Stiftung Tierärztliche Hochschule Hannover
University of Veterinary Medicine Hannover, Foundation

Institute for Terrestrial and Aquatic Wildlife Research (ITAW)

Effects of multiple exposure to pile-driving noise on harbour porpoise hearing during simulated flights

Tobias Schaffeld, Joseph Schnitzler, Johannes Baltzer, Benno Woelfing, Andreas Ruser, Ursula Siebert

The North Sea...

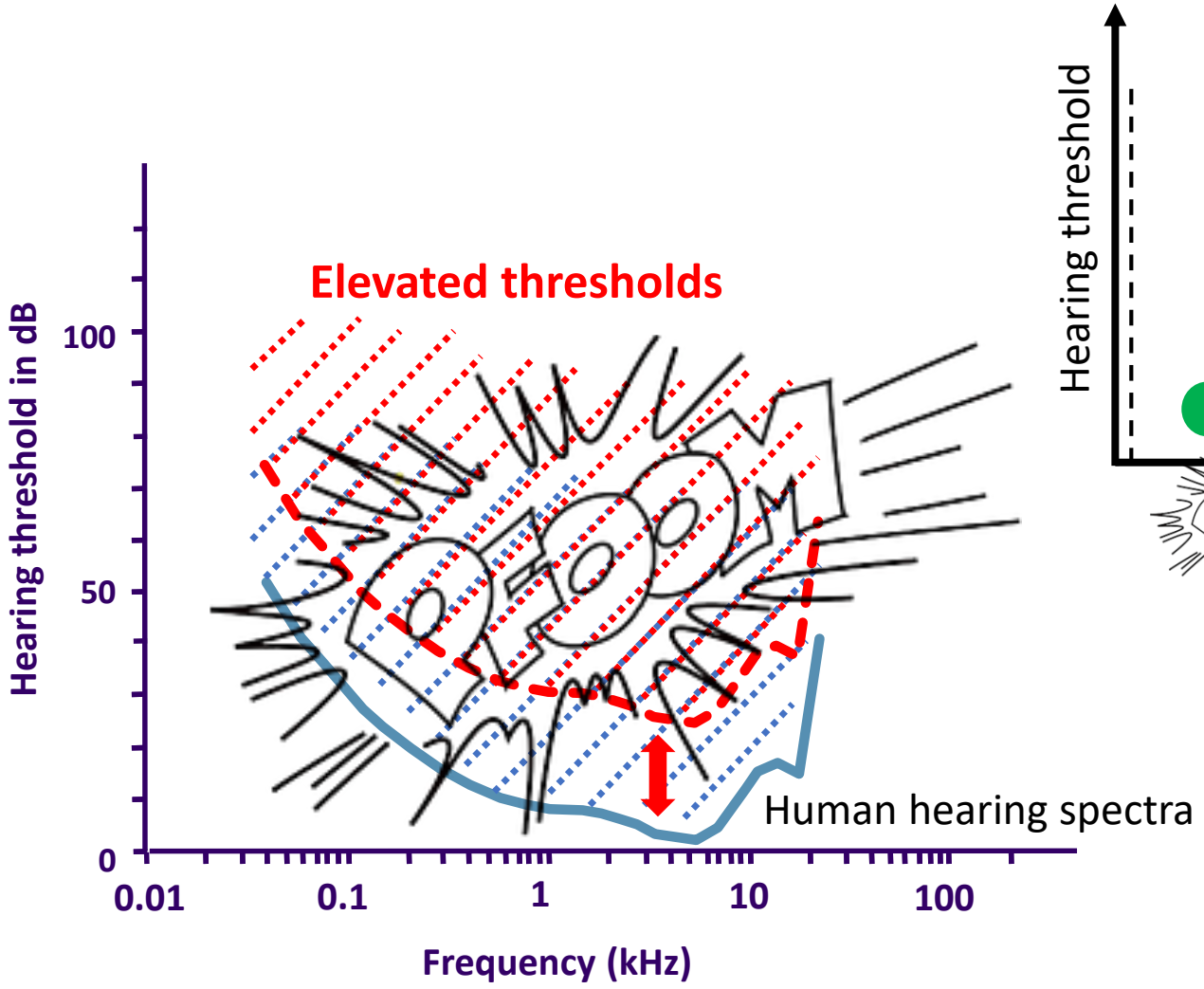
https://commons.wikimedia.org/wiki/File:2012-05-13_Nordsee-Luftbilder_DSCF8888.jpg

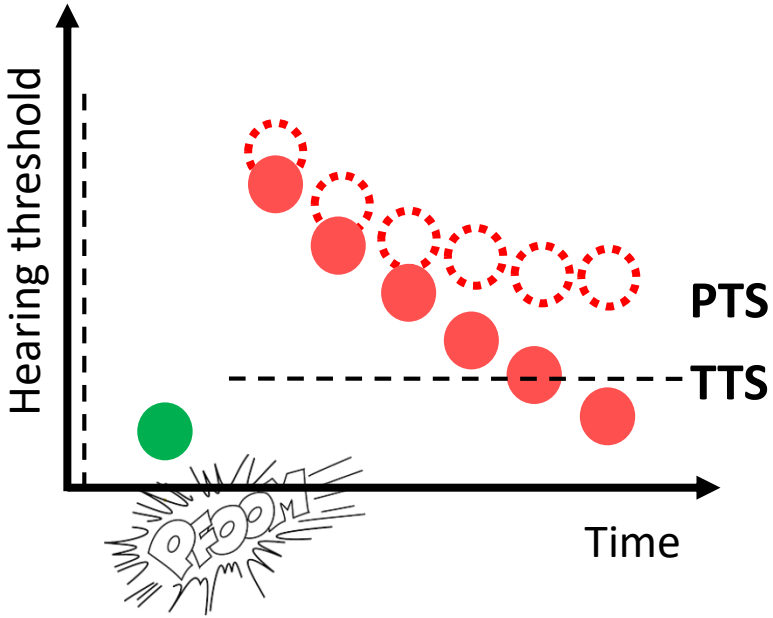
https://commons.wikimedia.org/wiki/File:Ecomare_-_bruinvis_Michael_in_2015_(bruinvis-michael2015-9313-sw).jpg

- The wind farms in the North Sea make an important contribution to achieving the European renewable energy targets.

