



Tolerance of harbour porpoise hearing to single airgun impulses

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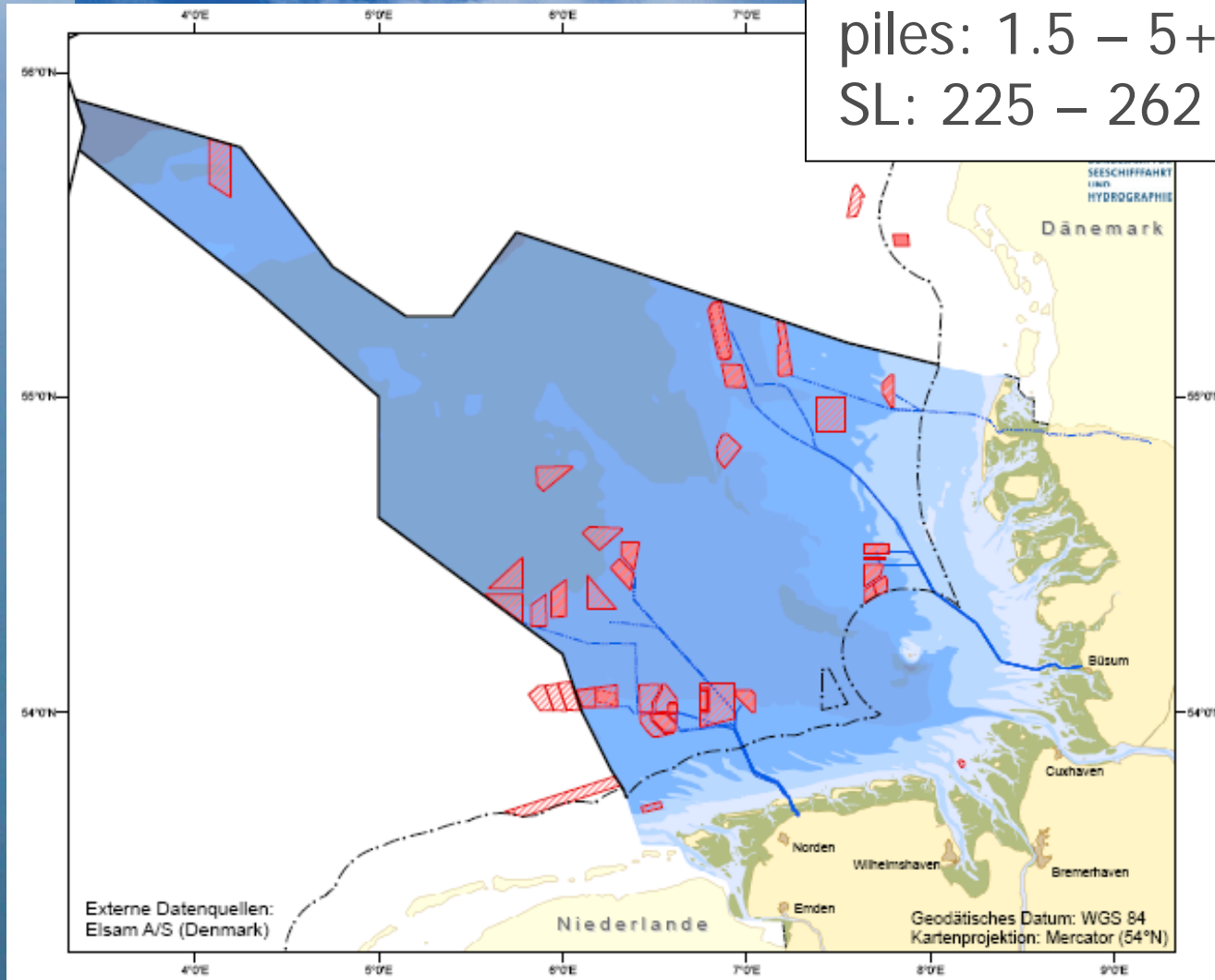
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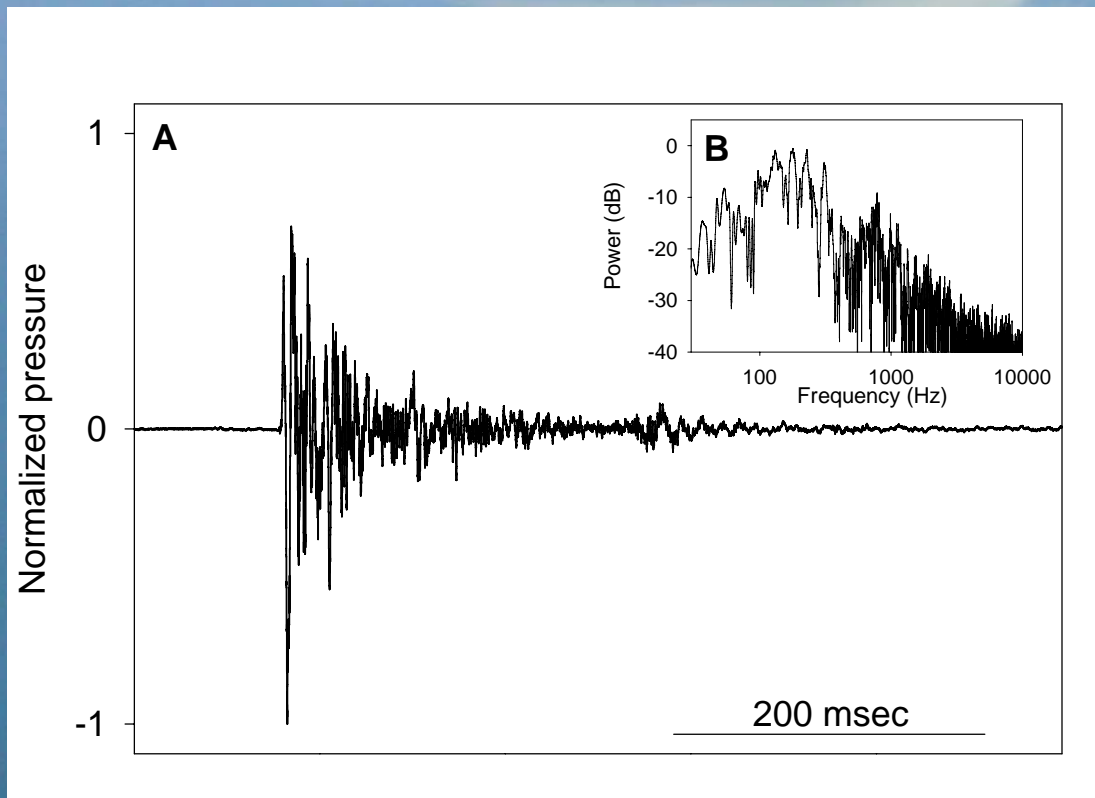
Offshore wind turbines

