

# Underwater construction and operational noise at alpha ventus

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Gefördert auf Grund eines Beschlusses  
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Projektträger

Koordination

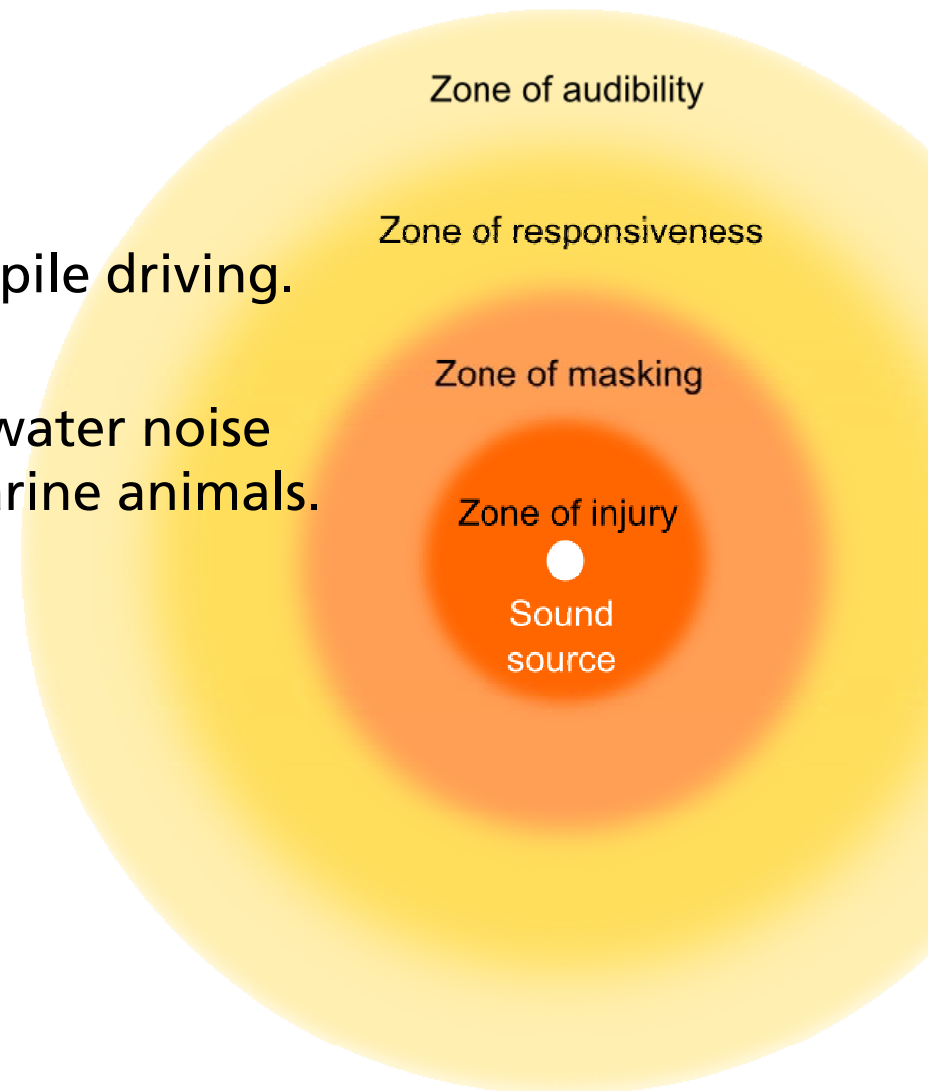


Bundesministerium  
für Umwelt, Naturschutz  
und Reaktorsicherheit



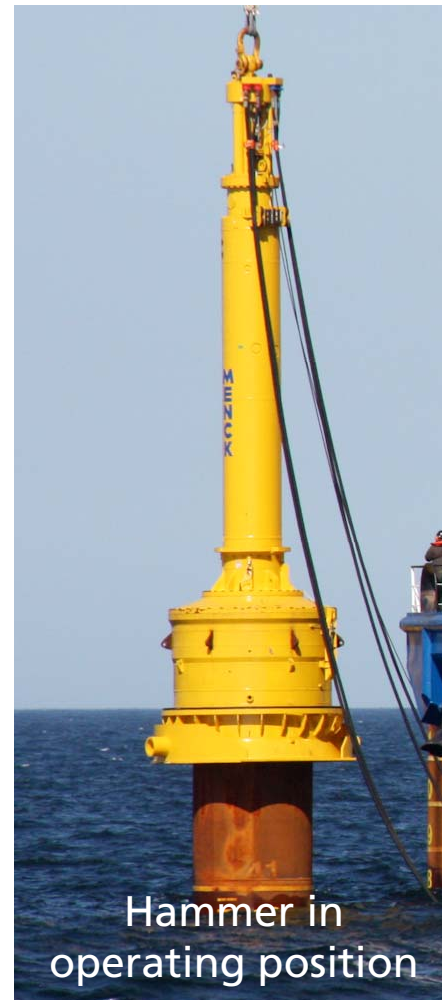
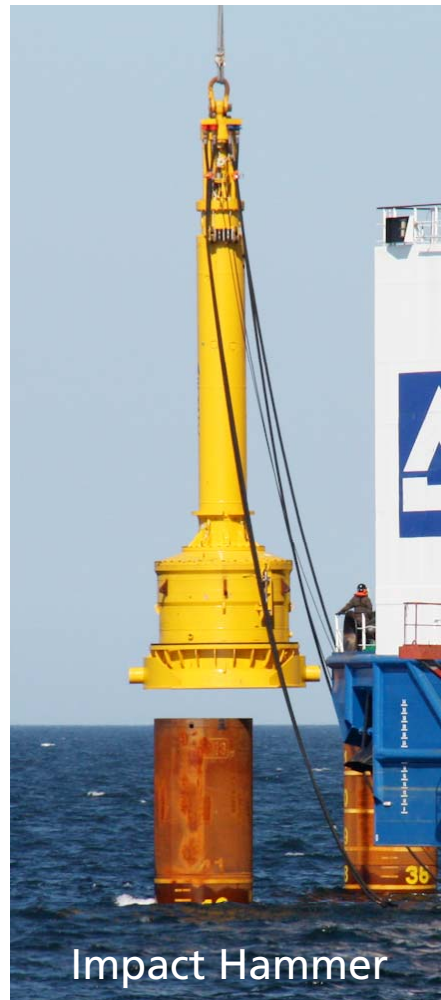
# Construction noise

- Most offshore wind turbines are constructed by means of impact pile driving.
- Pile driving causes strong underwater noise that is potentially harmful to marine animals.