- considered vulnerable because of high by-catch levels and increasing sound pollution.
- protected by both national and EU law.

Temporary Threshold Shift (TTS) is regarded as injury





- TTS is regarded as injury and therefore prohibited by law

TTS risks of multiple pile-driving strikes:

- Research on TTS has been focussed mainly on exposure to single impulsive sounds and little is known about the cumulative effects of exposure to intermittent sounds.
- Experiments with bottlenose dolphins showed the potential for accumulation of SEL from multiple exposures and for recovery of hearing during the quiet intervals between exposures (Finneran *et al.* 2010).

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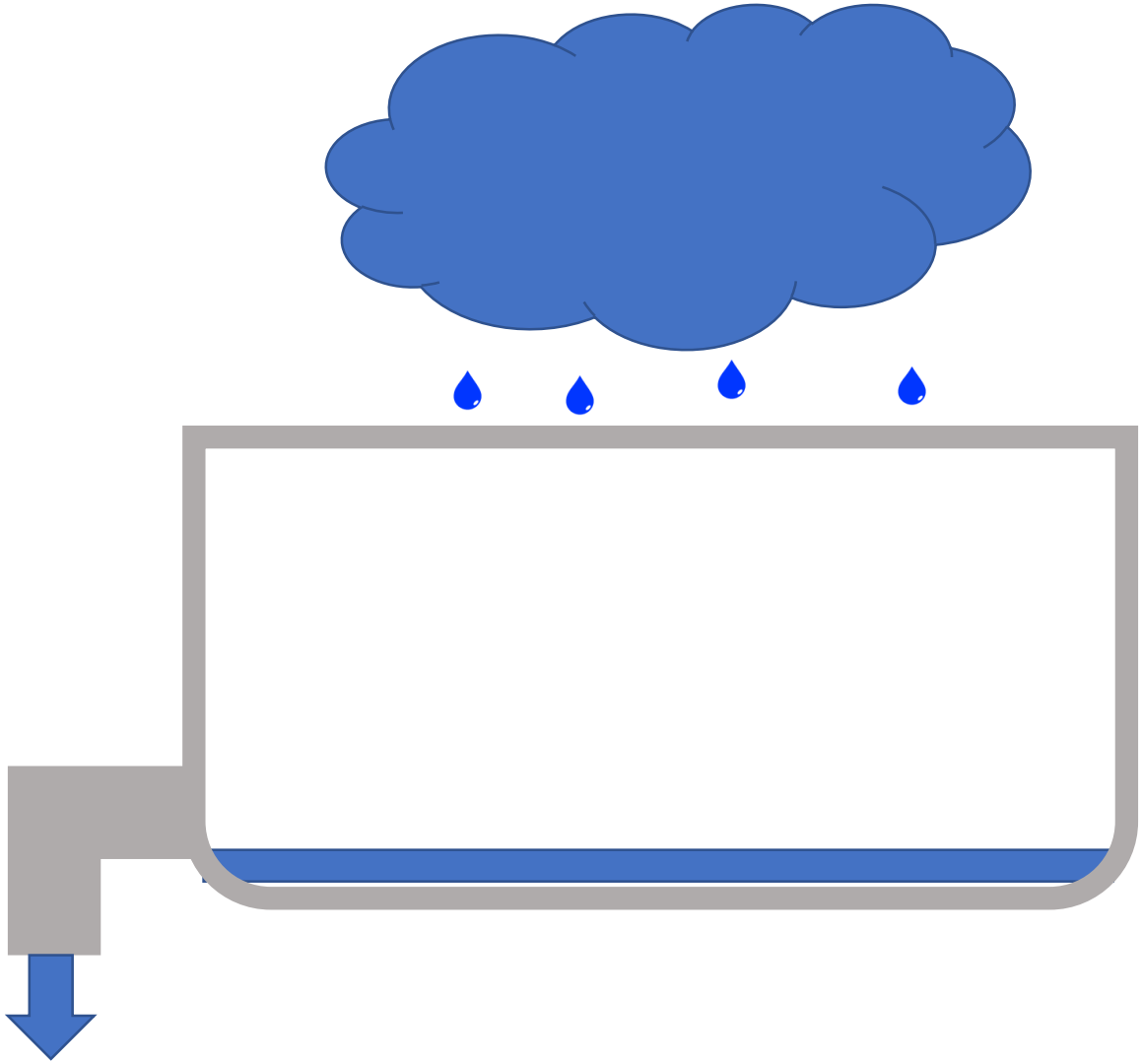