Ramming of foundation
piles: 1.5 – 5+ m diameter
SL: 225 – 262 dB_{peak} re 1 μPa



Noise Emission during Construction

Impact Pile driving

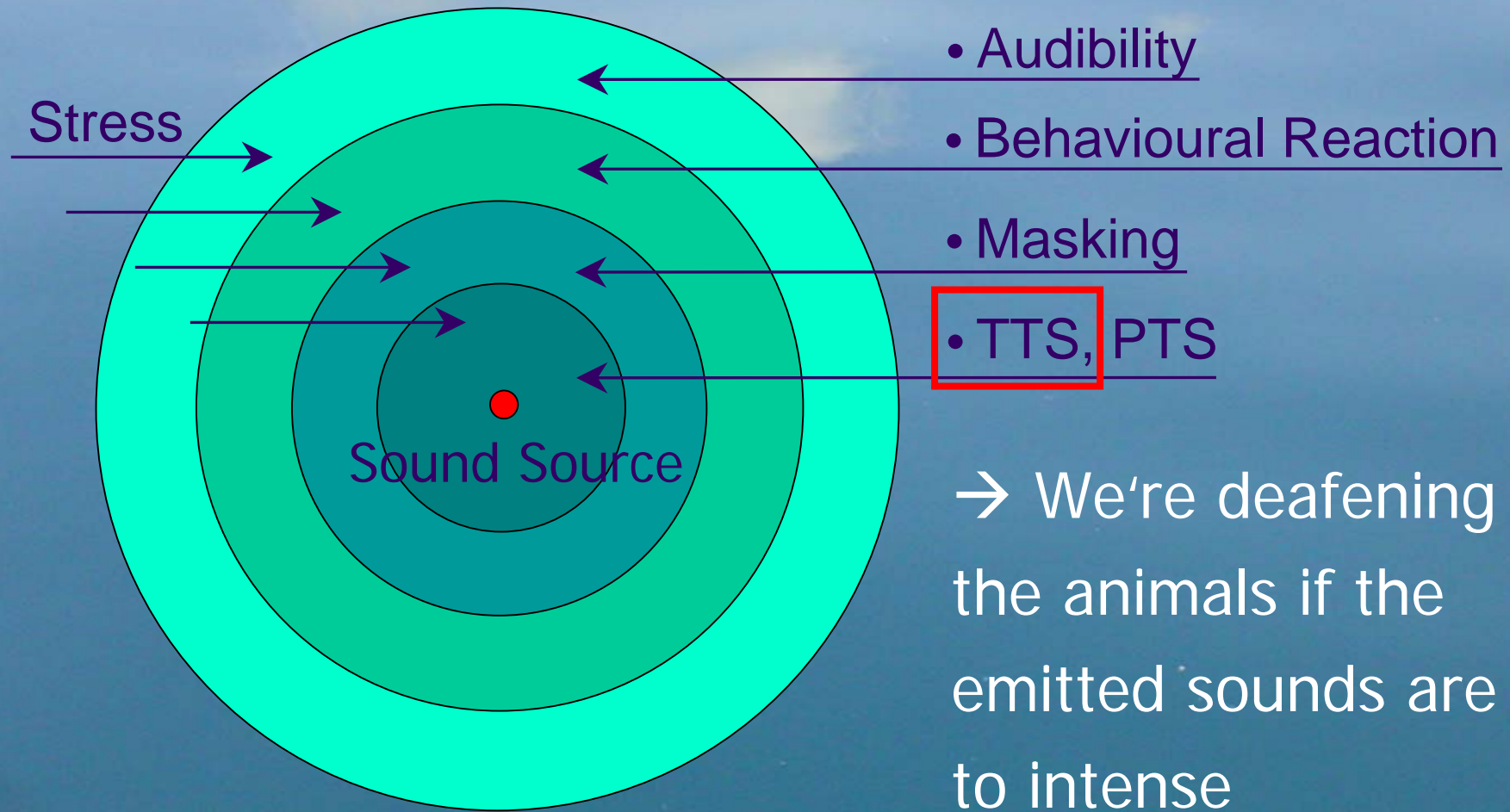


Frequency content:
Max. below 1 kHz

Components up to
100 kHz (Horns Rev)

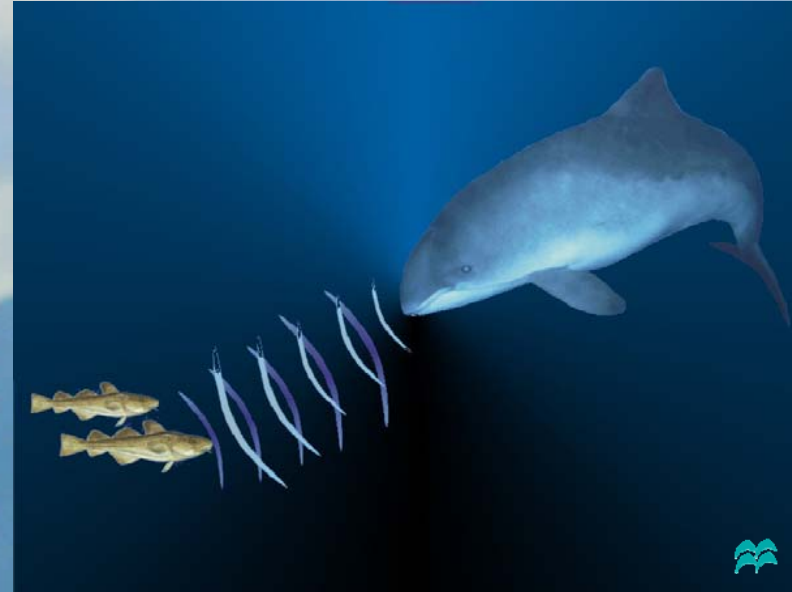
(Madsen et al., 2006)

