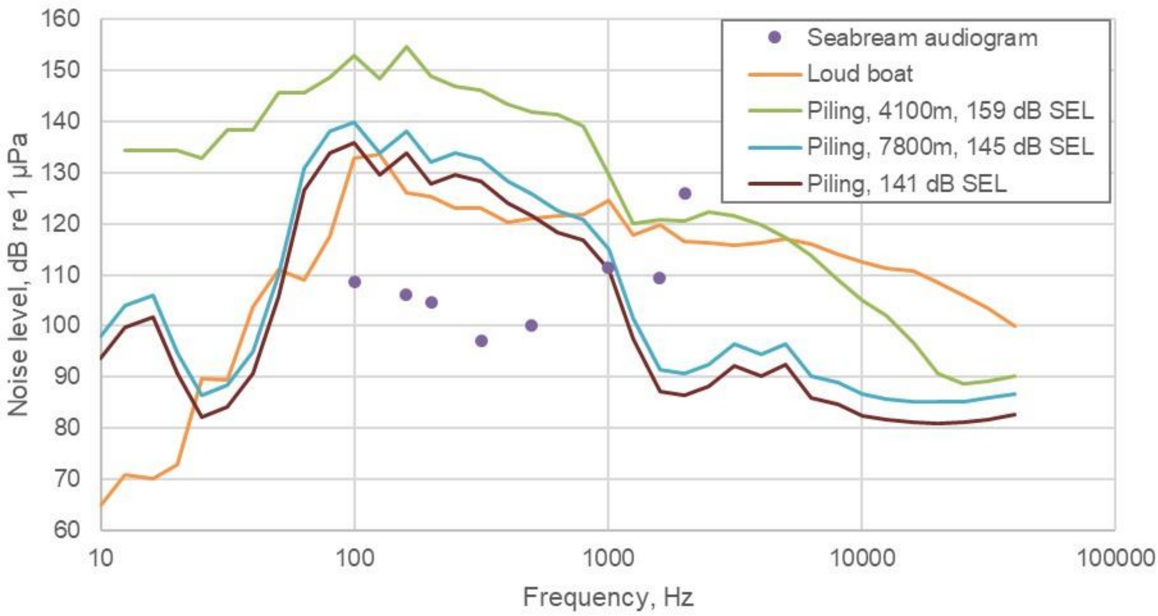

Figure 5- Kingmere MCZ "loud boat", seabream audiogram, and example measured pile strikes, 1/3rd octave band centre frequency noise spectra

Typically, the SEL_{ss} is of a similar magnitude to the SPL over the same period so indicative comparisons between the SEL and audiogram can be made. The average single strike Sound Exposure Level (SEL_{ss}) of the strike spectrum at 4100 m was 159 dB SEL_{ss} and nearly 50 dB above the seabream hearing threshold. The pulse at 7800 m is roughly 14 dB quieter, 145 dB SEL_{ss}.

Rampion Extension Development (RED) have previously suggested that a mitigated piling noise level of 147 dB SEL_{ss} as appropriate to avoid the risk of significant disturbance to the fish species. This was based on research by Radford *et al*. (2016)[1] which showed a stress

[1] Radford, A. N., Lebre, L., Lecaillon, G., Nedelec, S. L., and Simpson, S. D. (2016). Repeated exposure reduces the response to impulsive noise in European seabass. Global Change Biol. 22, 3349–3360, doi: 10.1111/gcb.13352

response (increased ventilation) in seabass (of the same order as seabream) to simulated pile driving noise at 147 dB SEL_{ss}. This proposed threshold was rejected by Natural England.

Research by Kastelein *et al.* (2017)[2] concluded that seabass exhibited an initial reaction to impulsive noise at levels of 141 dB SEL_{ss} but that this was short lived and there was there is no evidence for any consistent sustained response. The study concluded that there are there are unlikely to be any adverse effects on their ecology. As a result, 141 dB SEL_{ss} has been suggested as representing an alternative underwater noise piling disturbance threshold.

The findings of Radford *et al.* (2016) and Kastelein *et al.* (2017) may be considered to be at different points along a spectrum of possible behavioural effects, with Radford finding a slight physiological stress response at 147 dB and Kastelein finding only an initial startle response at 141 dB. It seems reasonable to suggest that the threshold at which a behavioural response would constitute a genuine disturbance may lie somewhere between 141 and 147 dB.

An additional frequency spectrum has been included on **Figure 5** that adjusts the 7800 m pile strike down to an equivalent noise level of 141 dB SEL_{ss}. It can be seen that this is only slightly higher than the “loud boat” spectrum. Therefore, at approximately 30 dB above the hearing threshold, it is anticipated that the risk of sustained disturbance is low. The calculated noise level for this would be worst case (maximum hammer energy)

Underwater noise modelling has been undertaken to investigate the propagation of underwater noise from piling on the northern boundary of the Rampion 2 site. Various noise attenuations have been applied, representing noise mitigation devices. The results are shown in **Figure 6**.