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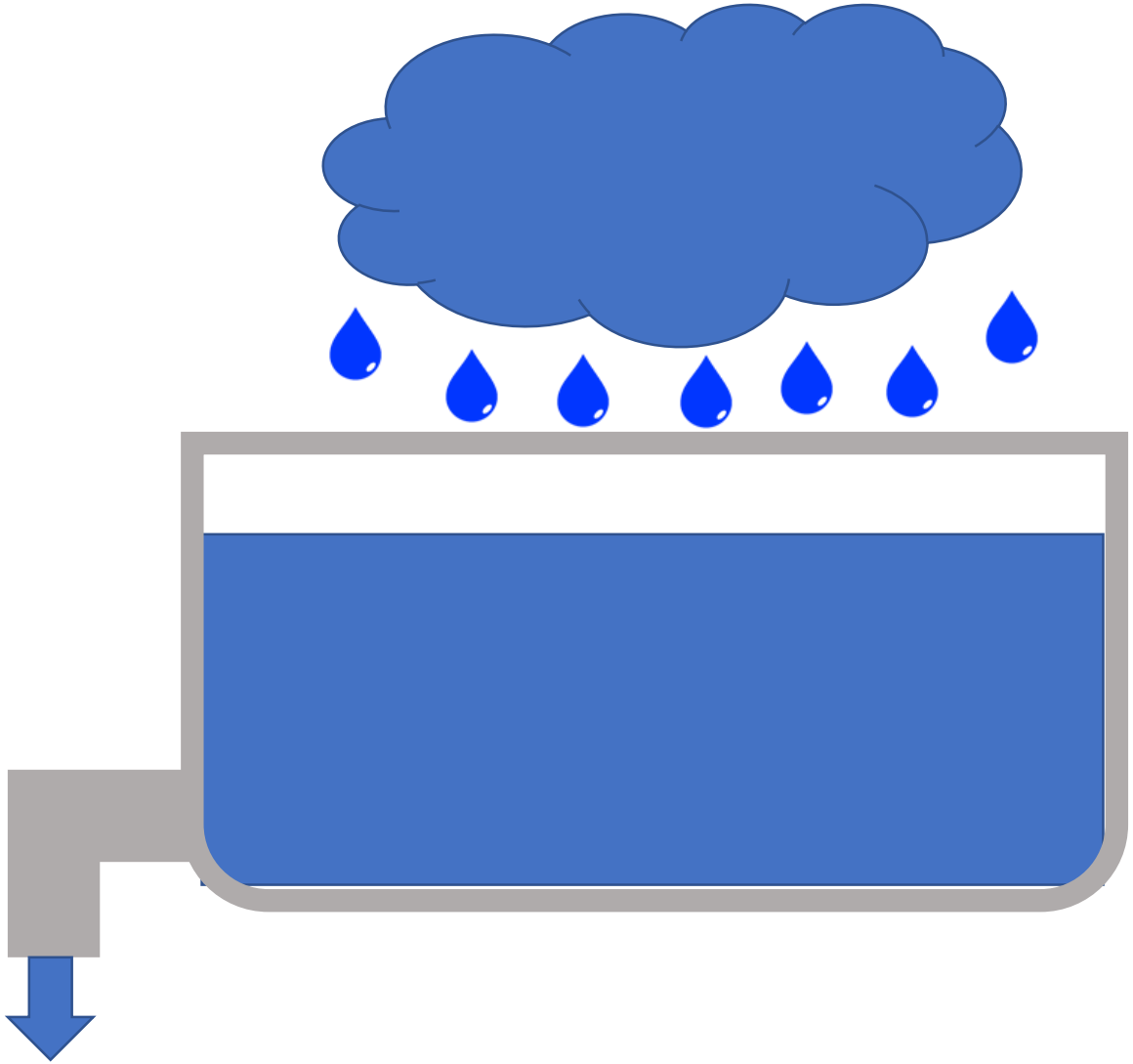