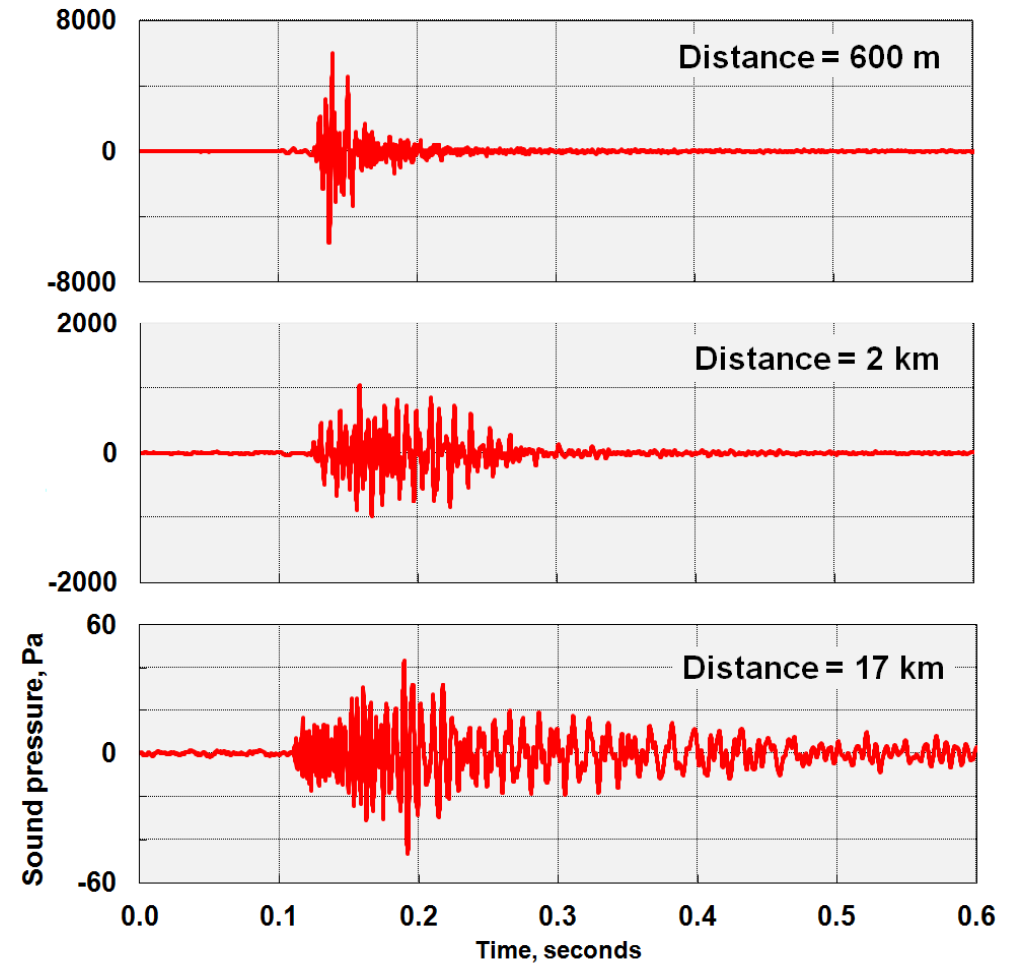


# Construction noise: Pile driving

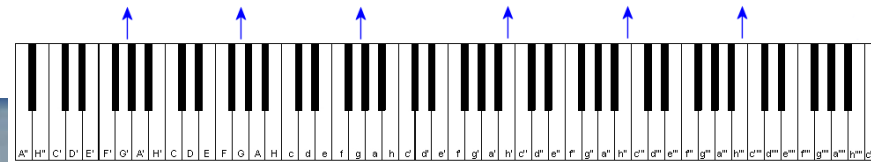
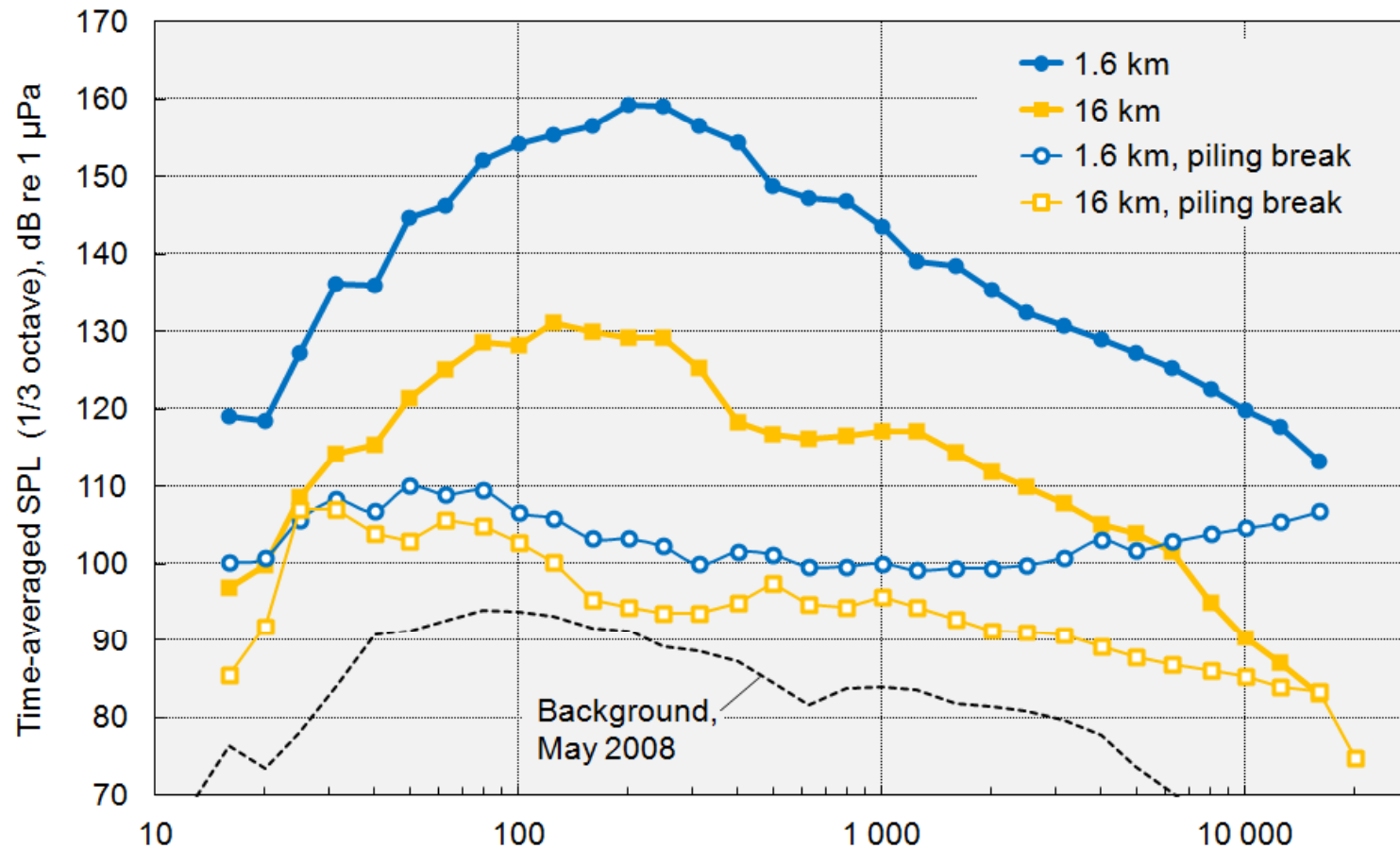


