

Lyd og havvind, problemstilling og mitigering?

Noise production , mitigation, evaluation

Jürgen Weissenberger



Humans are mainly “visual”

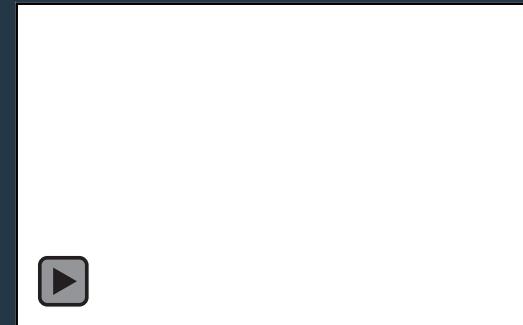
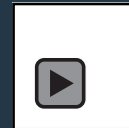
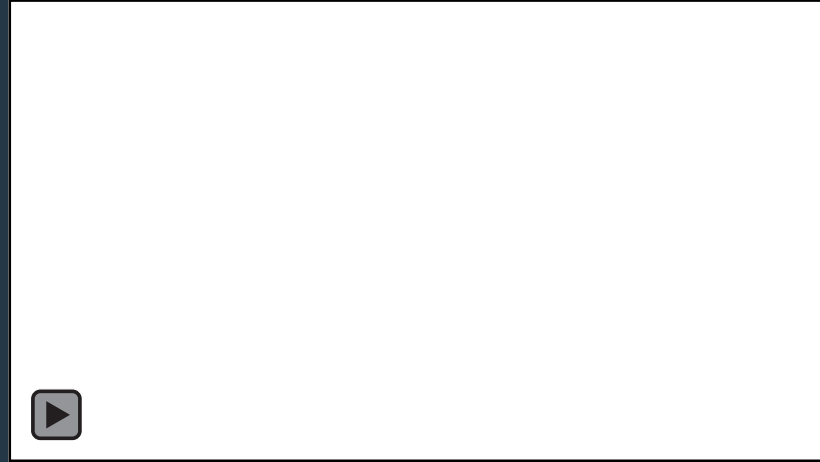
- Long distance information about our environment (several km)
- Resolution about 0.3m at 1km distance
- It is hard for us to imagine a world where we only can hear.





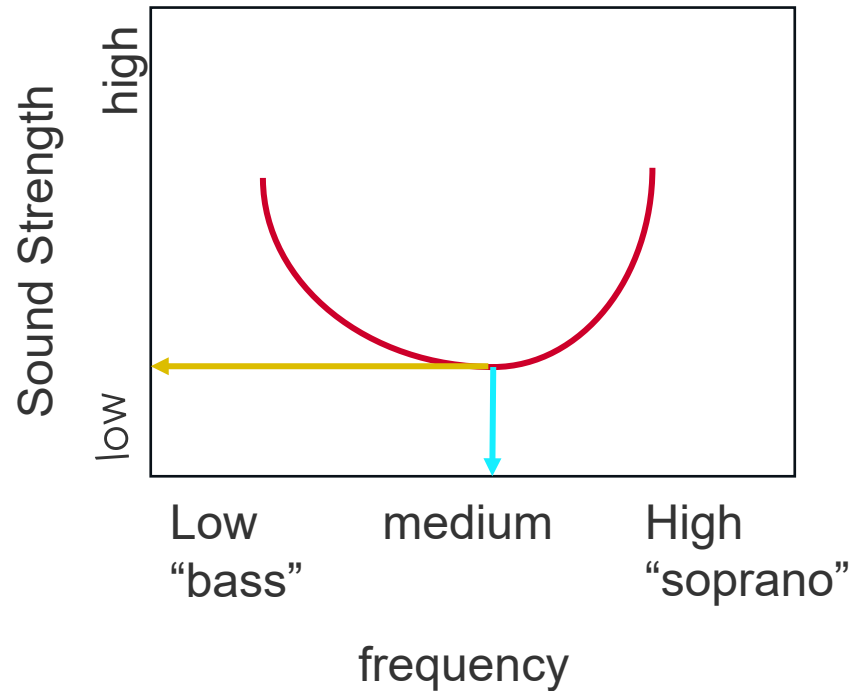
Marine organisms are mainly “auditory”

- Light is only present in uppermost layers in the water
- Visibility a few m
- Sound is the only means to get information over long distances





Relationship hearing and characteristics of noise



elephants,
blue whales

Humans 20Hz to 20kHz

dogs, cats,
dolphins

The point where the hearing curve is lowest indicates the frequency of best hearing and the sound strength that is needed to hear that tone.

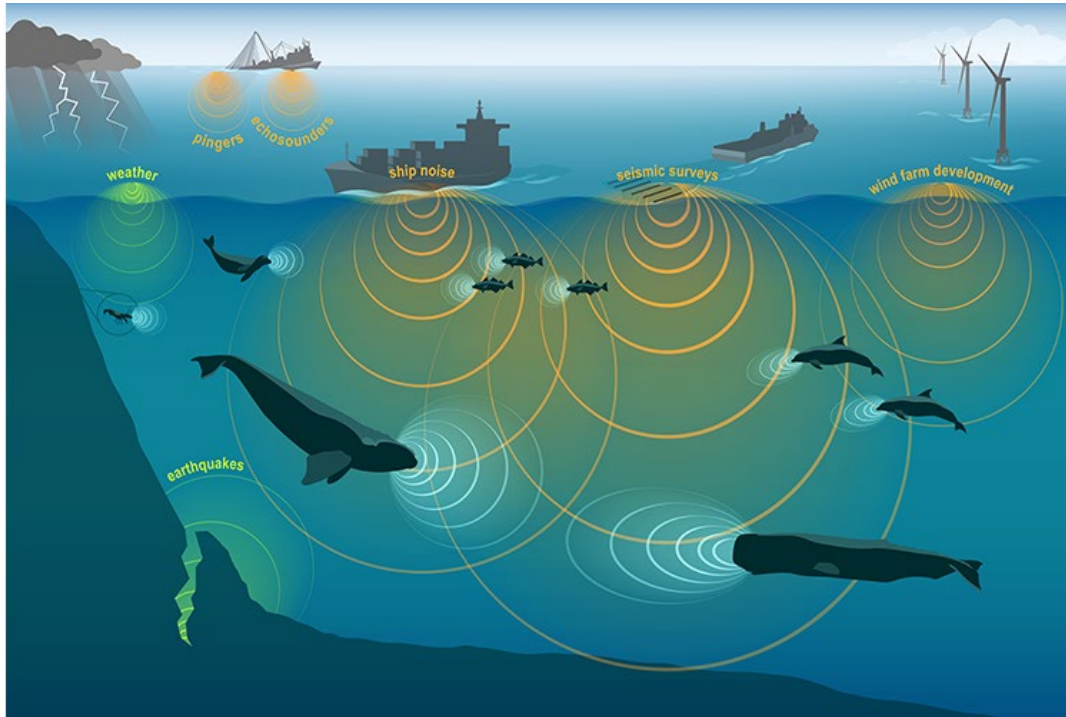
When moving to higher or lower frequencies, the sound strength must be stronger to hear the respective tone.