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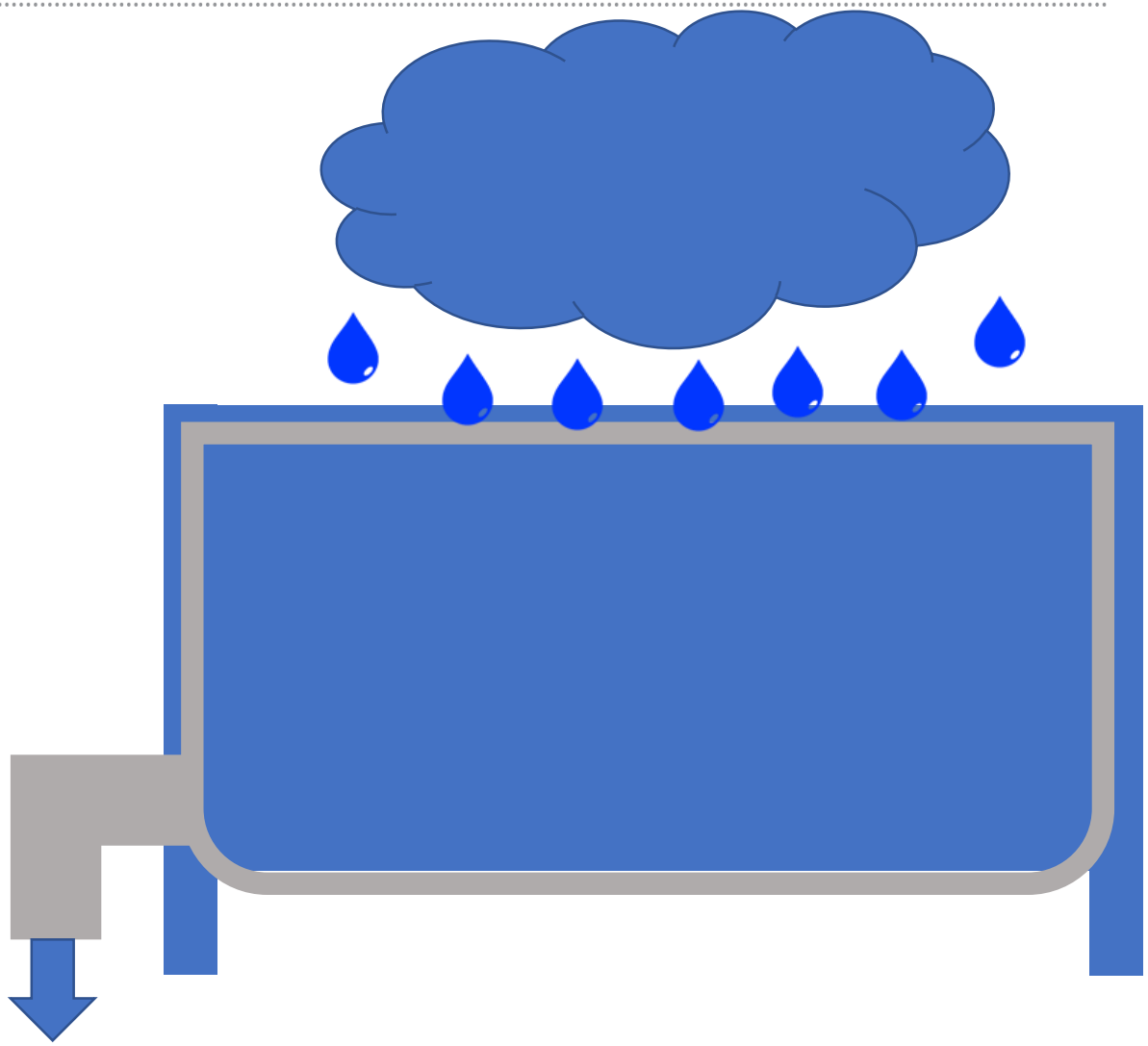
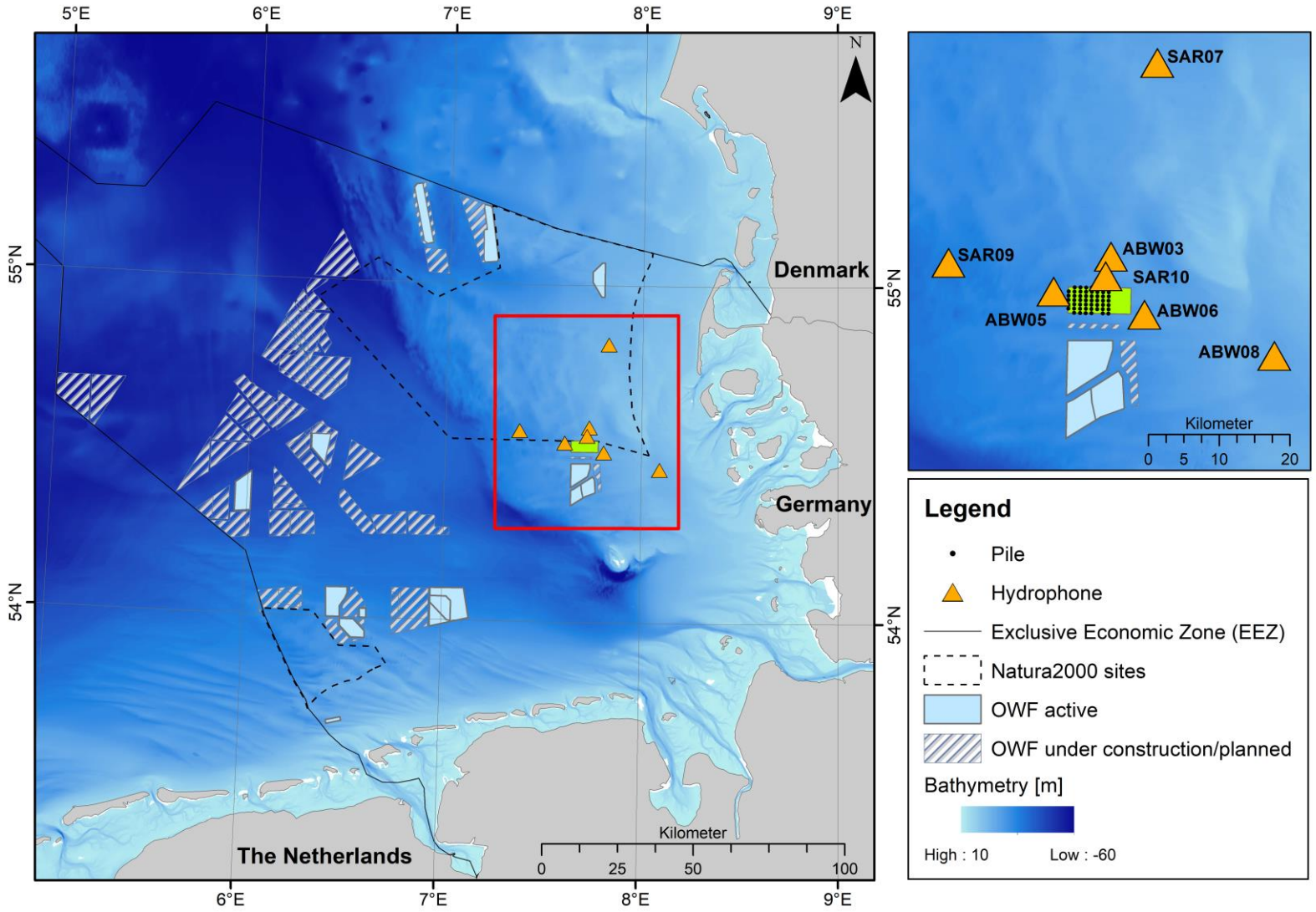
- Recent studies on harbour porpoises showed that besides the danger from a single pulse with high energy, the reception of multiple pile-driving strikes with single strike sound exposure levels (SEL_{SS}) well below the legal threshold can also induce a TTS, because of the total received energy (Kastelein *et al*. 2015, 2016).