# Pile driving: Sound pressure versus time

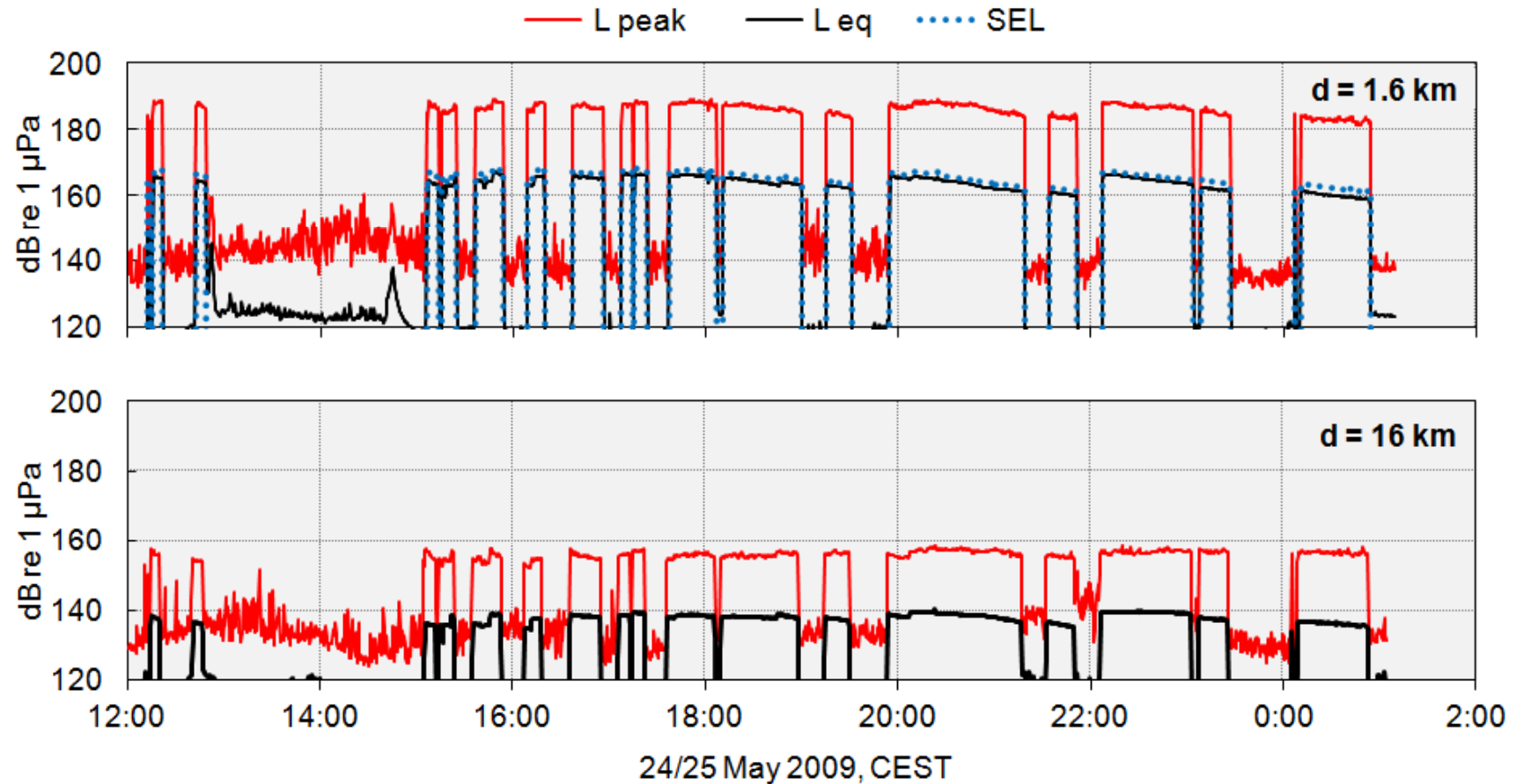
- 2400 - 8700 strokes per pile
- Typical rate: 40 per minute