Humans and marine mammals have very similar hearing organs, acoustic sensing in other groups of animals may differ, but all have of hearing curve relating sound strength and frequency that can be heard

Strong sound can damage ears, and sound must be heard to elicit behavioural reactions

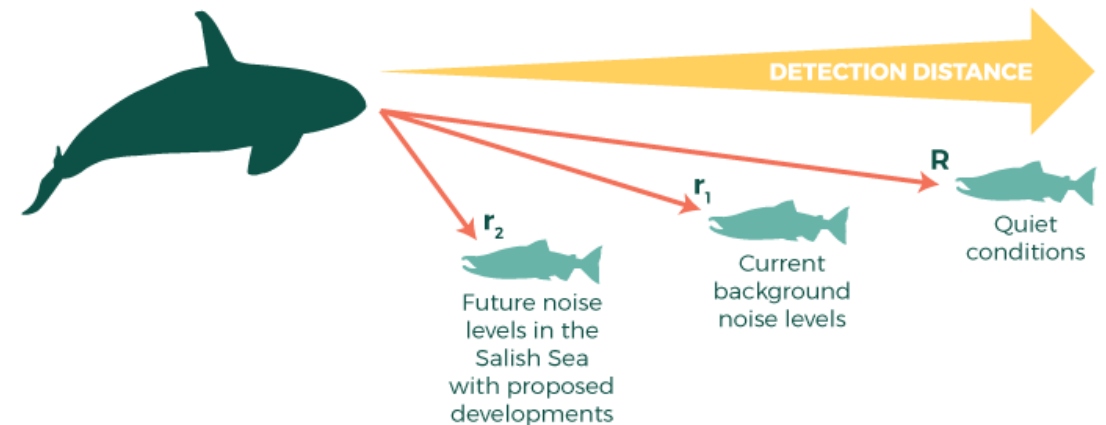


Consequences of increasing noise in the environment and reduction of the “acoustic space” for species relying on acoustic information.



Injury to ears at strong noise levels
Reduced ability to communicate with conspecifics
and behavioural reactions at lower noise levels

Detection of prey decreases as underwater noise increases



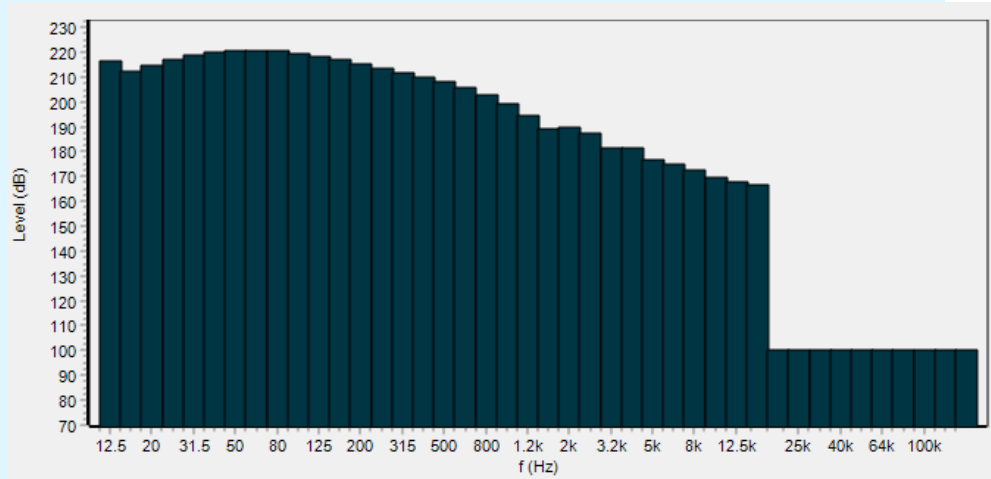
Whales have lived in the ocean for 50mill years without anthropogenic noise. (Even in the memory of recent very long living species like Bowhead whale).



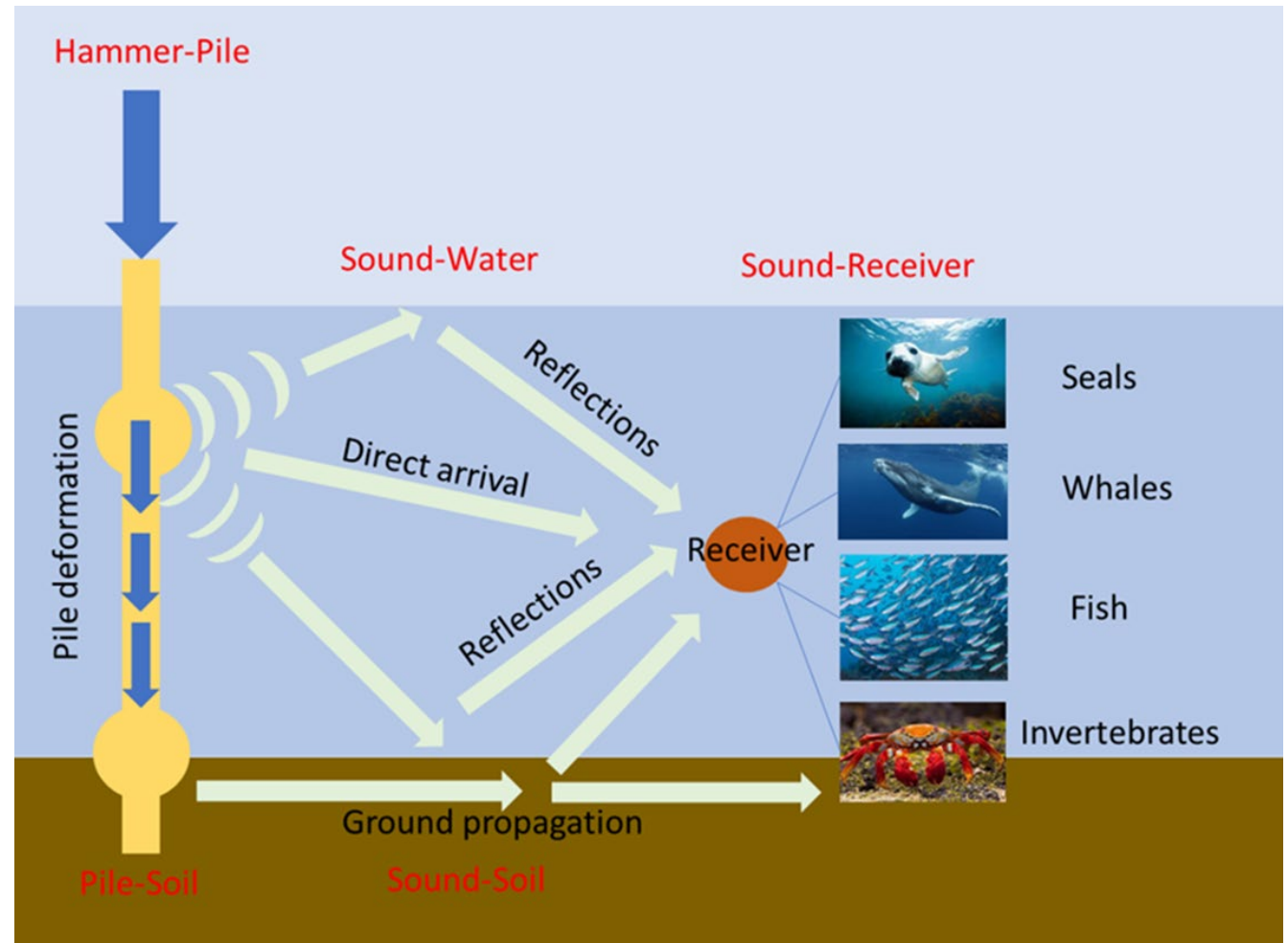
Noise from pile driving for foundations of wind turbines

Noise is created by a pile deformation rushing down the pile and impacting the soil, several path of sound generation

Frequency spectrum 9.6m pile



“Low frequency, impulsive broadband noise”

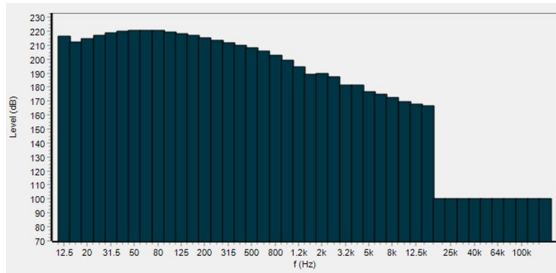


Noise dampening measures are required in many countries, e.g. limits on **SEL single stroke**, or **SELcumweighted** over 24 hours



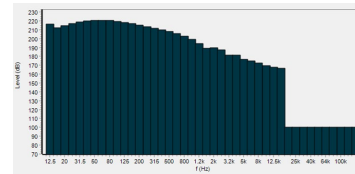
Two different concepts are used to regulate sound regarding the potential to create injury.