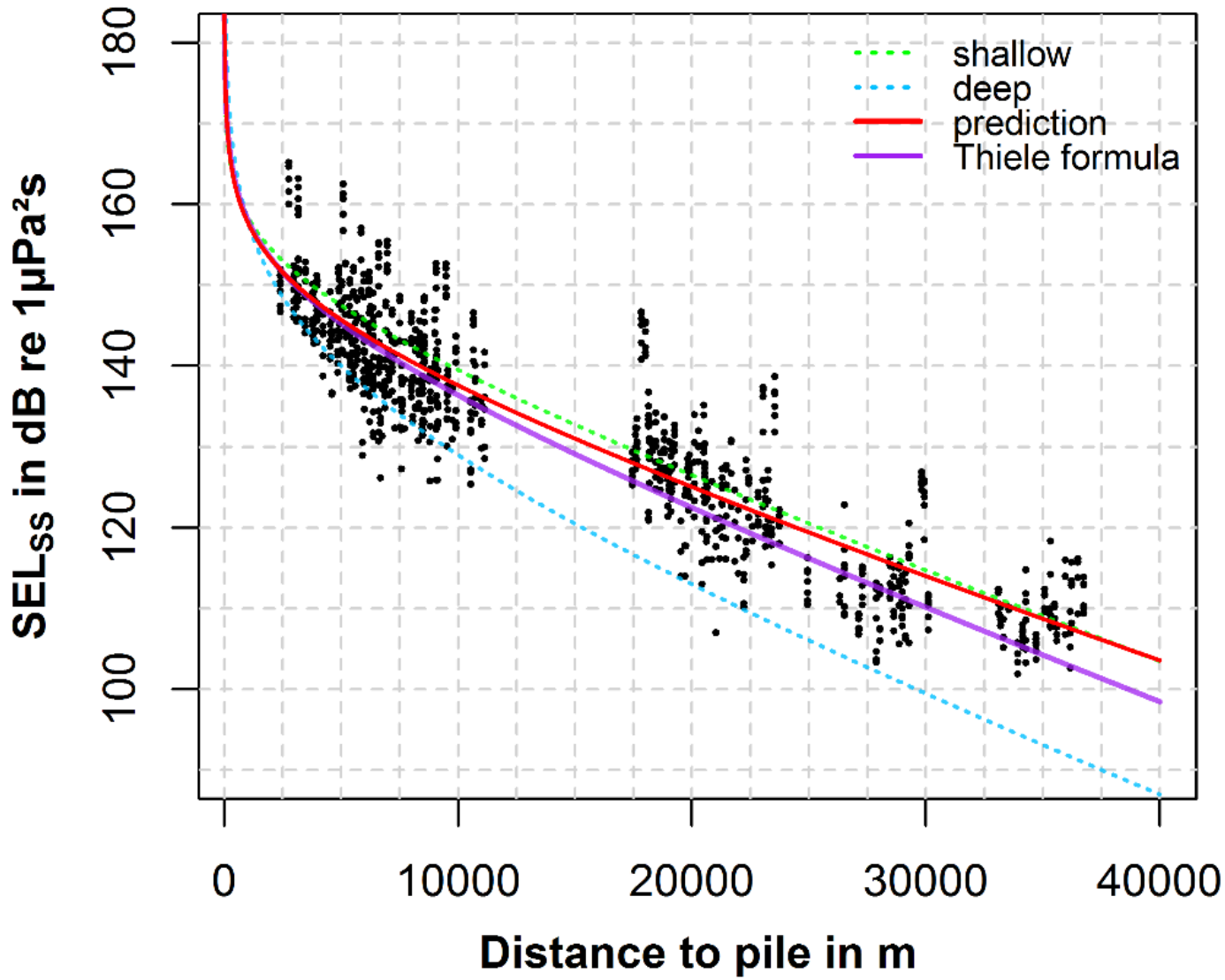


TTS_{onset}	**SEL_{cum}**	**175 dB re 1 µPa²s**
Effective quiet	**SEL_{SS}**	**145 dB re 1 µPa²s**

