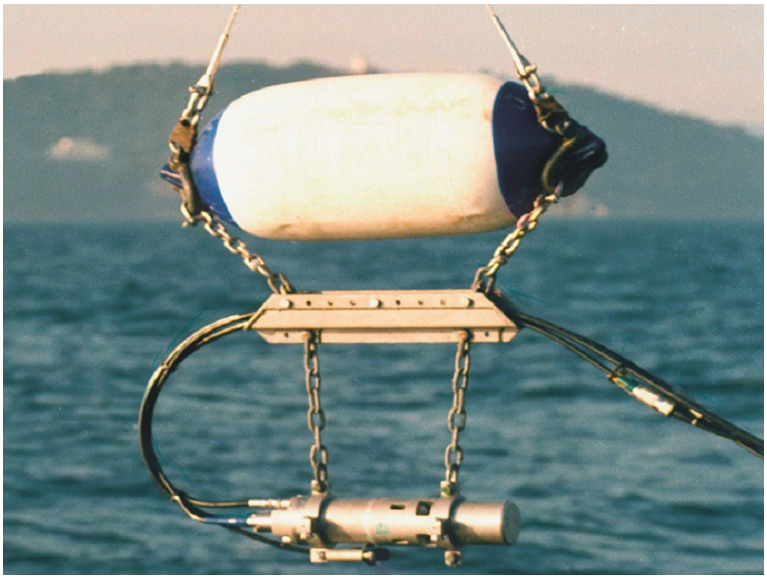
Extension of seismic survey at Energy Island North Sea

Assessment of impact on marine mammals from surveys with a 40 cu-inch airgun

Scientific briefing from DCE – Danish Centre for Environment and Energy

Date: 22 August 2022 | **54**



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Data sheet

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Subtitle: Assessment of impact on marine mammals from surveys with a 40 cu-inch air-gun

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External comment: EnerginetDK. The comments can be found here: http://dce2.au.dk/pub/komm/N2022_54_komm.pdf

Claimant: EnerginetDK

Please cite as: Tougaard, J. 2022. Extension of seismic survey at Energy Island North Sea. Assessment of impact on marine mammals from surveys with a 40 cu-inch airgun. Aarhus University, DCE - Danish Centre for Environment and Energy, 9 s. – Scientific briefing no. 2021|54 https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2022/N2022_54.pdf

Front page photo: Mini-G airgun. Source: Sercel

Number of pages: 9

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1 Background

EnerginetDK plans to conduct a seismic survey in the Danish North Sea, in the survey area designated for the Energy Island North Sea (see map). The survey is planned to be conducted with a 20-40 cu-inch airgun (Mini G Gun). Shot frequency is expected to be one shot every 5 seconds. Shooting is planned along 9 transects, eight in the proposed location of the artificial island and one line connecting to the Ida-1 drilled well for stratigraphic alignment. Total transect line is about 120 km on effort, which is expected to be conducted in 3 days with a survey speed of 4 knots.

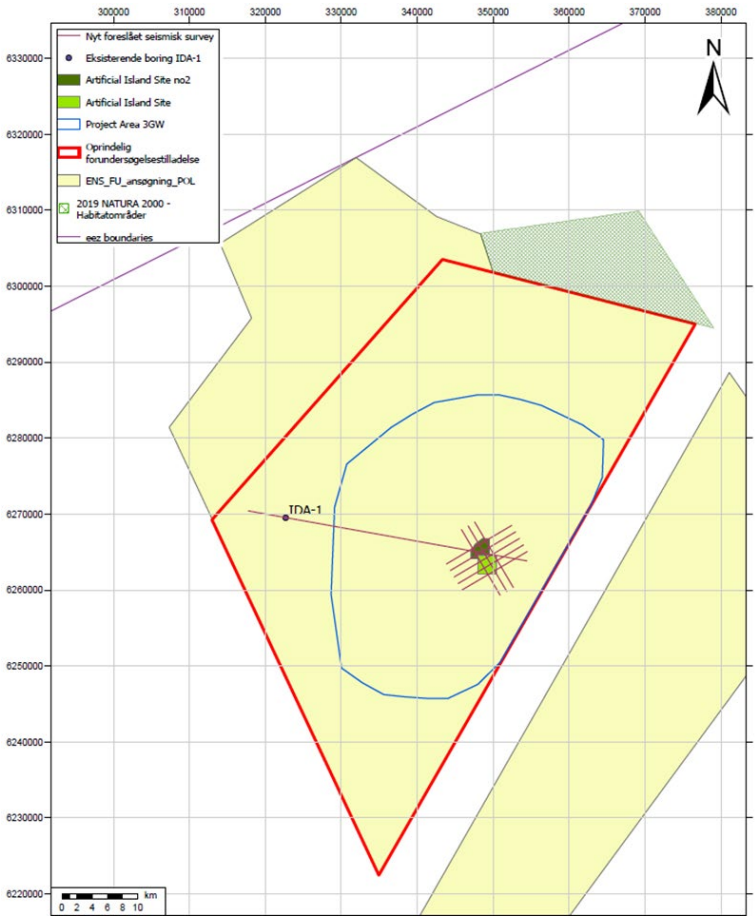

Figure 1.1. Proposed survey layout inside the Energy Island project area (yellow), with the survey transect lines indicated as purple lines. Source: EnerginetDK