SEL single stroke < 160dB at 750m



Total risk is assumed as acceptable if this criteria is fulfilled

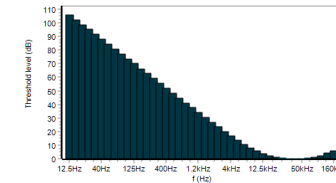
SELcum for the duration of the sound creation in relation to threshold for injury (PTS, TTS)



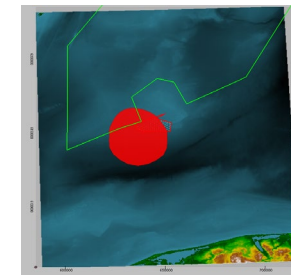
SEL single stroke times number of strokes



Weighted in accordance to hearing



Areas above threshold are estimated, and number of potentially affected animals

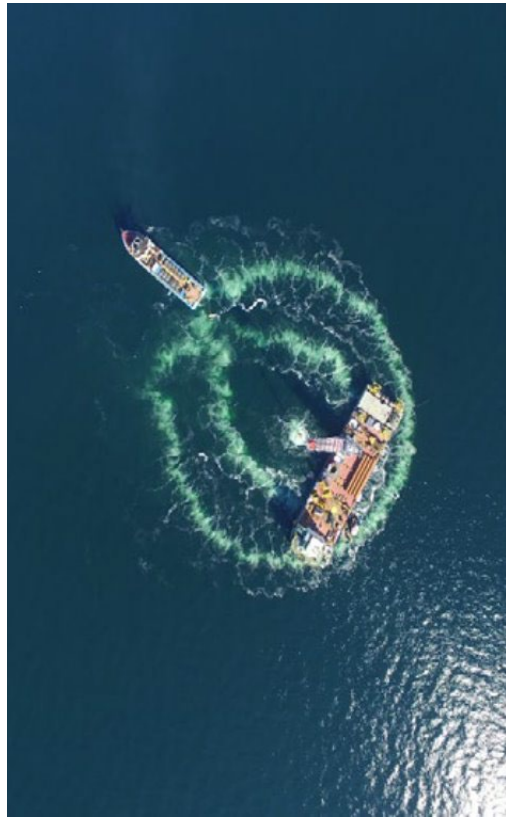


A decision is made if the respective risk is acceptable or not, based on vulnerability and other factors



To be compliant, noise mitigation technologies (sound dampening) must be used, all have different performances regarding frequency dependent damping

DBBC: Double Big Bubble Curtain



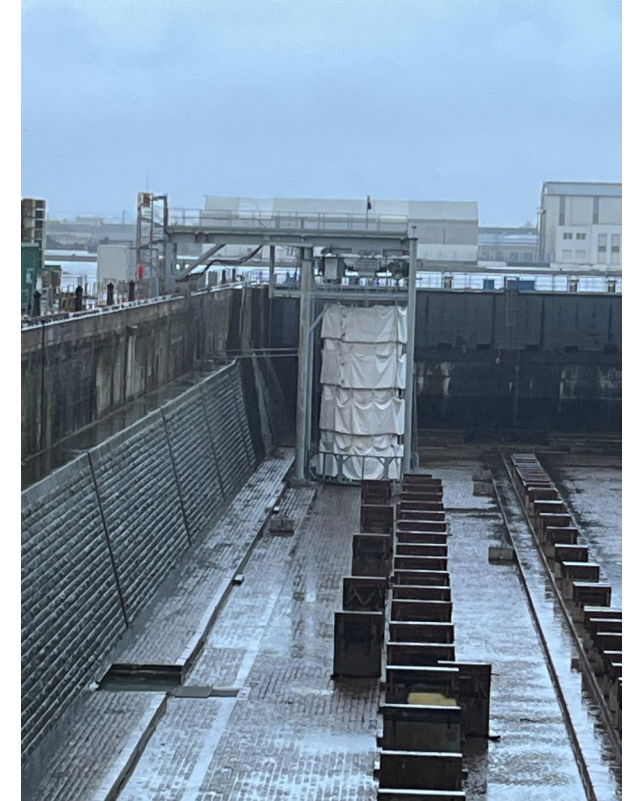
HSD: Hydro Sound Damper



IMI: Integrated Monopile Installer

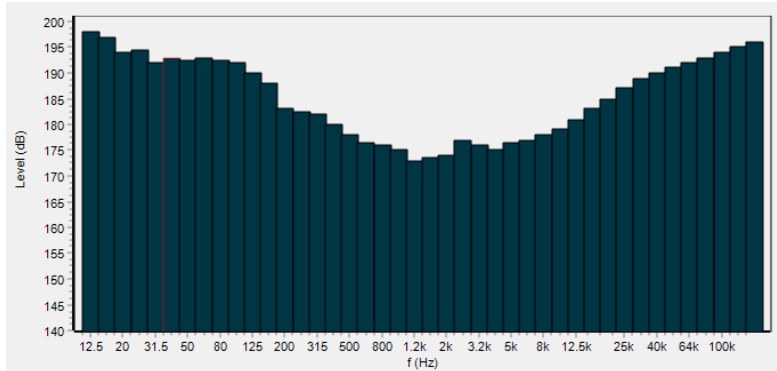


SSQ: Sub Sea Quiter

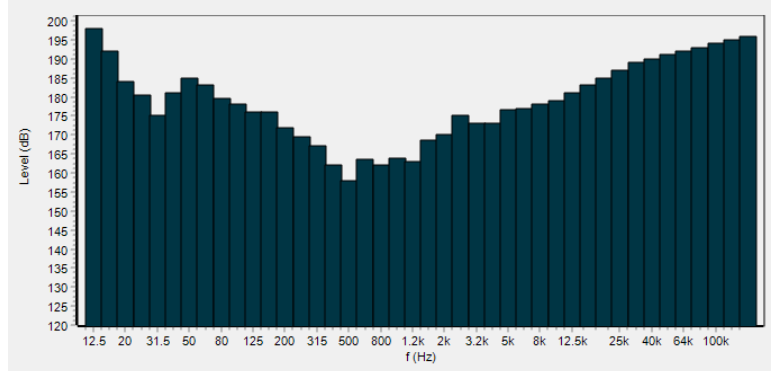




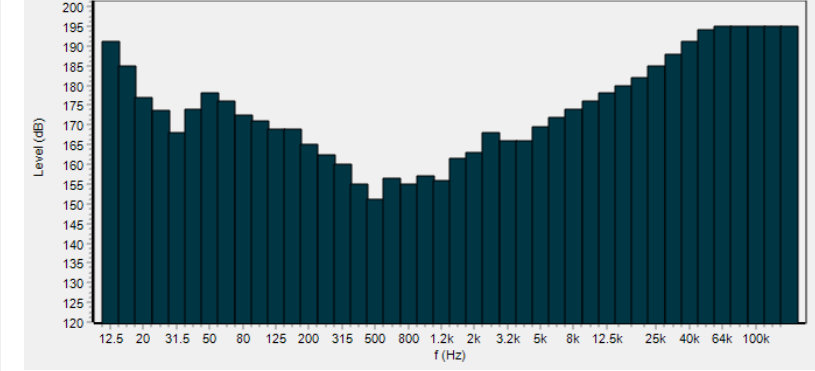
Several mitigation methods in combinations



Big Bubble Curtain
- 10dB broadband



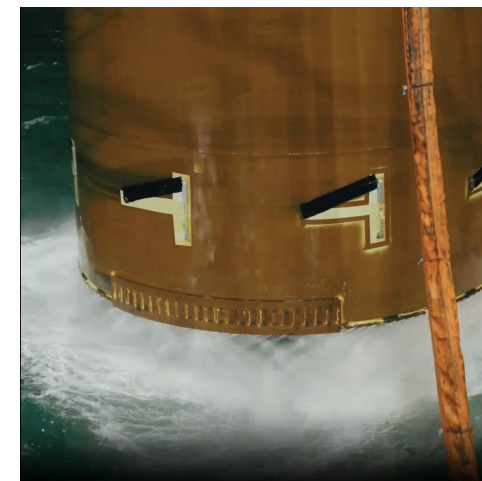
Big Bubble Curtain plus Hydro Sound
Damper - 11dB broadband



Big Bubble Curtain plus Hydro Sound
Damper plus Pulse 13dB broadband

Several new noise mitigation systems or more silent methods of piling are in the pipeline, e.g. vibropiling, or water jetting to reduce friction on the pile.