Research area in the German North Sea



Calculated the sound propagation with a non linear regression



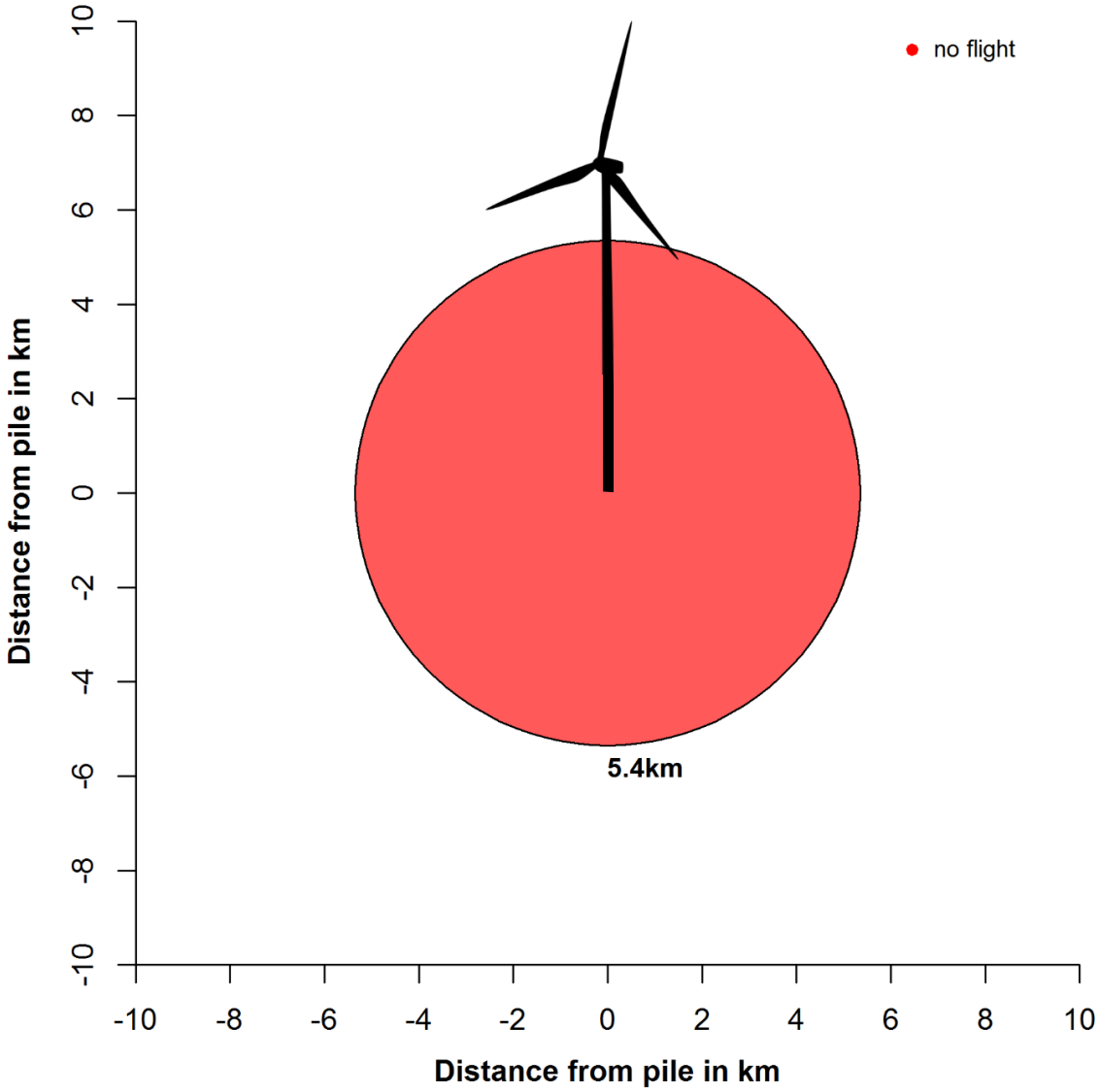
Calculation of a hazard radius where porpoises are at risk

- The hazard radius corresponds maximum radius where a TTS can be induced from multiple pile-driving strikes above the effective quiet threshold
- We determined a safe distance using the slope, intercept and the absorption coefficient of the modelled sound propagation along with the effective quiet threshold within the following equation:

$$safe\ distance = \frac{\alpha \times W\left(\frac{10^{\frac{EQT}{slope}-\frac{intercept}{slope}} \times \alpha \times \log(10)}{slope}\right)}{intercept \times \log(10)}$$

Radii of hazard zones around a pile-driving site

- The hazard radius corresponds to the maximum radius where a TTS can be induced from multiple pile-driving strikes above the effective quiet threshold is at 5.4 Km
- according to an assumed pulse interval of 1.3 s, the SELcum value would exceed the TTS onset of 175 dB re 1µPa²s after 1001 single pile strikes within 21.7 minutes.