# Pile driving: Frequency spectra

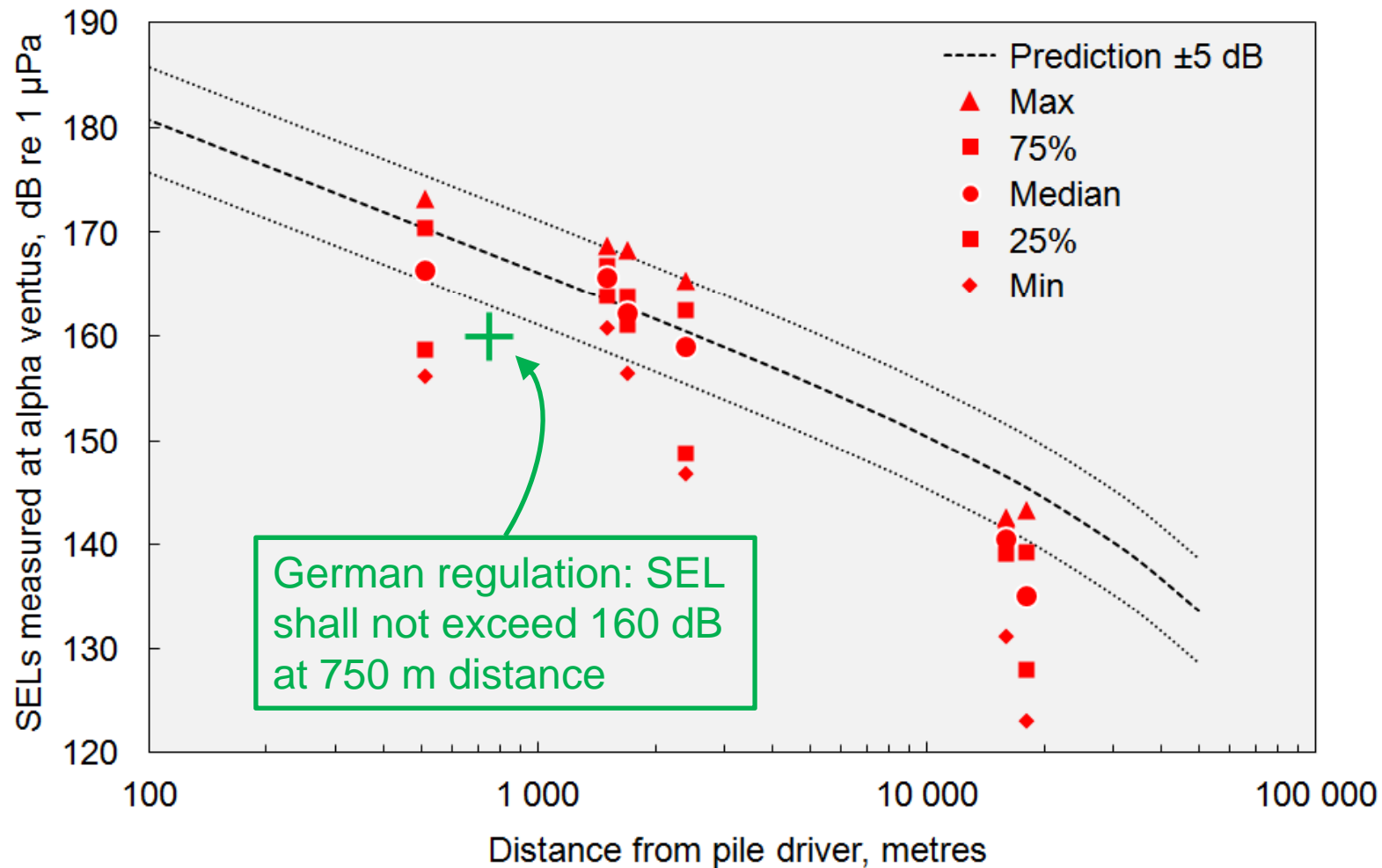


# Pile driving: Sound level versus time (example from AV 8)



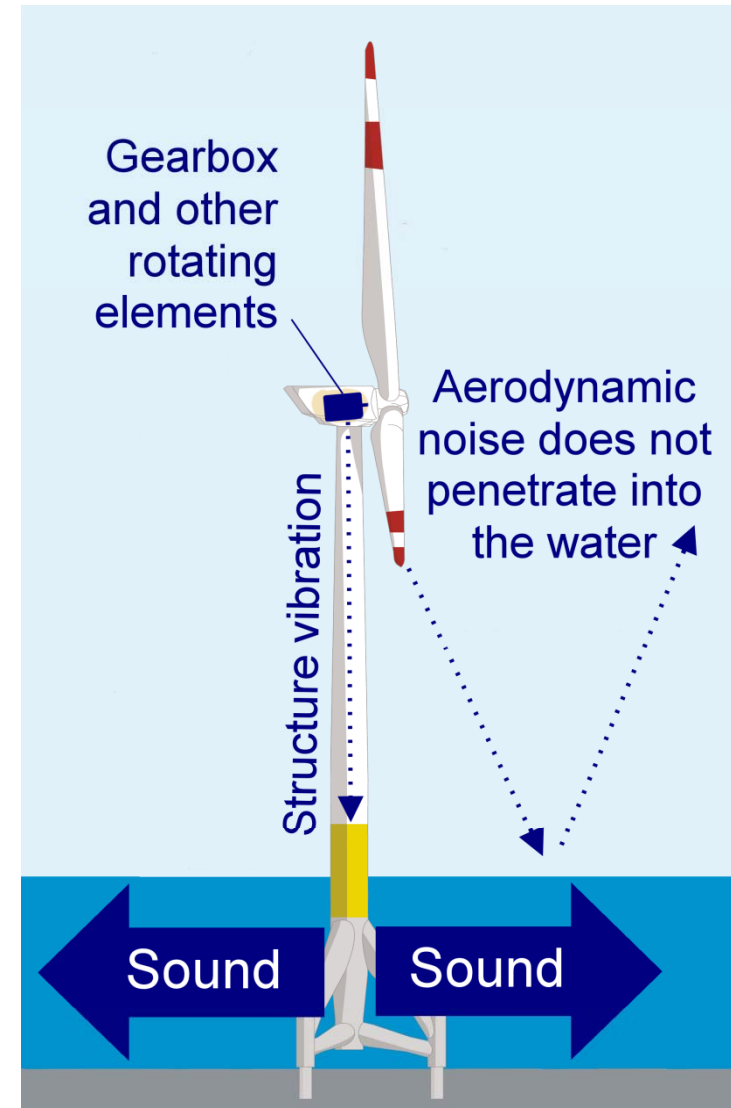


# Pile driving: Noise levels and official regulations



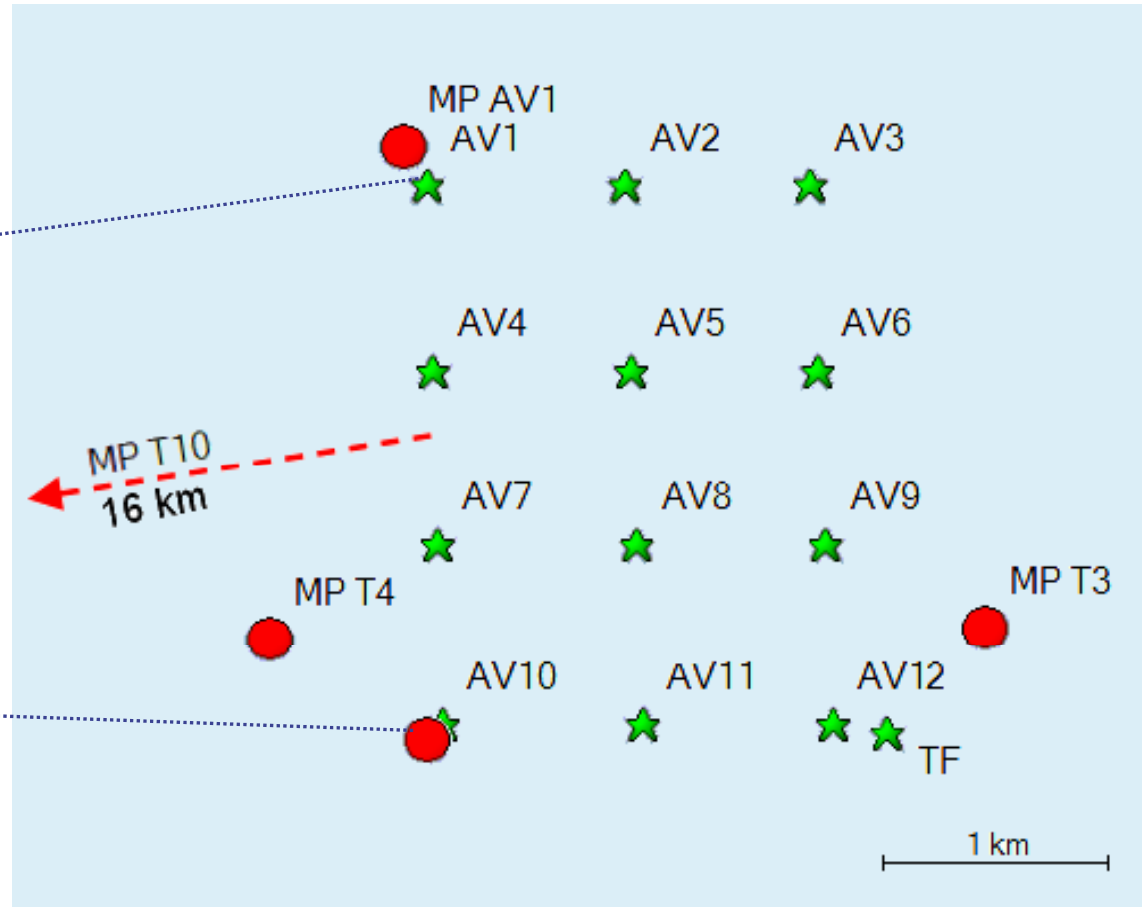
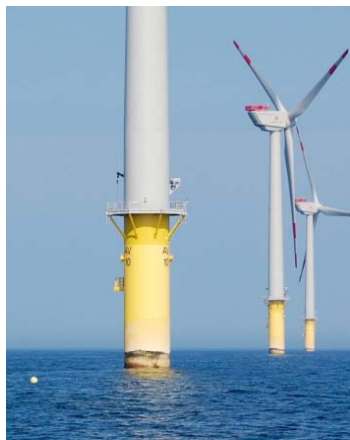
# Operational noise

- Noise sources: Gearbox, generator, motors, fans, transformers, inductors
- The noise is tonal (not broadband), e.g. at tooth mesh frequencies.
- Different foundation types (monopile, jacket, tripod) may induce different noise levels into the sea.
- Contrary to construction noise, the noise is almost permanent.