(numbers are just examples from one case, no to be generalised)



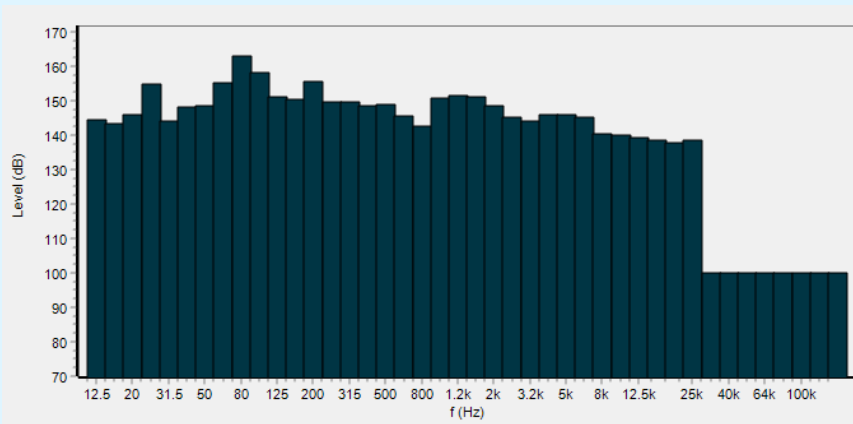
Ørsted
Godewind 3
test Ørsted successfully pilots
new technology that further optimises
offshore wind monopile installation
(orsted.com)



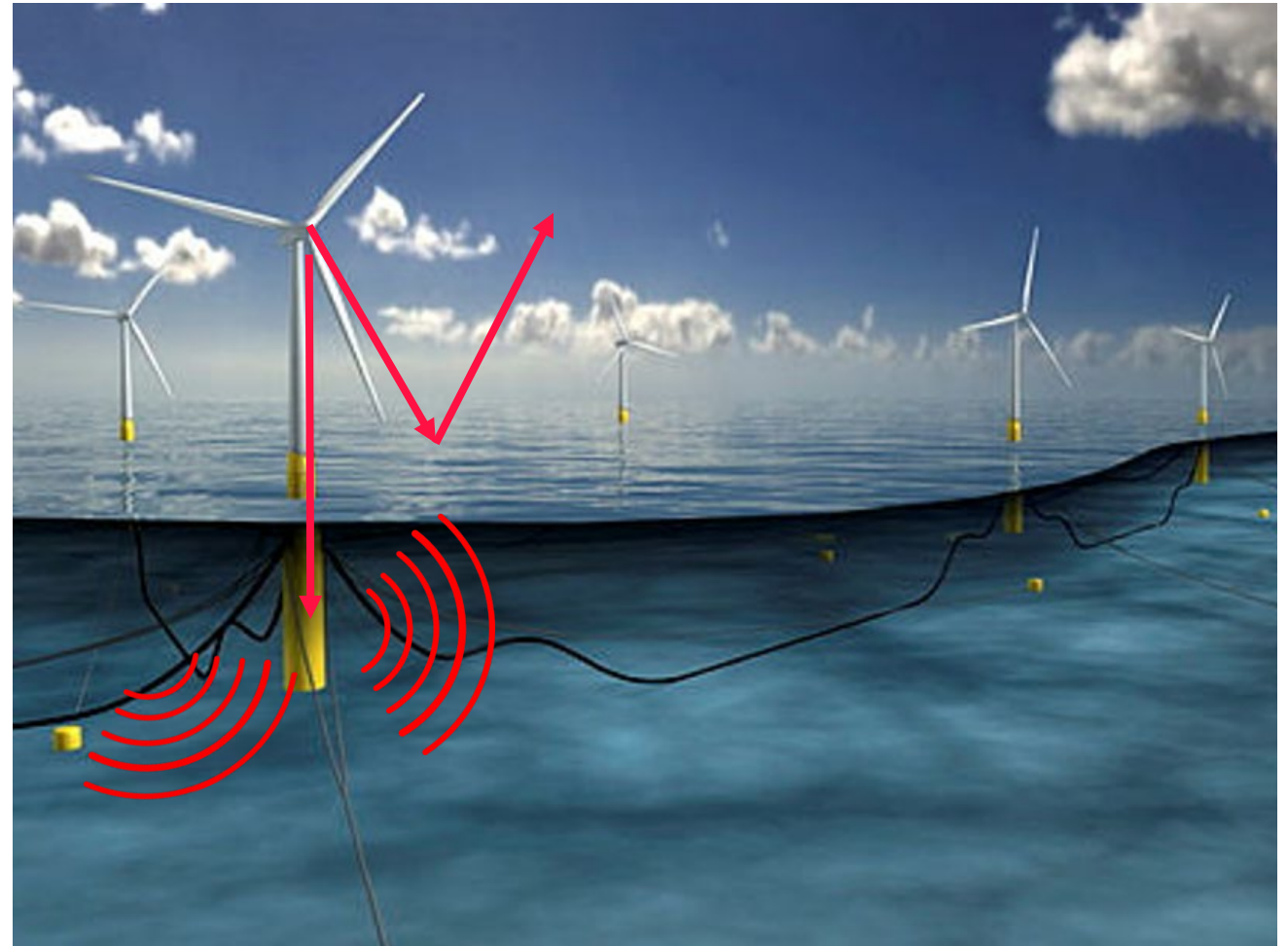
Noise from operations of wind turbines

Noise is created by rotating machinery and

Frequency spectrum Hywind Scotland at 25kn wind speed



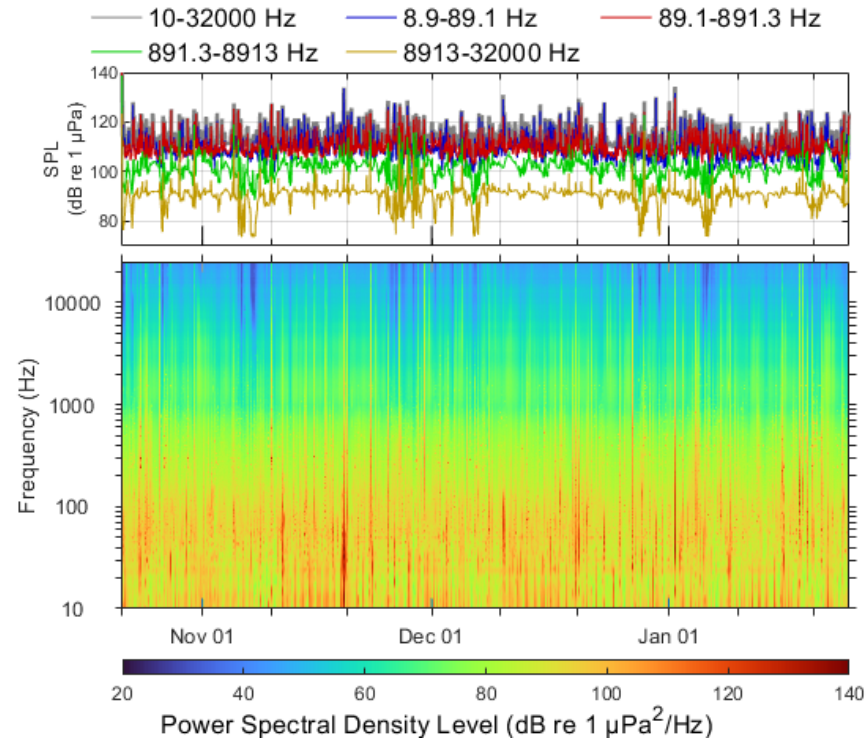
“Low frequency continuous broadband noise”