Effects of Sound



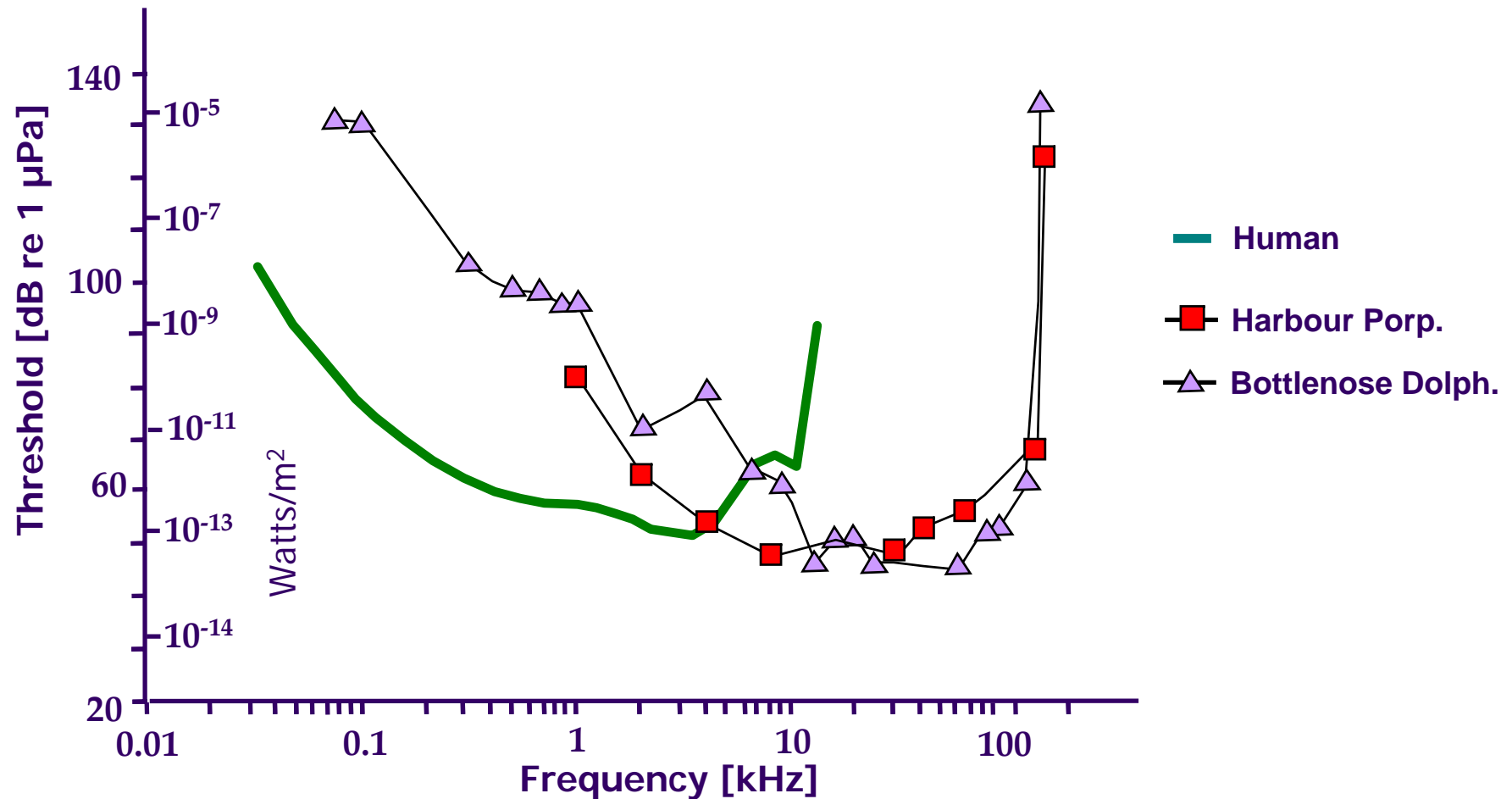
Sound and marine mammals

- Finding prey
- Orientation
- Predator avoidance
- Obstacle avoidance
- Communication