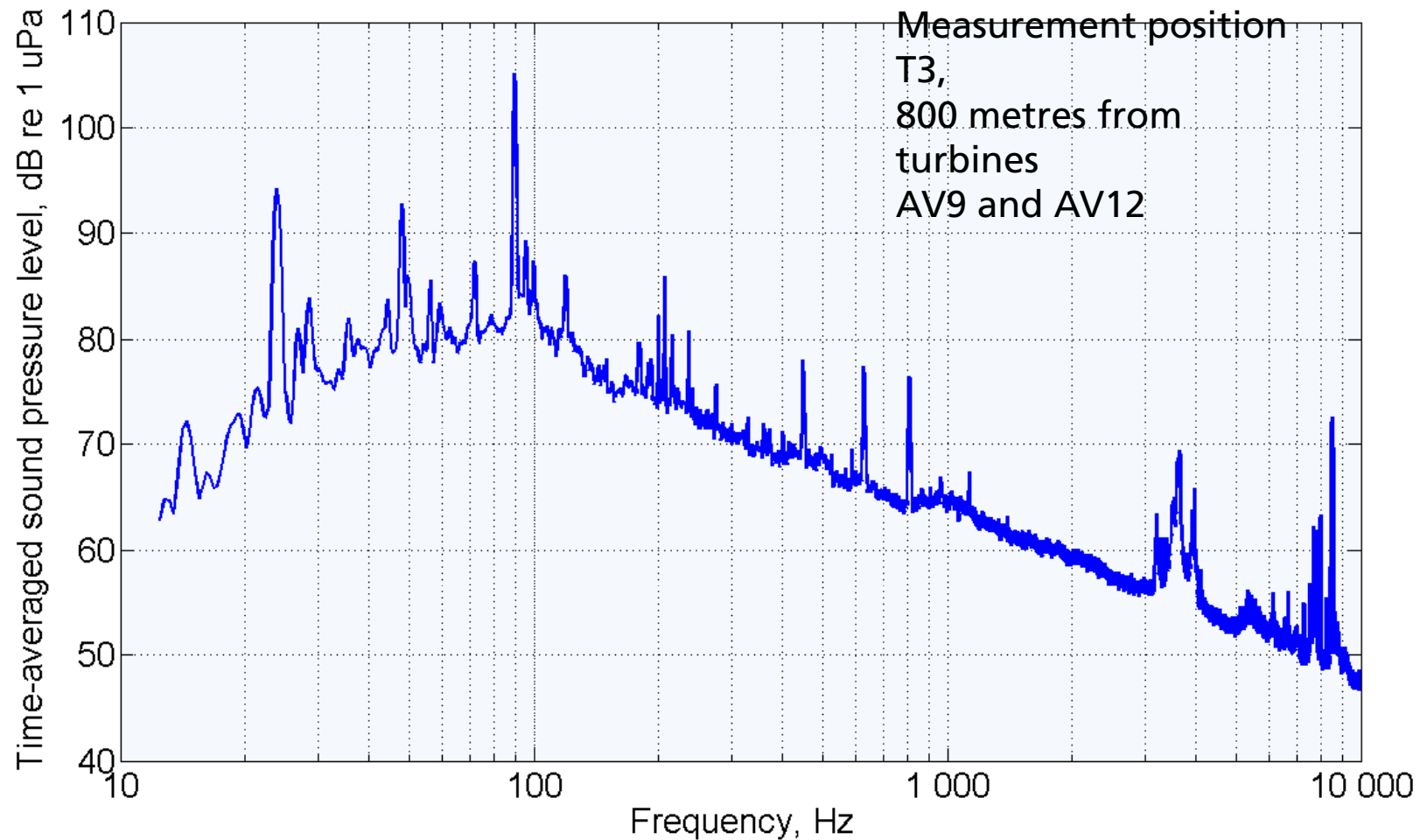




# Operational noise: Measurement geometry, May - June 2011

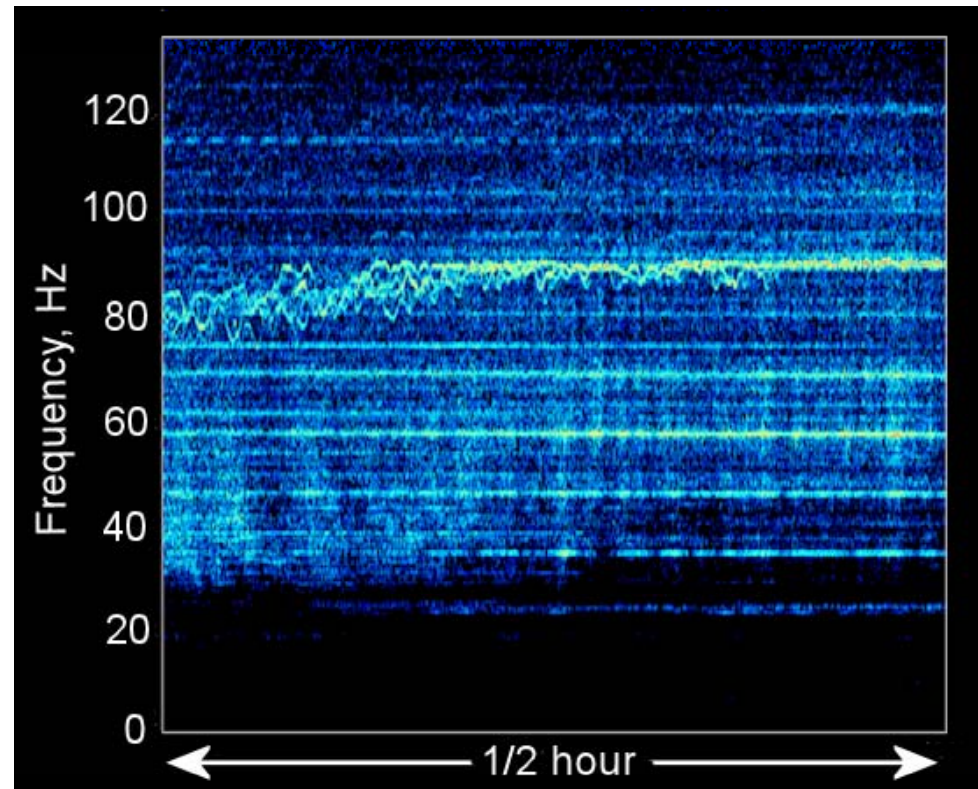


# Operational noise: Narrowband spectrum with tones

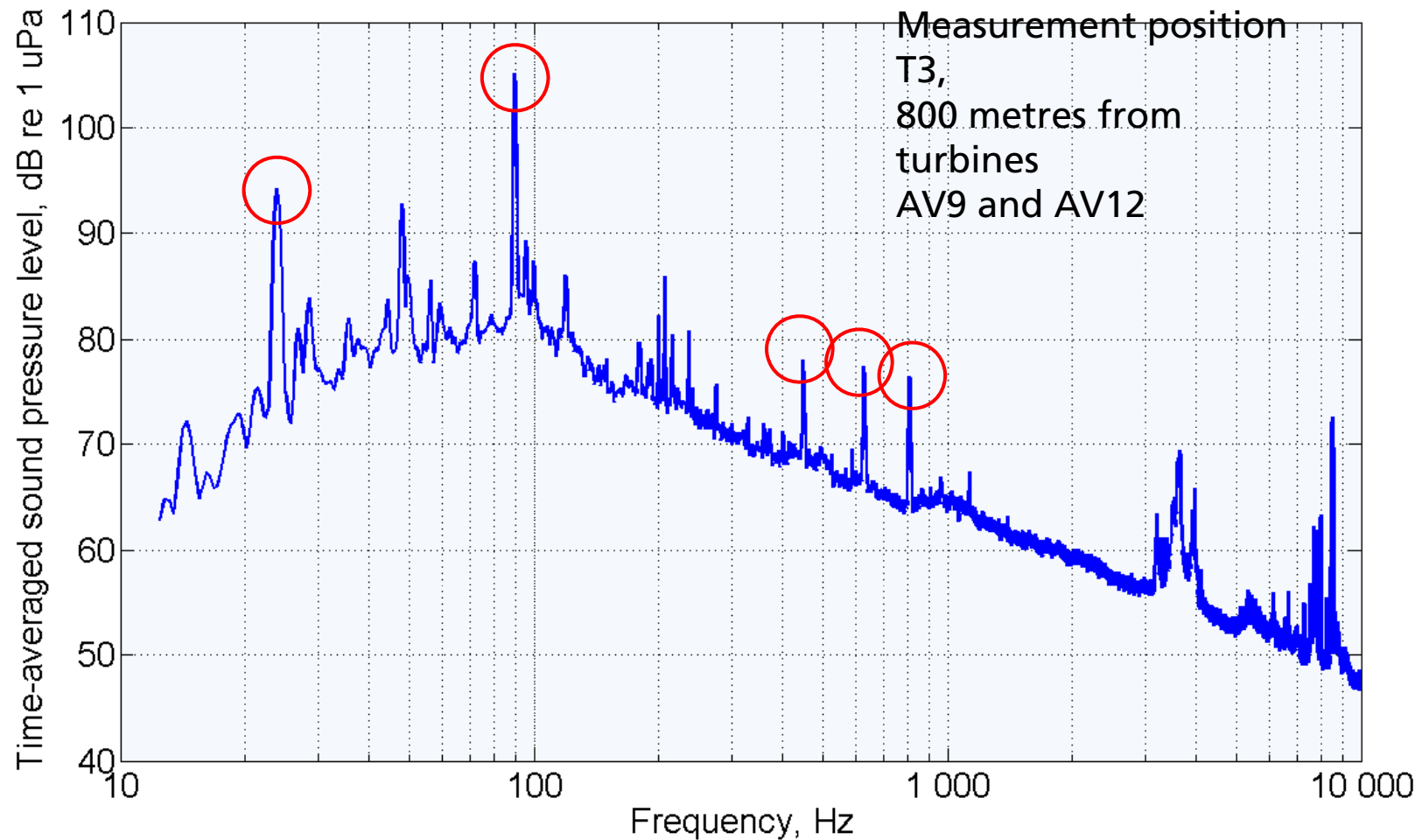


# Operational noise: Identifying turbine noise

- Comparing data from different measurement positions and times