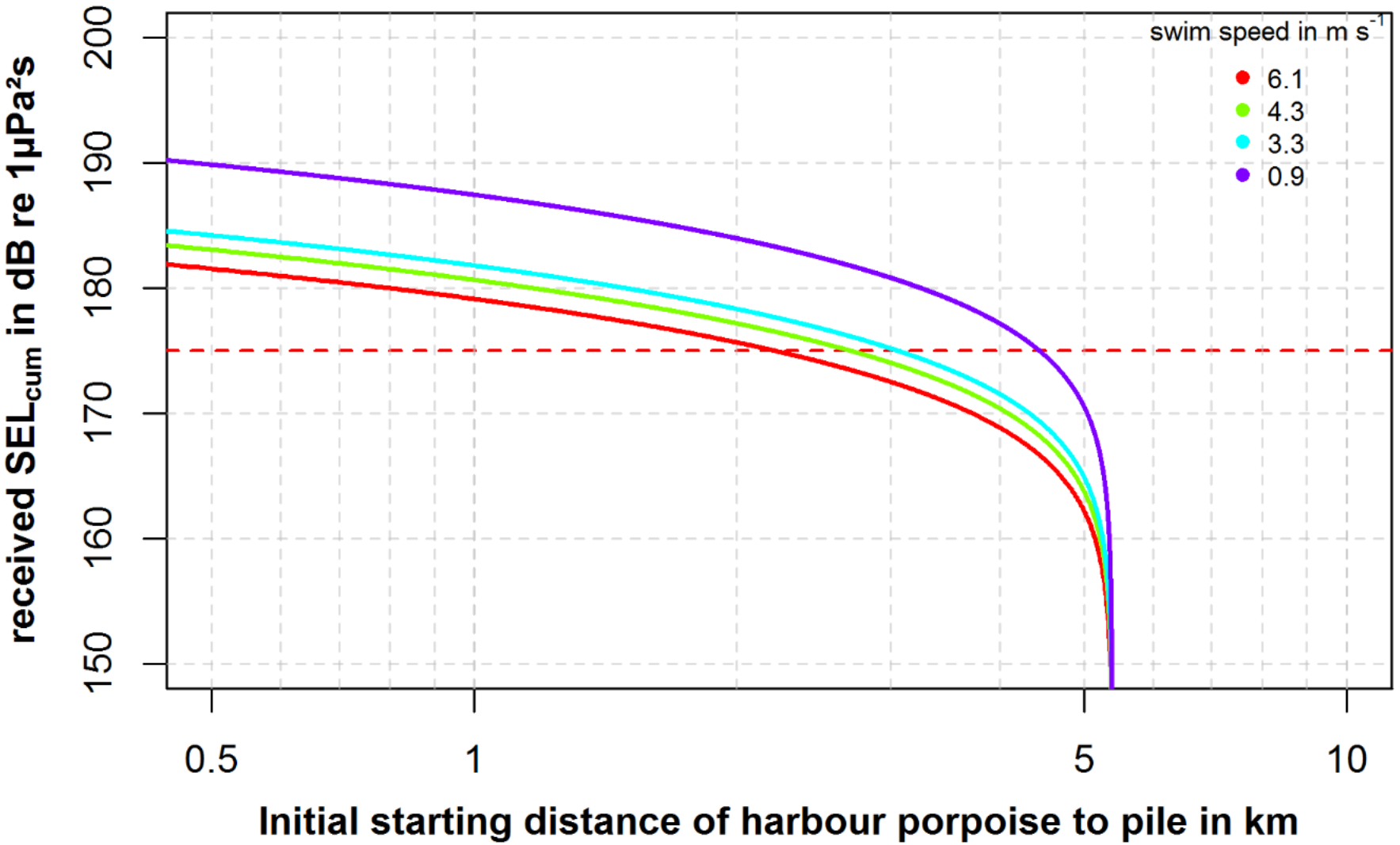


Risk for a fleeing porpoise:

- In contrast to direct effects on hearing, behavioural reactions of free-ranging harbour porpoises to pile-driving strikes are not fully understood yet.
- Harbour porpoise flights were simulated at a swimming speed of 0.9, 3.3, 4.3 and 6.1 m s^{-1}.
- The received SEL_{cum} for the complete track of a harbour porpoise swimming straight away from the sound source from a specific position, up to the safe distance is given by following equation:

$$SEL_{cum} = 10 \times log_{10} \left\{ \frac{10^{\left(\frac{1}{10} \times intercept\right)} \times \left(safe\ distance^{slope+1} - start\ distance^{slope+1}\right)}{pulse\ interval \times speed \times \left(1 + \frac{slope}{10}\right)} \right\}$$

Risk for a fleeing porpoise:



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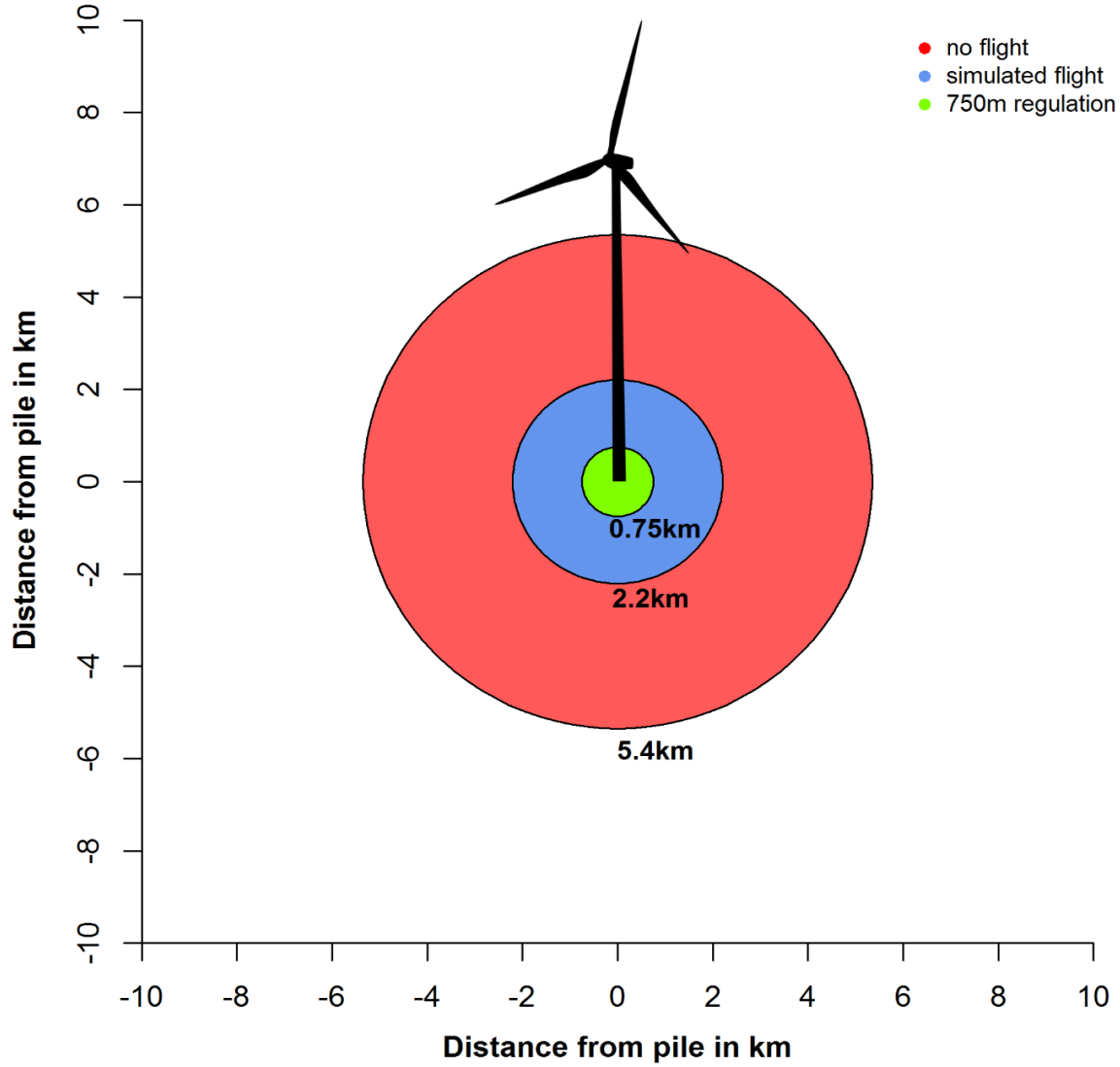