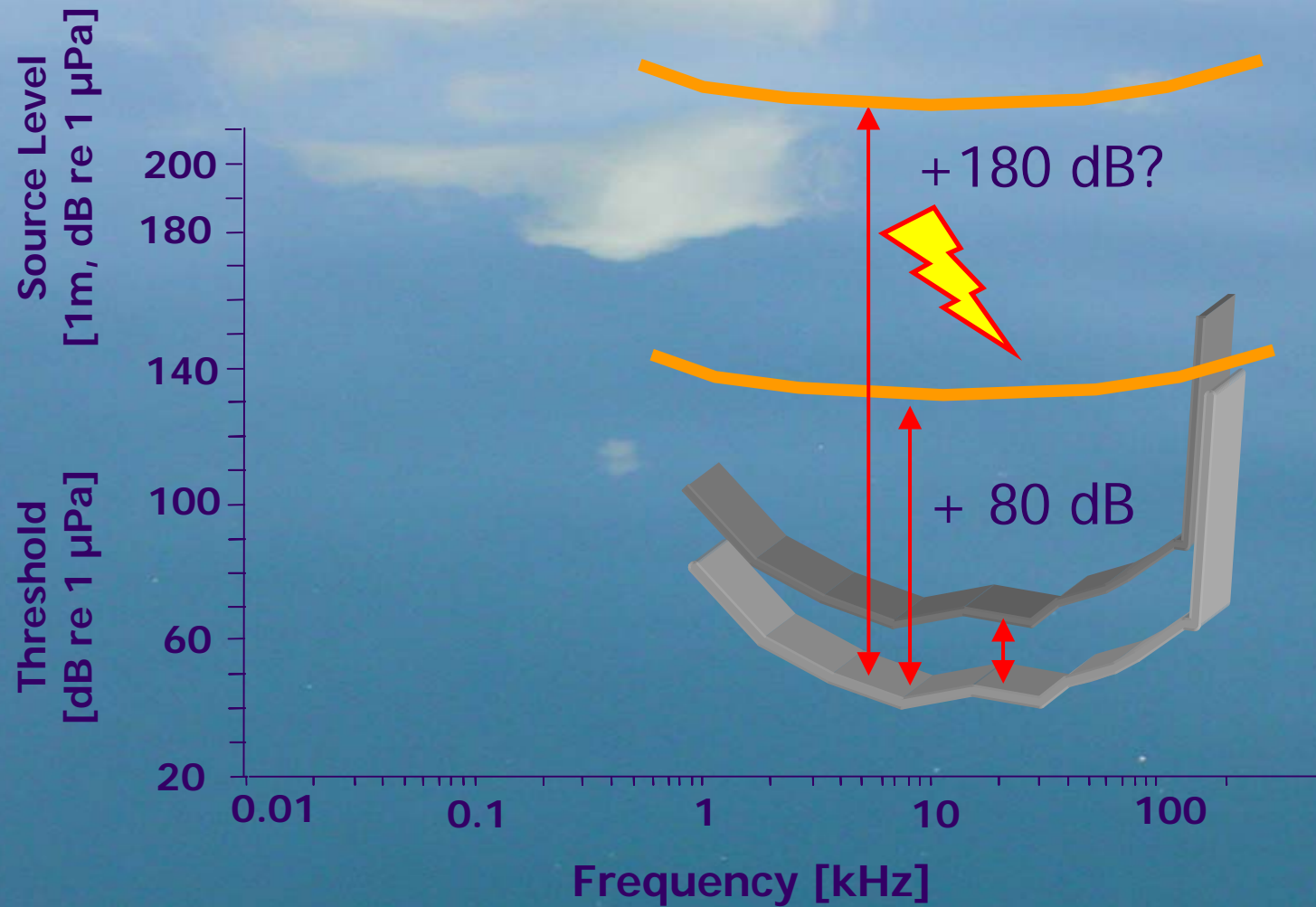


Underwater sound is one of the primary triggers for behavioural reactions in marine mammals!

Hearing in toothed whales



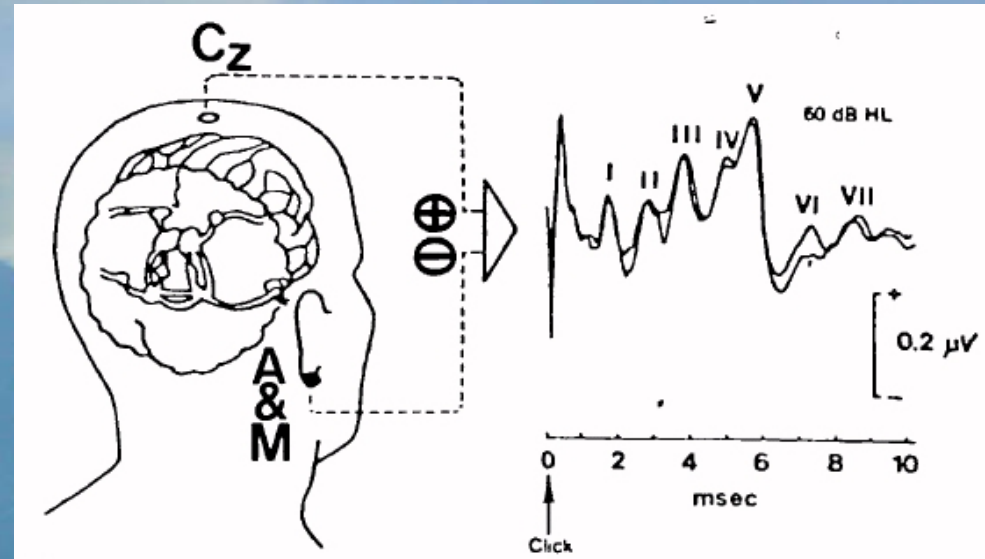
Temporary Threshold Shift, TTS



Auditory Evoked Potentials (AEP)