- Statistical methods (e.g. percentile sound levels)
- Evaluating spectrograms (see figure right)
- Simultaneous measurement of structure vibration (was not feasible at alpha ventus)

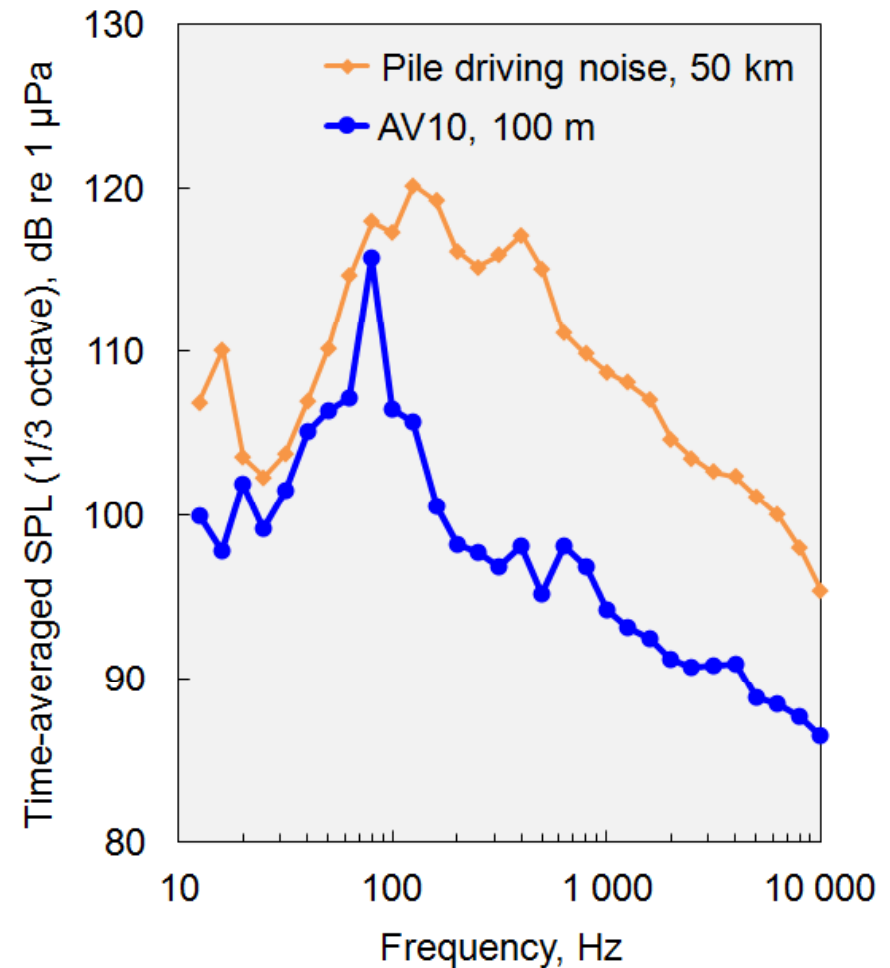
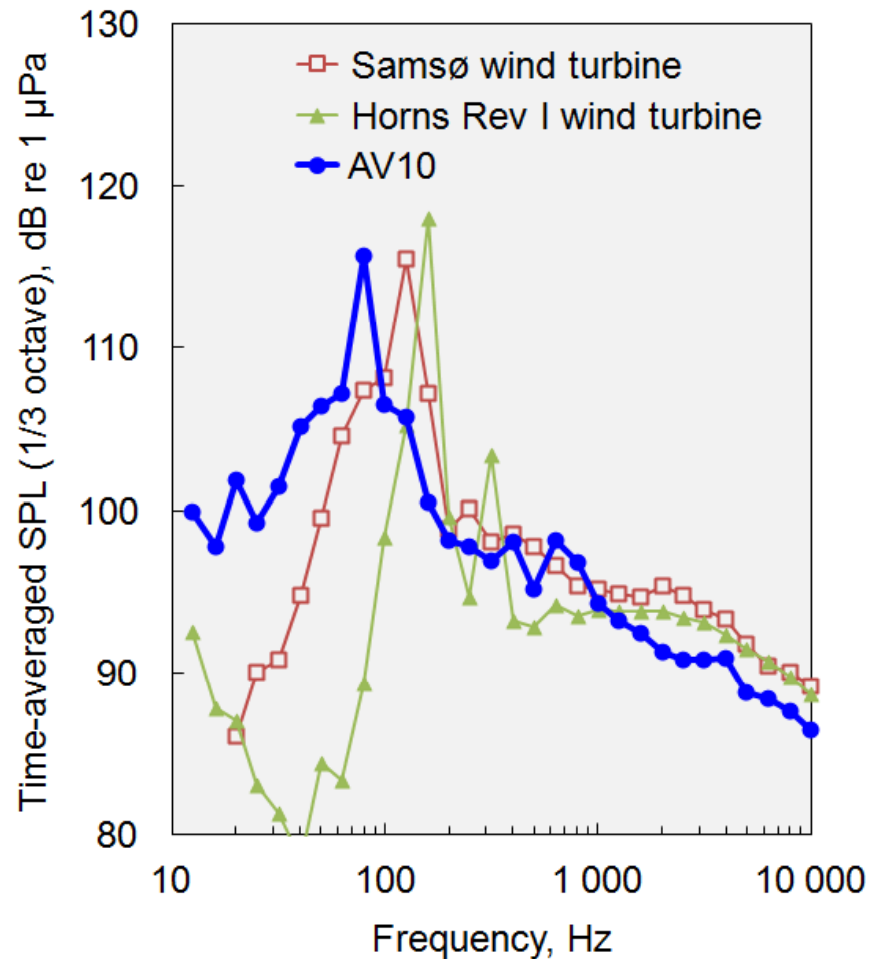