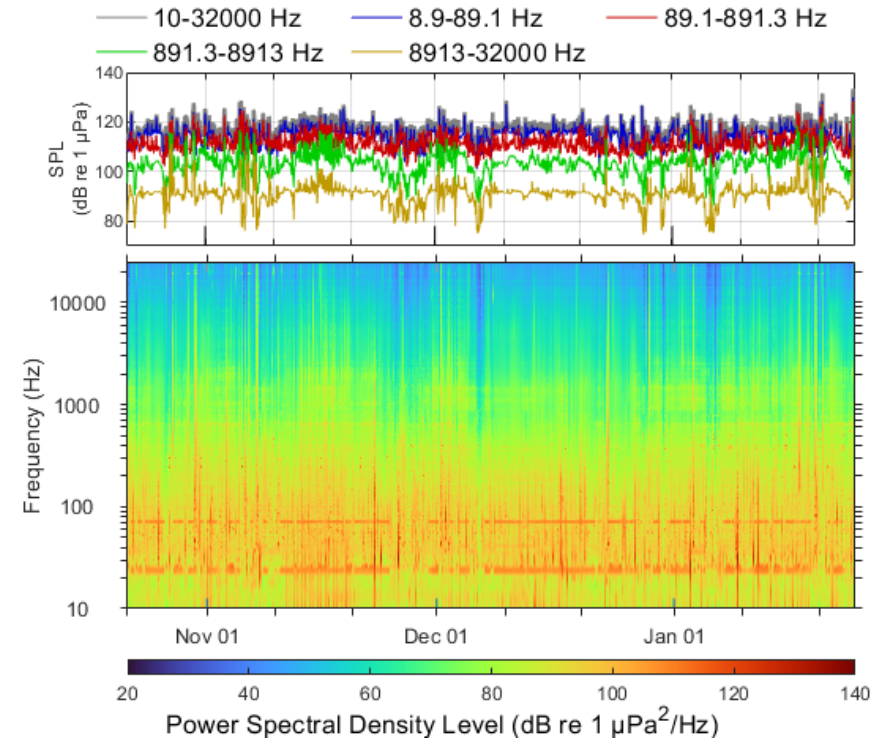
Total Sound Levels



CONTROL



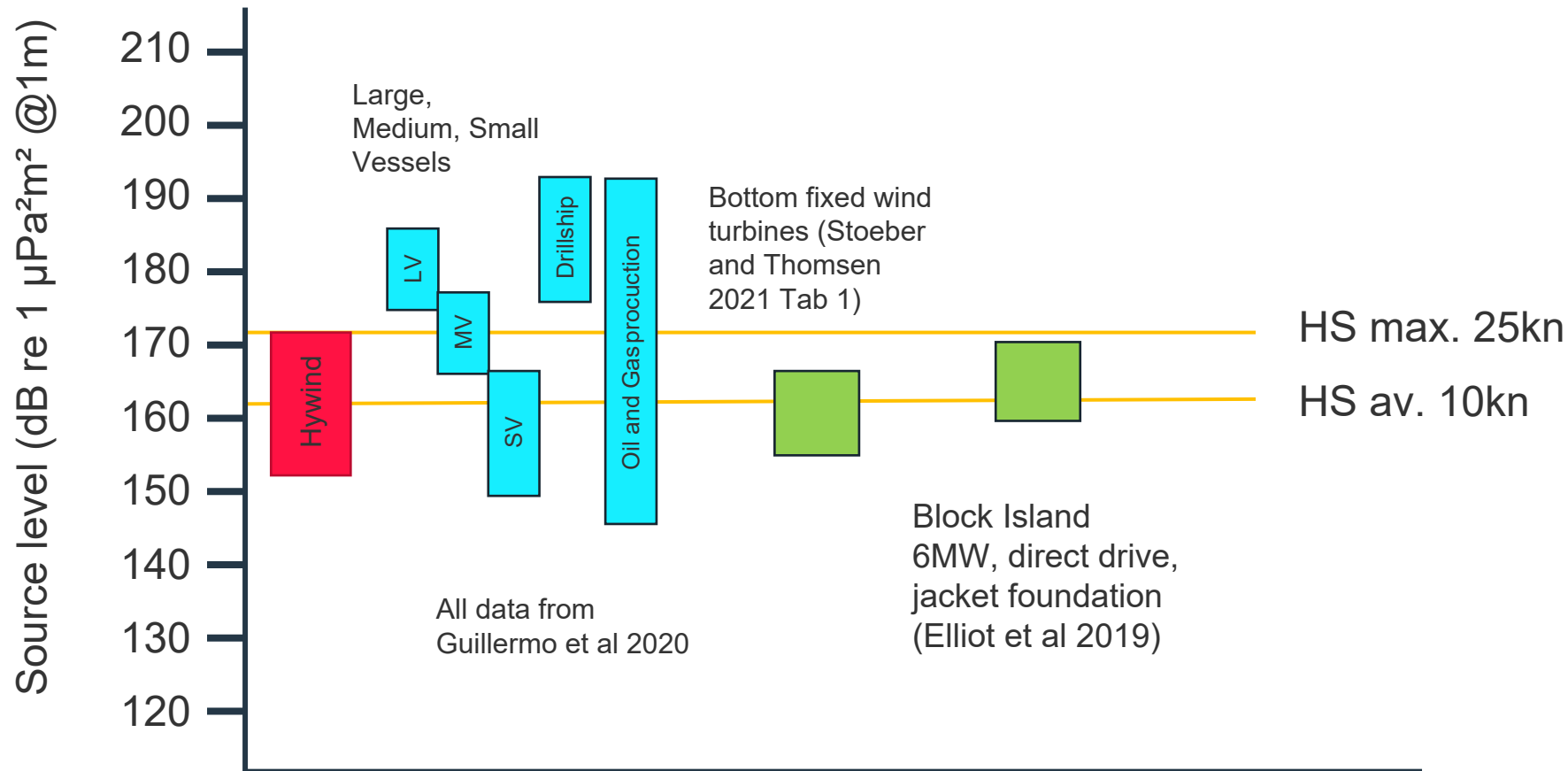
HYWIND



- Median sounds levels at 24 and 72 Hz: **10-20dB higher at Hywind site in this frequency bands**
- Higher levels at Hywind at 100–400 Hz – transient creaks