Five different species of marine mammals can be expected to be encountered in the survey area: harbour porpoise (marsvin), whitebeaked dolphin (hvidnæse), minke whale (vågehval), harbour seal (spættet sæl) and grey seal (gråsæl) (Tougaard et al., 2020). The possible impact on these species, in terms of injury and disturbance, is assessed below. Risk of injury, by the criterion of risk of infliction of minimal hearing loss, is assessed for all species, whereas the potential impact of disturbance is restricted to cetaceans, all included on the EU habitats directive annex 4 (European Commission, 2008). Seals are only listed on annex 2, which mandates establishment of habitat (Natura2000) areas. As there are no Natura2000 areas with seals as part of the designation within tens of km from the proposed survey site, behavioural disturbance of seals have not been assessed.

2 Injrury and hearing loss

The risk of injury is assessed by considering the acoustic exposure required to induce minimal permanent threshold shift (PTS), which is considered a precautionary criterion for acoustic injury (Southall et al., 2007; Southall et al., 2019; Tougaard, 2021b). Thresholds for the five different marine mammals are given by Tougaard (2021b), derived from Southall et al. (2019) and listed in Table 2.1. Thresholds are expressed as cumulative sound exposure level (SEL), which is the summed acoustic energy of all airgun pulses received by an animal over the duration of the encounter with the survey.

Table 2.1. Thresholds for onset of permanent threshold shift (PTS) in species of marine mammals relevant to the survey

Species	Frequency weighting	Threshold (dB re 1μPa^{2}s)
Harbour porpoise	VHF	155
White-beaked dolphin	HF	185
Minke whale	LF	183
Harbour and grey seal	PCW	185

5Unweighted SEL of a single pulse of a similar sized airgun (Sleeve gun 40-I, Haliburton) was measured by Hermannsen et al. (2015) to be 159 dB re 1 μPa^{2}s (unweighted) at a distance of 120 m from the airgun and the corresponding frequency weighted levels for porpoises and seals were 122 dB re 1 μPa^{2}s and 138 dB re 1 μPa^{2}s, respectively[1], also at a distance of 120 m. See Figure 2.

Assuming that subsequent pulses are of similar amplitude the summed acoustic energy, SEL_{cum}, over N pulses is given as:

$$SEL_{cum} = SEL_{SS} + 10\log_{10} N \qquad \text{Eqn. 1}$$

where SEL_{SS} is the SEL of a single pulse. Eqn. 1 can be rearranged to make it possible to solve it for N, such that SEL_{cum} equals the PTS threshold means that the number of pulses required to induce minimal PTS at a distance of 120 m from the airgun can be estimated for seals and porpoises.

$$N = 10^{(SEL_{PTS\ onset} - SEL_{SS})/10} \qquad \text{Eqn. 2}$$

For porpoises, 1,600 pulses are required to reach the PTS threshold and for seals, 50,000 pulses are required. As one pulse is generated approximately every 5 seconds, it is considered completely unlikely that a porpoise or a seal would ever be exposed to sound exposure levels capable of inducing permanent hearing loss in the animals, as this would require the animals to remain very close to the survey vessel for prolonged periods. For the porpoise, the time it would take to accumulate sufficient acoustic energy to reach the PTS onset threshold at a distance of 120 m is more than 2 hours and significantly longer for the seal.

[1] These values were weighted with inverted audiograms, which is qualitatively similar to the VHF and PCW frequency weighting curves recommended by Southall et al. (2019) and Tougaard (2021). Absolute values are likely to differ by some dB, unlikely to be large enough to affect conclusions.