Due to the vicinity of the edge of the site to Kingmere MCZ, mitigation may still be necessary to reduce the underwater noise to 141 dB SEL within the closest proximity array area to the MCZ.

Note the attenuations suggested are only intended as indicative targets to be determined with detailed future investigation based on site specific conditions and parameters.

The following generic performances of mitigation options being explored are offered as a guide (although other emergent technology and suppliers may also be considered, prior to any commitment to which if any mitigation would be applied):

- IHC Pulse hammer (4-6 dB reduction)
- MENCK MNRU hammer (9-11 dB reduction)

[2] Kastelein RA, Jennings N, Kommeren A, Helder-Hoek L, Schop J. Acoustic dose-behavioral response relationship in sea bass (Dicentrarchus labrax) exposed to playbacks of pile driving sounds. Mar Environ Res. 2017 Sep;130:315-324. doi: 10.1016/j.marenvres.2017.08.010. Epub 2017 Aug 31. PMID: 28874258.

- Double bubble curtain (potential 15 dB reduction)
- Double bubble curtain and MENCK MNRU hammer (potential 25 dB reduction)

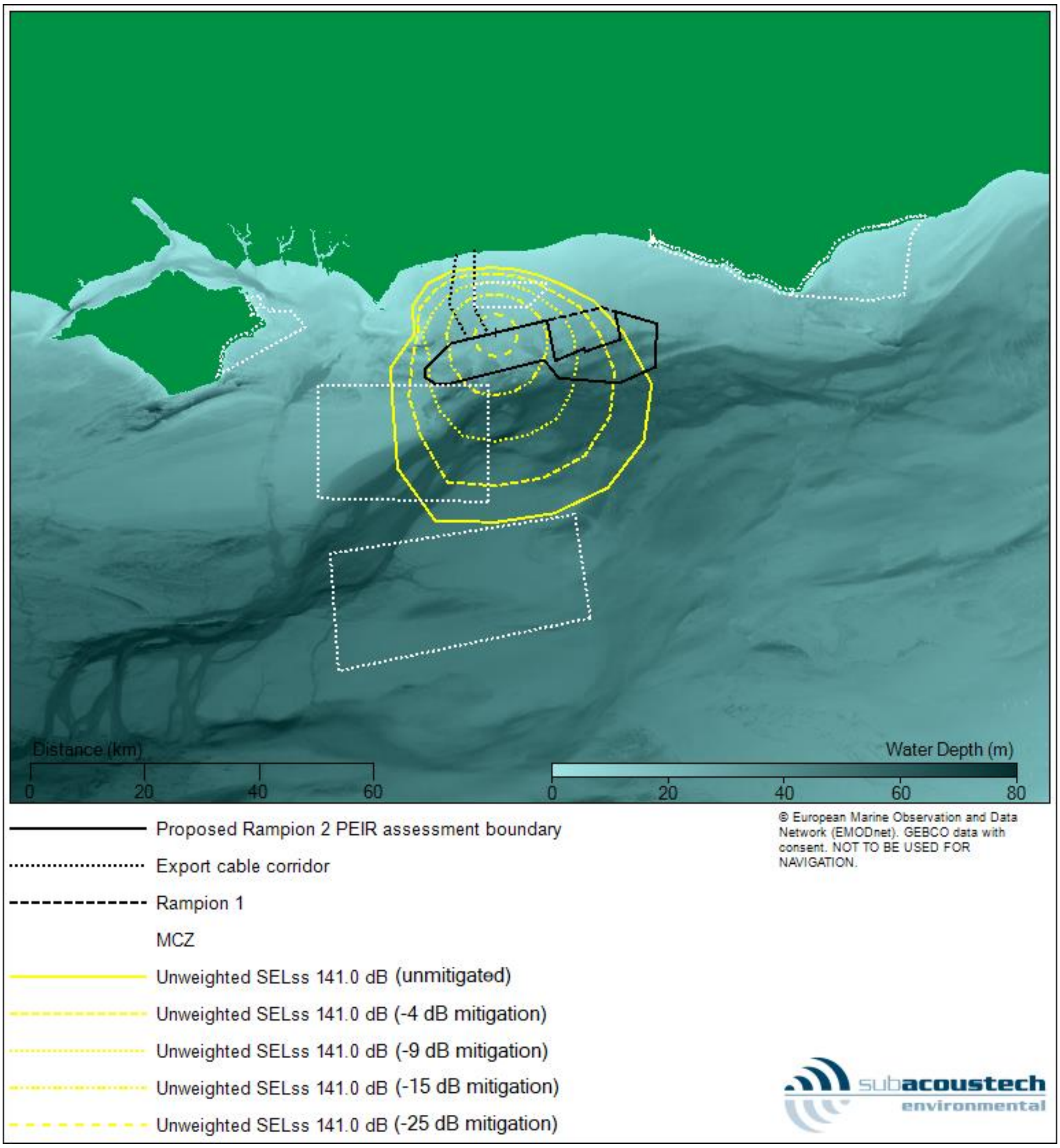

Figure 6– INSPIRE Light Noise modelling for 141 dB SEL pile strike, with various mitigations

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