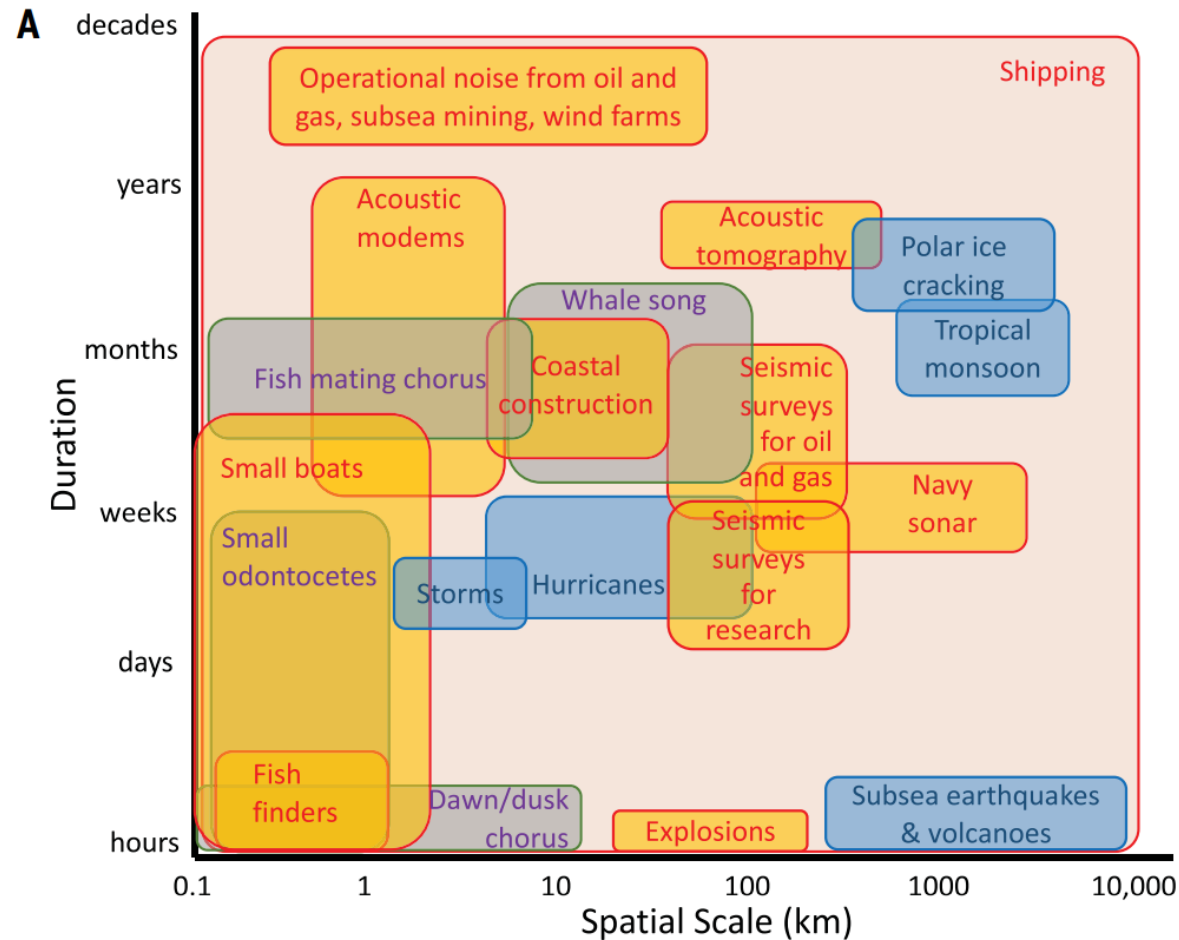
How strong is the noise compared to other sources of underwater noise? (for comparison only nonimpulsive noise sources are considered)



Note: Comparisons are difficult to make mostly due to different distances where measurement has been made and quality of reporting



Inventory of anthropogenic sound sources is changing.



Spatial scale of floating wind will be determined by the size of the area occupied plus some buffer zone.

The temporal scale is defined by the lifetime of the wind park (25-30 years)

Duarte C. M. et al 2021 "The soundscape of the Anthropocene ocean"



Thank you

Underwater noise and offshore wind

© Equinor ASA

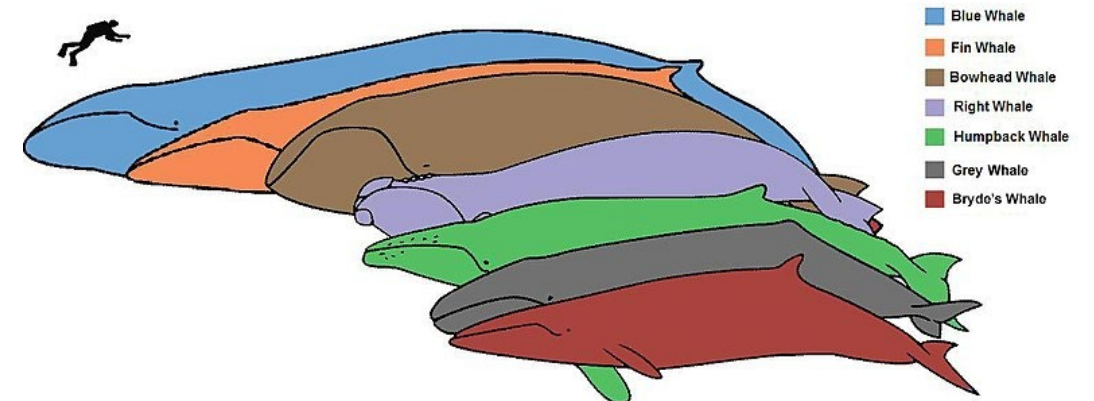
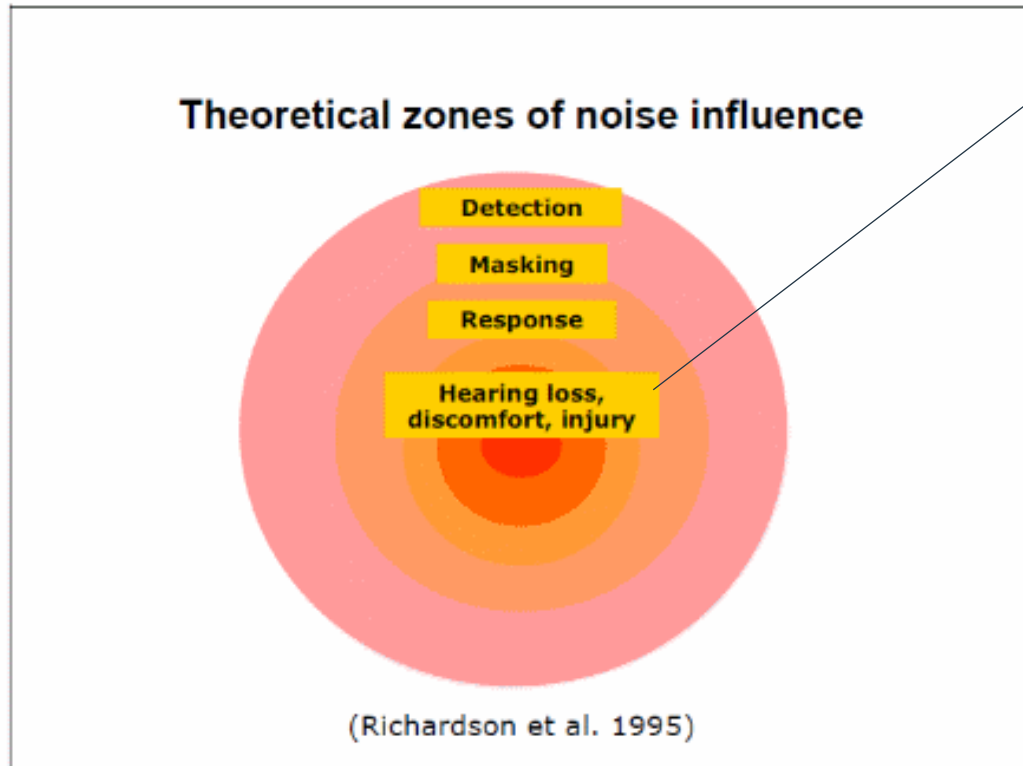
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Possible impact on marine organisms