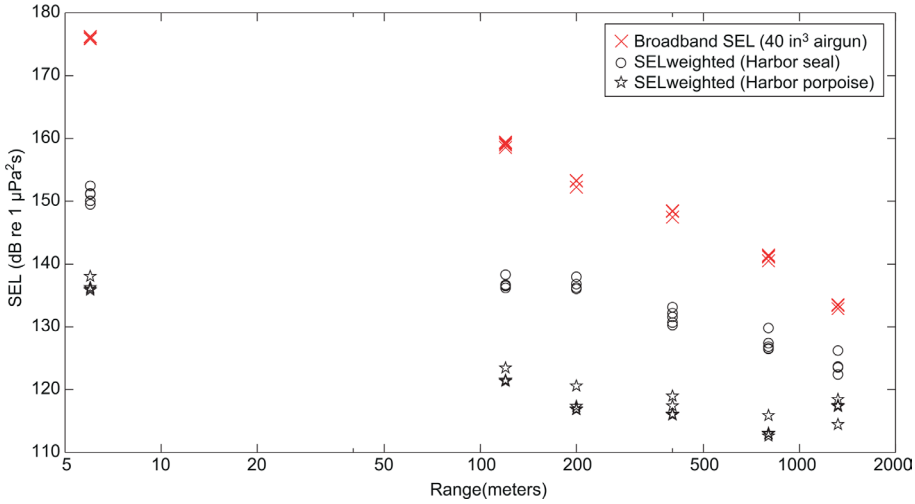

Figure 2.1. Measured single pulse sound exposure level (SEL_{SS}) at different distances from the airgun. Unweighted, and audiogram-weighted values are given. From Hermannsen et al (2015).

Similar estimates can be made for whitebeaked dolphins and minke whales, but in the absence of frequency weighted measures of the airgun signal, this has not been done. Instead it is assumed that the harbour porpoise is the most sensitive of the five species (commonly accepted, see e.g. Southall et al., 2019) and assessment is based on this species.[2]

In summary, it is assessed that it would be unlikely for any of the five species of marine mammals to remain close enough to the airgun for a sufficient length of time to be at risk of acquiring permanent hearing damage. **The risk of the survey thus inflicting injury to marine mammals is considered negligible.**

[2] The LF frequency weighted SEL_{SS} is likely to be very close to the unweighted level, as most of the energy in an airgun pulse is present in the assumed range of best hearing for baleen whales. This means that we can use the unweighted SELSS as a precautionary proxy. If this is done, the PTS onset threshold is reached after about 400 pulses, equal to 30 minutes of exposure at a distance of 120 m from the airgun.

3 Behavioural disturbance

Behavioural disturbance is in itself not harmful to the animals. Significant impact occurs if sufficient animals are disturbed or displaced for a sufficient amount of time. Thus, the potential impact can be roughly estimated by knowing the reaction distance to the airguns. From the reaction distance, the impacted area can be found and together with estimates of animal densities and the duration of the disturbance the magnitude of the impact can be assessed.

3.1 Harbour porpoise

Behavioural reaction distances for porpoises have been shown to be well predicted by the frequency weighted sound pressure level, calculated over the equivalent of the auditory integration time of the animals (Tougaard, 2021a). If the VHF-weighted sound pressure level exceeds 103 dB re 1 µPa there is thus an increased likelihood of displacement of the animals.

(Hermannsen et al., 2015) do not give frequency weighted sound pressure levels for the airgun, but the frequency weighting factor (difference between weighted and unweighted) can be assumed to be the same for the SEL_{SS}, which are given. This weighting factor at 120 m distance is 37 dB. Thus, the weighted sound pressure level at 120 m amounts to 167 dB re 1µPa – 37 dB = 130 dB re 1 µPa VHF weighted.

To estimate the range at which the threshold of 103 dB re 1 µPa is reached, the transmission loss is modelled as $17\log_{10}(\text{range})$, whereby the range where received level equals 103 dB re 1 µPa is found as

$$r_{L_p=103} = 120m \cdot 10^{\frac{(130-103)}{17}} = 4{,}600\ m \qquad \text{Eqn. 3.}$$

This value can be compared to reaction distances for harbour porpoises measured during real seismic surveys. Two studies are available, one involving a 470 cu-inch array in Moray Firth, Scotland (Thompson et al., 2013), and a second involving a 3,600 cu-inch array in the central North Sea (Sarnocińska et al., 2020), i.e. significantly larger arrays than the single airgun in the present survey. Reactions to the 470 cu-inch array were observed 5-10 km from the survey ship, whereas reactions to the larger 3,600 cu-inch were observed 8-12 km away. Both studies, involving significantly larger sources, thus supports an estimated reaction range of nearly 5 km as a precautionary upper estimate.

Given that the survey is to be conducted in the open North Sea, well away from protected areas (Natura2000) and known aggregations of harbour porpoises, the temporary loss of less than 100 km² of habitat for the duration of the survey (3 days) is **assessed to constitute a minor impact** on harbour porpoises and without any significant long-term effects on the population of porpoises in the NE-North Sea.

3.2 Other cetaceans

There is very little empirical evidence available about the effect of seismic surveys on other species of cetaceans. Visual observations from the survey ships themselves show that both dolphins and minke whales respond to the surveys

(Stone et al., 2017; Stone and Tasker, 2006), but it is not possible to supply reaction thresholds or reaction distances. Fin whales in the Mediterranean have been shown to react to pile driving noise, not unlike air gun noise, at distances of more than 100 km (Borsani et al., 2008). However, given that the expected densities of both minke whales and white-beaked dolphins are significantly smaller than for porpoises, the absolute number of animals disturbed by the seismic survey, combined with the short period of disturbance, means that **the impact on these species through displacement/disturbance is assessed as minor to negligible.**

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