TTS =

The acoustical perception of the environment is of key importance for harbour porpoises to navigate (Villadsgaard et al., 2007), find and catch prey items (DeRuiter et al., 2009; Wisniewska et al., 2016) and intra-specific communication (Clausen et al., 2010; Sørensen et al., 2018) and any impairment could potentially negatively affect individual fitness, reproduction or survival.

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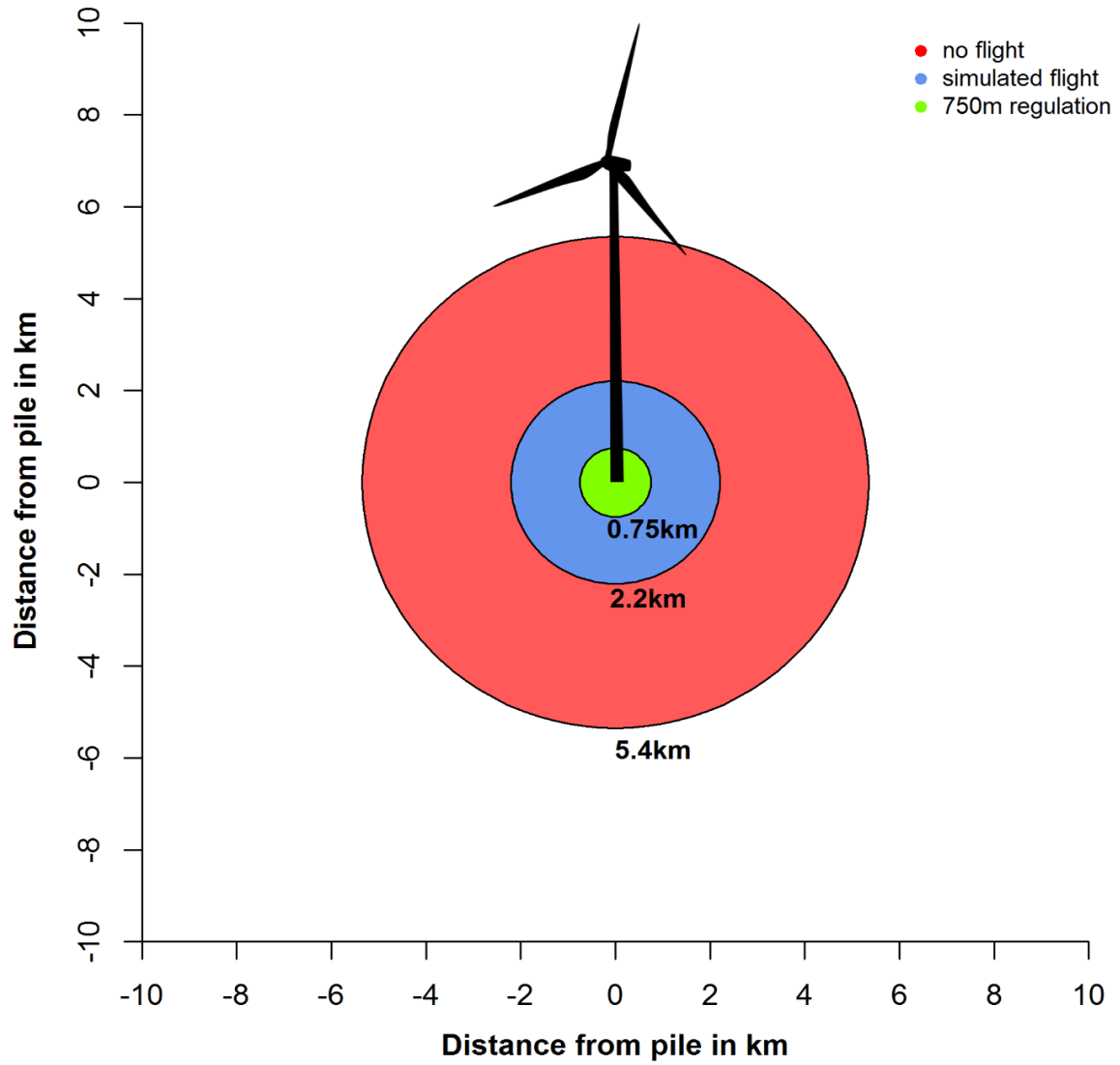
Energetic costs =

The resulting drag from moving in a medium increases with the square of swim speed and likewise the needed costs of locomotion for propulsion against the drag (Gallagher et al., 2018; van der Hoop et al., 2014). Harbour porpoises are living on an energetic knife edge, which makes them particularly vulnerable to anthropogenic disturbance (Wisniewska et al., 2016).

Only the combination of:

- **Noise mitigation,**
- **Previous deterrence effort and**
- **A soft start phase**

can ensure that a porpoise escapes a TTS.



Thanks for your attention!