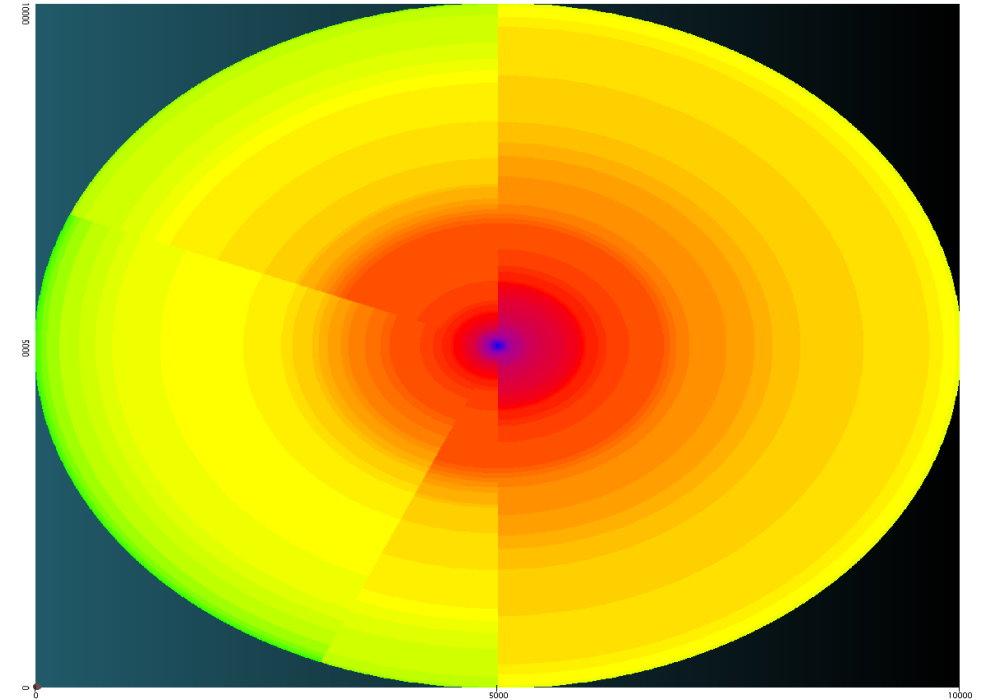
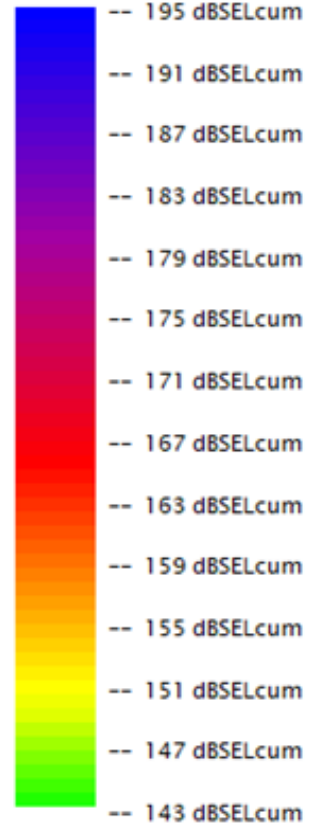
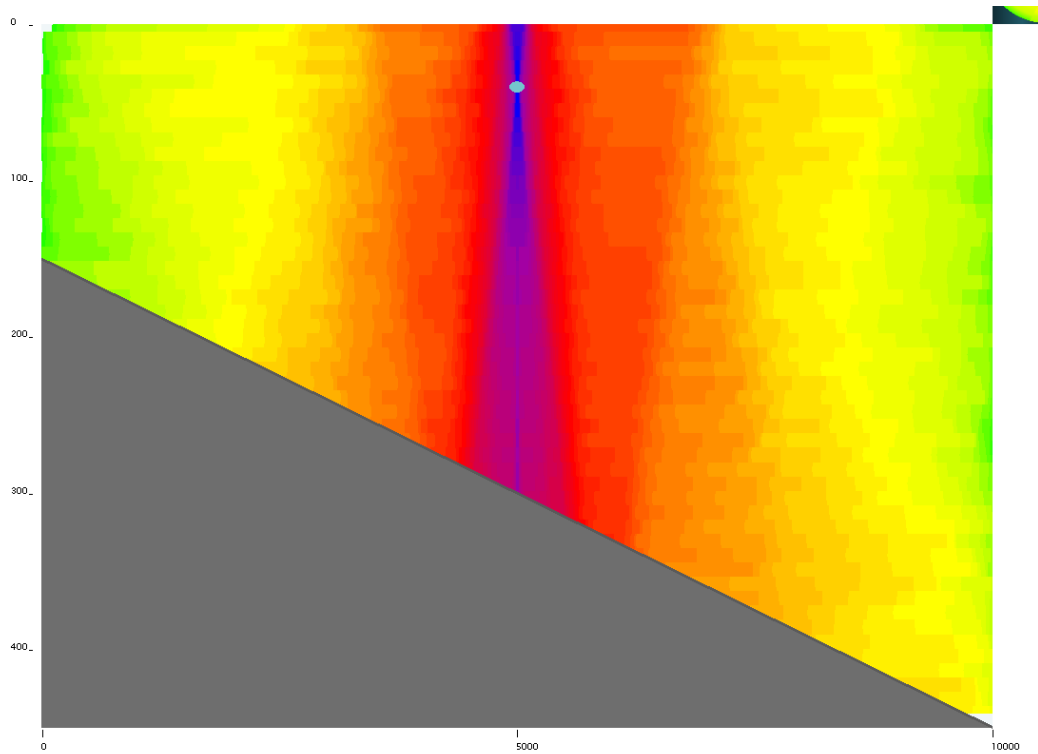
Main driver for rules and regulations. Internationally accepted threshold levels exist, but some uncertainty remain:

- Difficulties to estimate impact on populations from impact on individuals
- Lack of audiograms for some species, especially big whales, lead to very precautious assumption on possible impact thresholds and thus big impact zones.



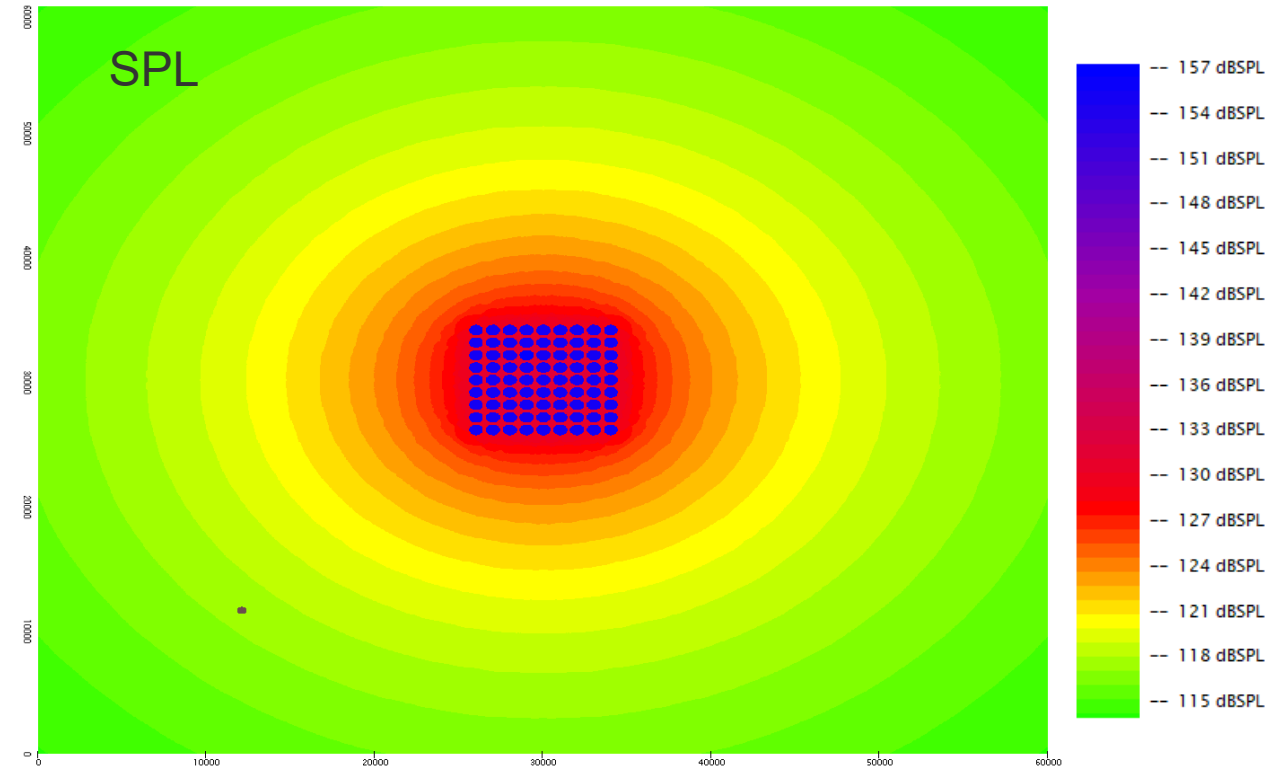
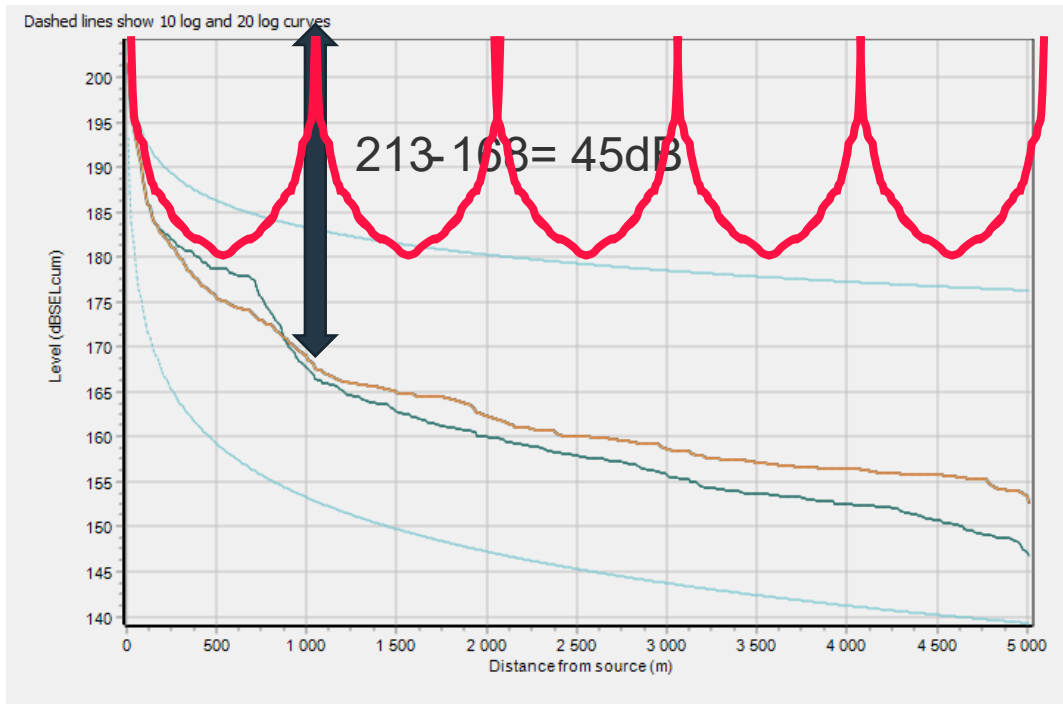