# Operational noise: Tones caused by turbines



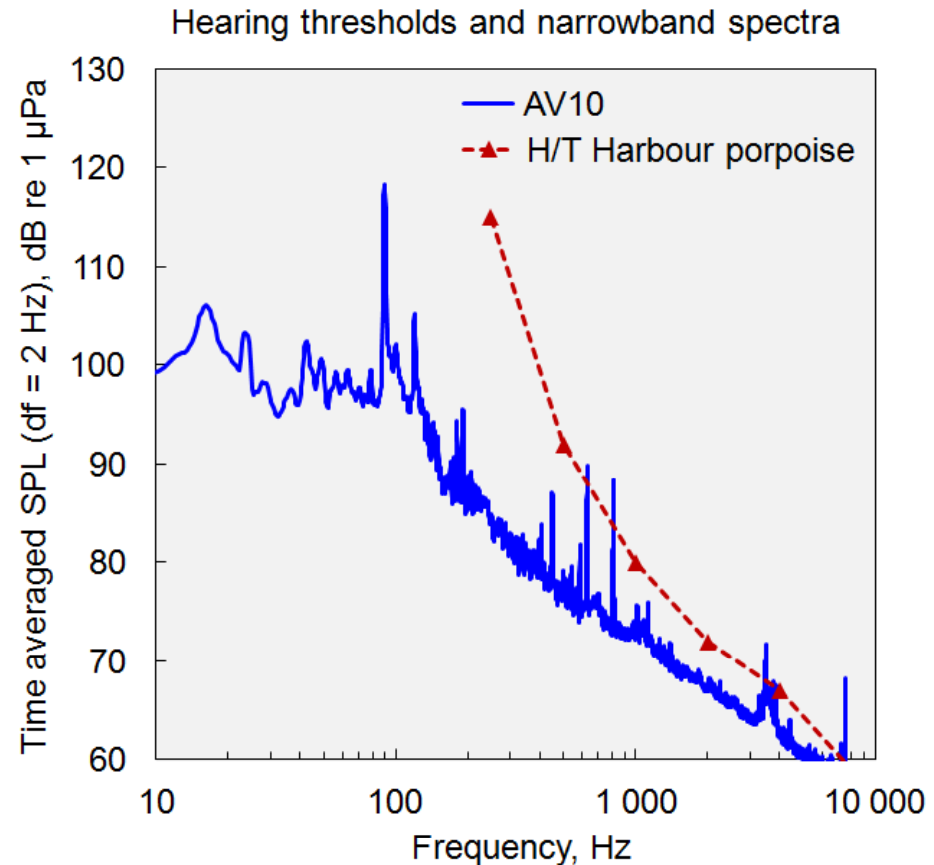


# Operational noise: Comparison with other noise



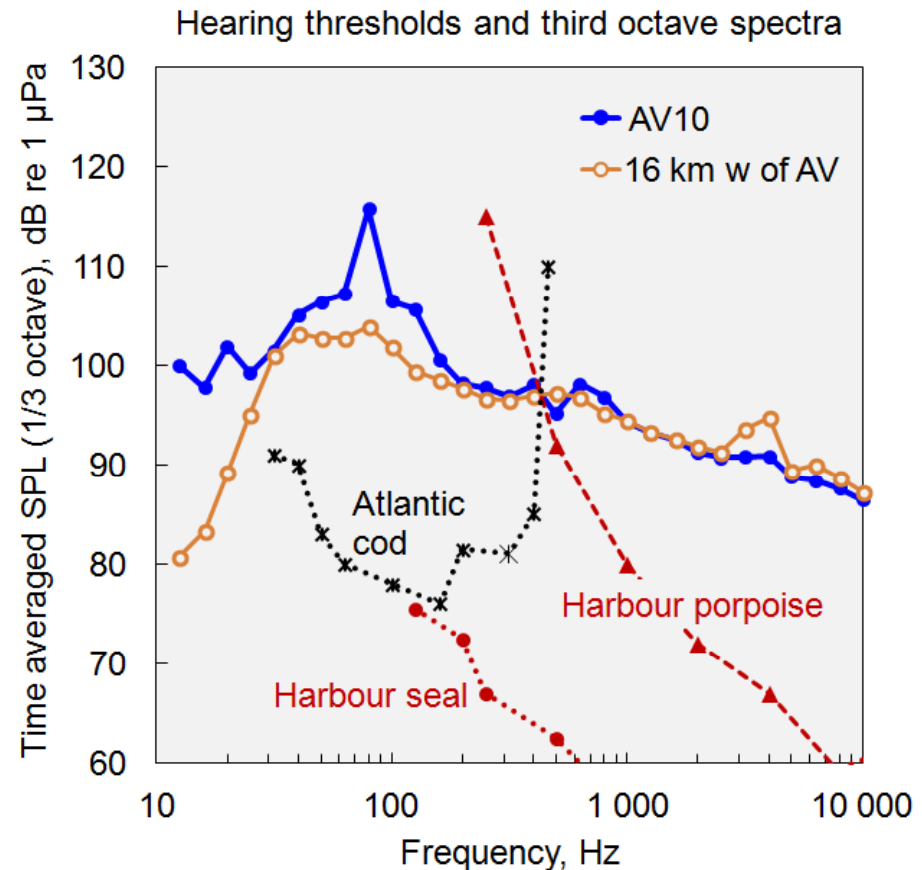
# Operational noise: Possible biological impact

- Is the noise audible to marine animals?
- How can the data be compared to hearing thresholds? (What kind of averaging is adequate? Which spectral resolution, narrowband, third octave or *critical band*?)
- Does audibility also mean disturbance or induce reactions?



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Threshold data from: Kastelein et al.  
2002, Kastelein et al. 2011, Enger 1967



# Thank you

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