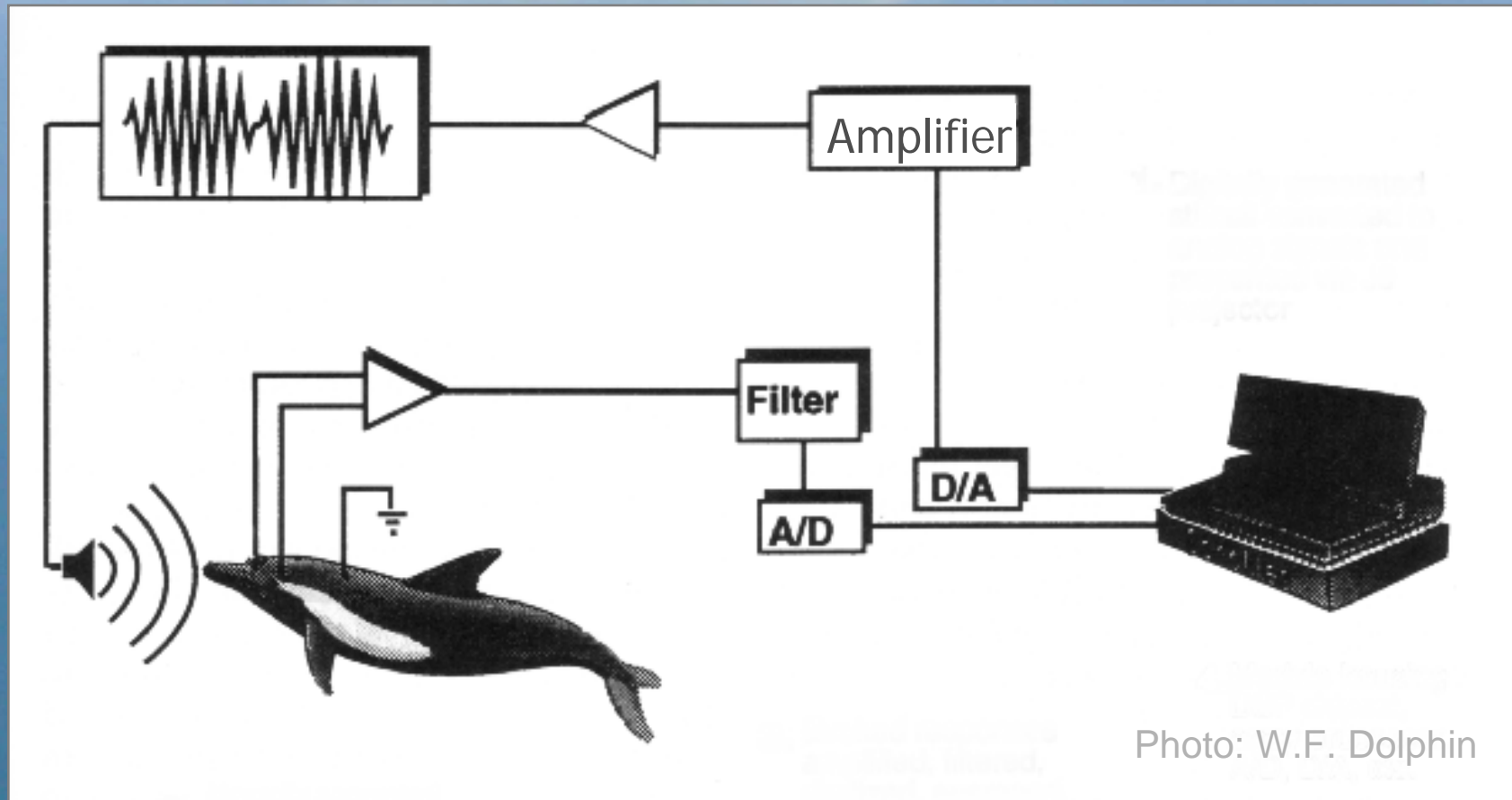
AEP-Method
(Auditory Evoked Potentials)



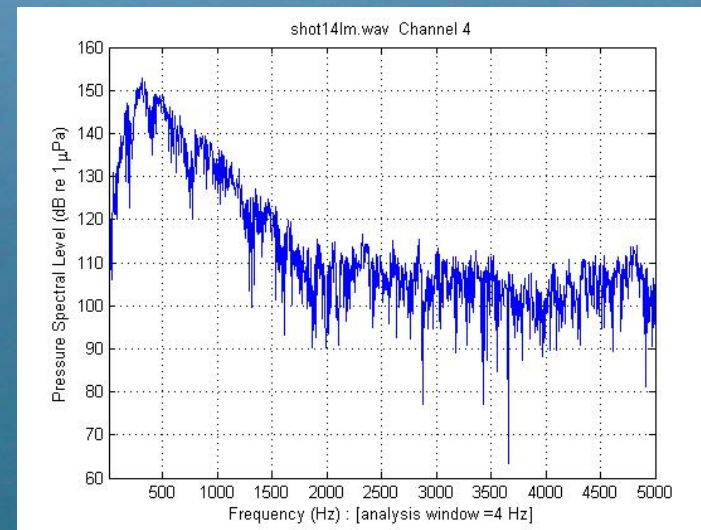