Sound Exposure Level(SEL) accumulated over 24h





Do individual turbines influence each other?

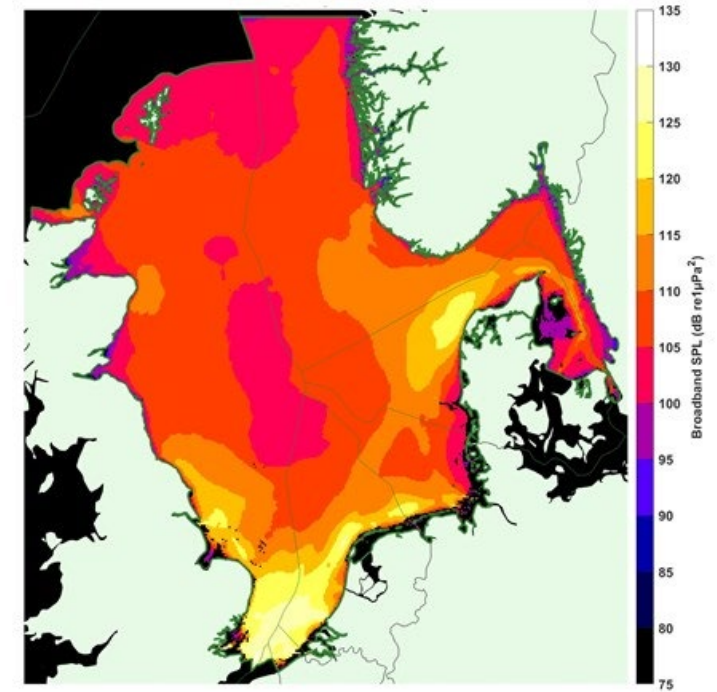
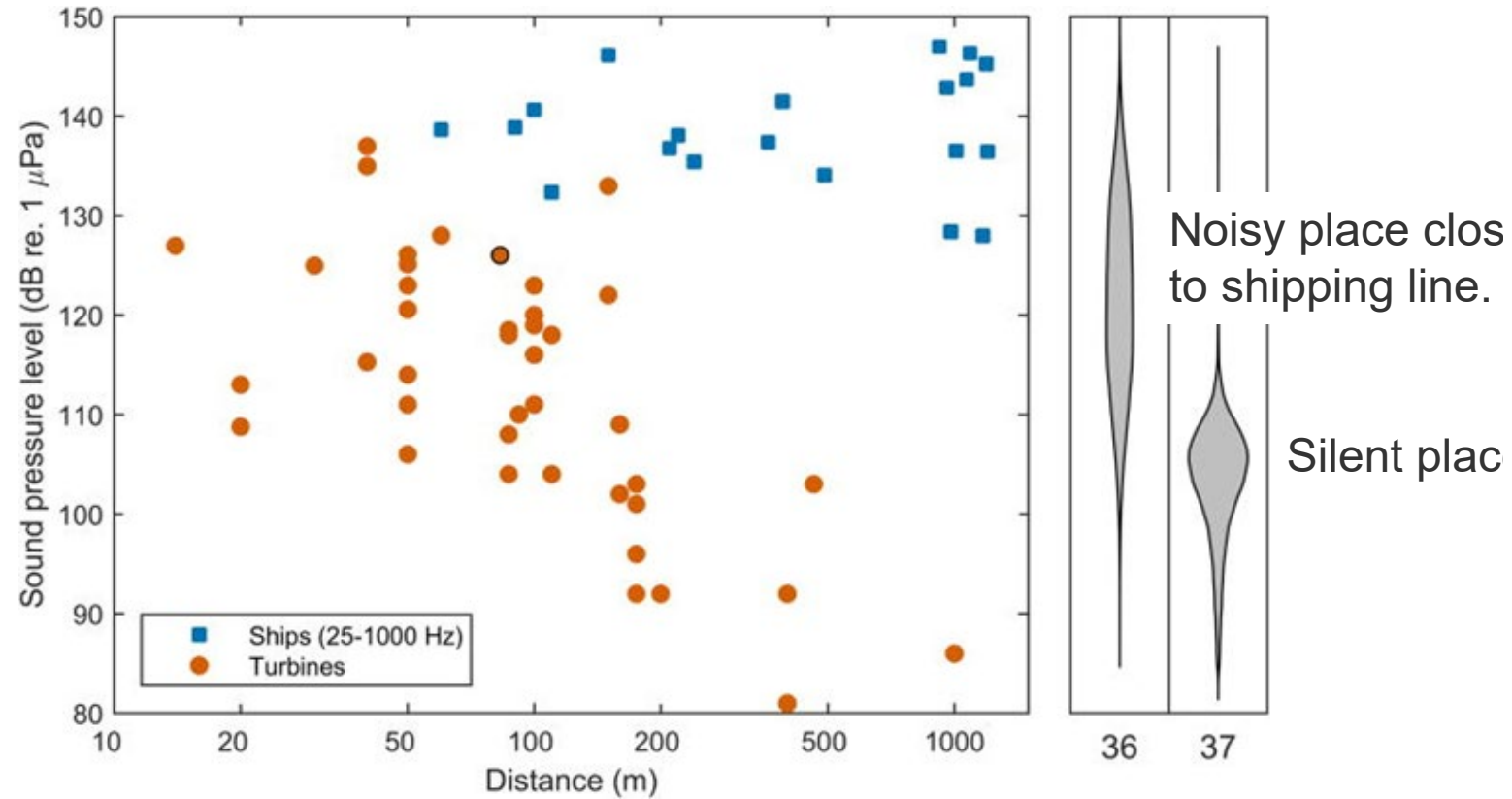


SELcum24hunweighted for very high frequency whales

(results from noise modelling done in dBSea, modeller Jürgen Weissenberger)



Windpark operational noise in relation to noise from shipping



JOMOPANS noise map

From Tougaard et al. 2020 " How loud is the underwater noise from operating offshore wind turbines!
J. Acoust. Soc. Am. 148, 2885-2893.