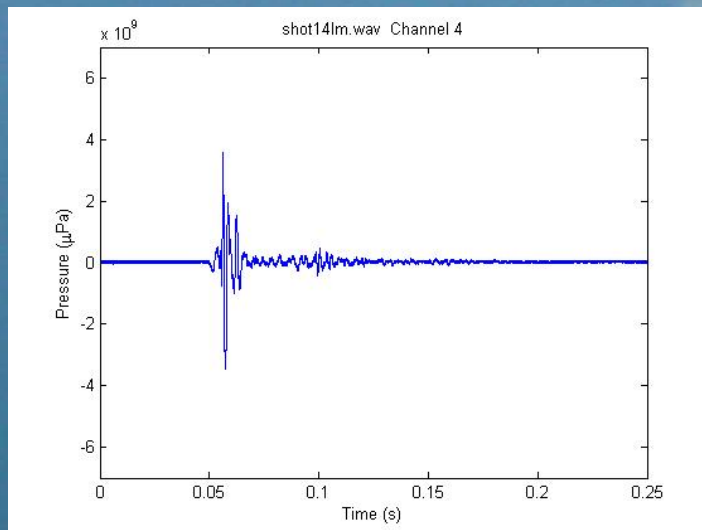
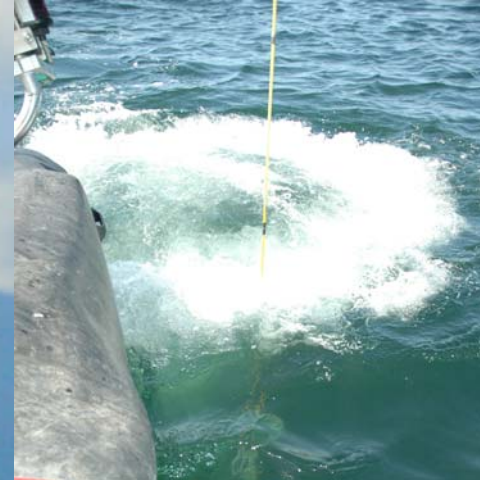
Advantages:

- No training required
- Non-invasive
- Rapid

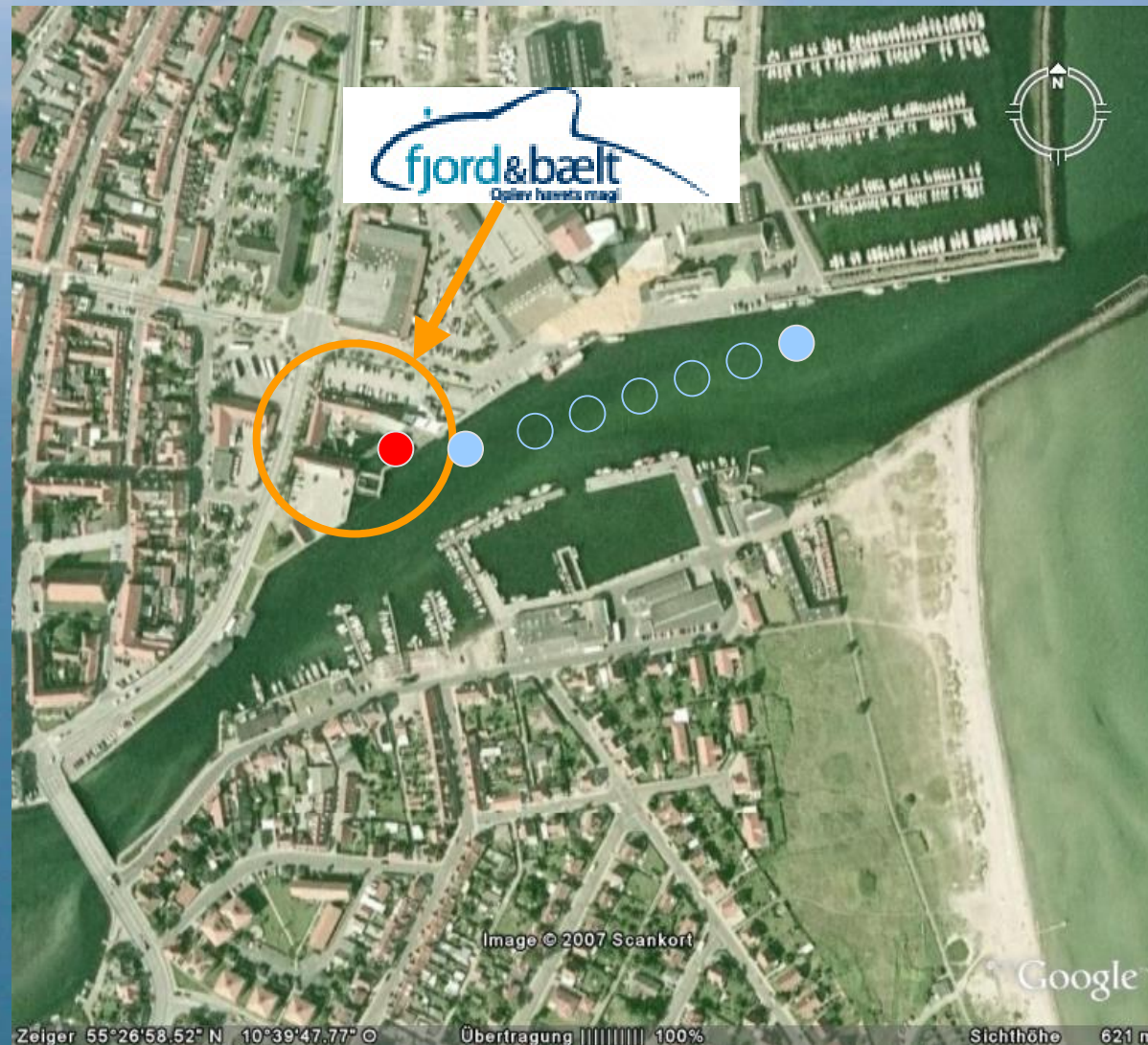
Testing marine mammal hearing



TTS-tests on a harbour porpoise

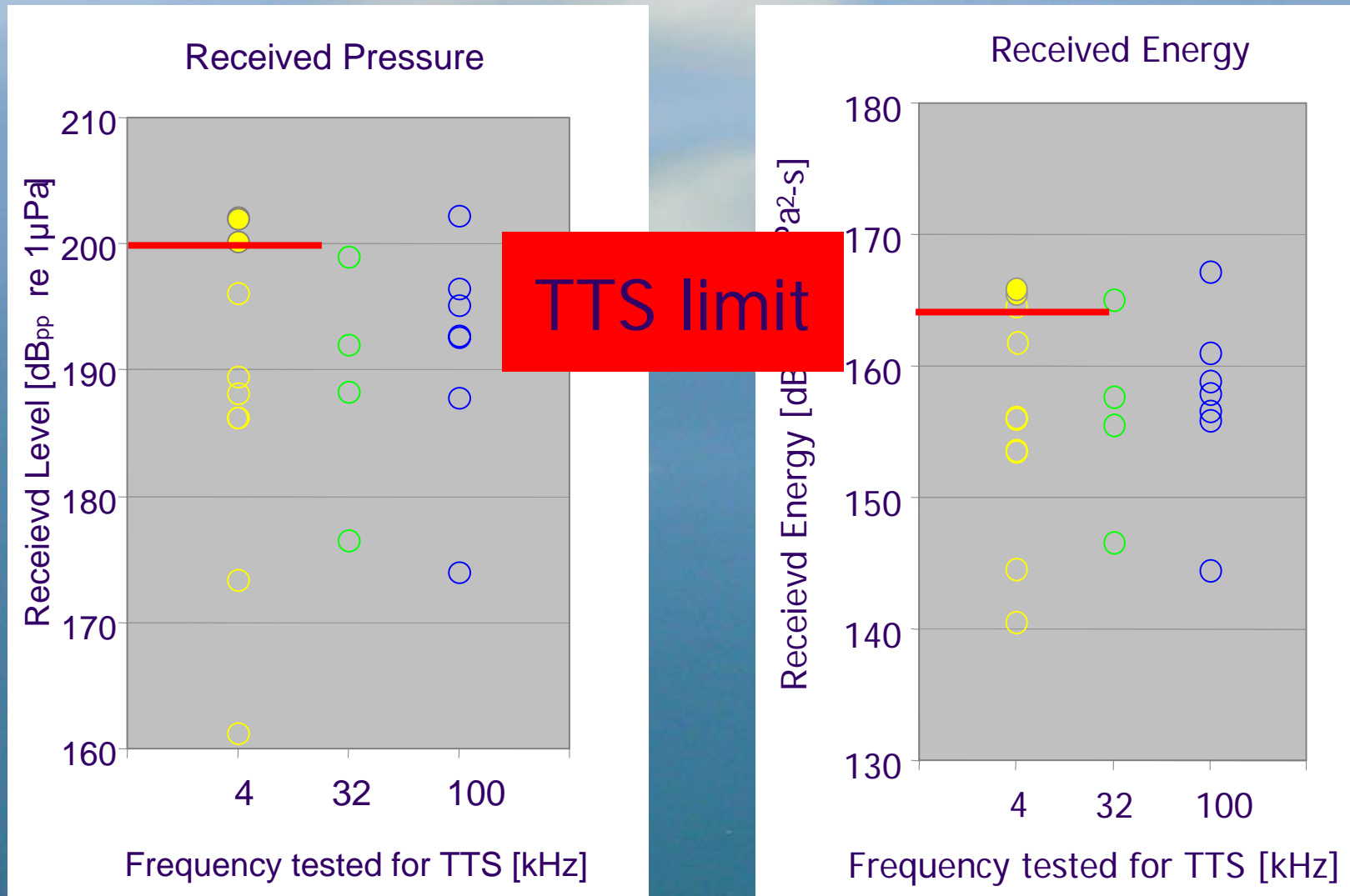


TTS-tests on a harbour porpoise



TTS-limit for harbour porpoises

(for single exposure to impulsive sounds)



Results - Summary

1. TTS was proven at 4 kHz at a received pressure level of 200 dB_{peak} re 1 μPa and a received energy of 164 dB re 1 μPa²s respectively
2. Hearing threshold was elevated at 32 kHz and not affected at 100 kHz
3. Recovery from TTS took more than 1 day (at a TTS level of 9.1 dB)

... next steps

- Tolerance to multiple exposures and longer stimuli
 - Enlarge sample size / include other species
 - Development of an acoustic logger (for anthropogenic sounds, i.e. low frequency sound)
 - Development of a non-invasive attachment method for harbour porpoises
-
- Conclusions on the effect of anthropogenic sound on the behaviour of marine mammals

Key messages / 1

- Harbour porpoises are negatively affected by intense sound at lower levels than marine mammal species tested so far
- A noise exposure criterion combining sound pressure level ($200 \text{ dB}_{\text{peak}}$ re $1 \mu\text{Pa}$) and sound exposure level (164 dB re $1 \mu\text{Pa}^2\text{s}$) should be applied for anthropogenic activities
- The cumulative effect of multiple exposures and continuous signals on harbour porpoises needs to be tested

Key messages / 2

- Simple and effective sound mitigation measures need to be developed and applied wherever possible
- Seals (harbour seal + grey seal) need to be considered in this context too