ECS2010 Workshop: Pile driving in offshore windfarms

Effects on harbour porpoises, mitigation measures and standards, 21 March 2010, Stralsund

Pile Driving Noise Reduction Using New Hydro Sound Dampers

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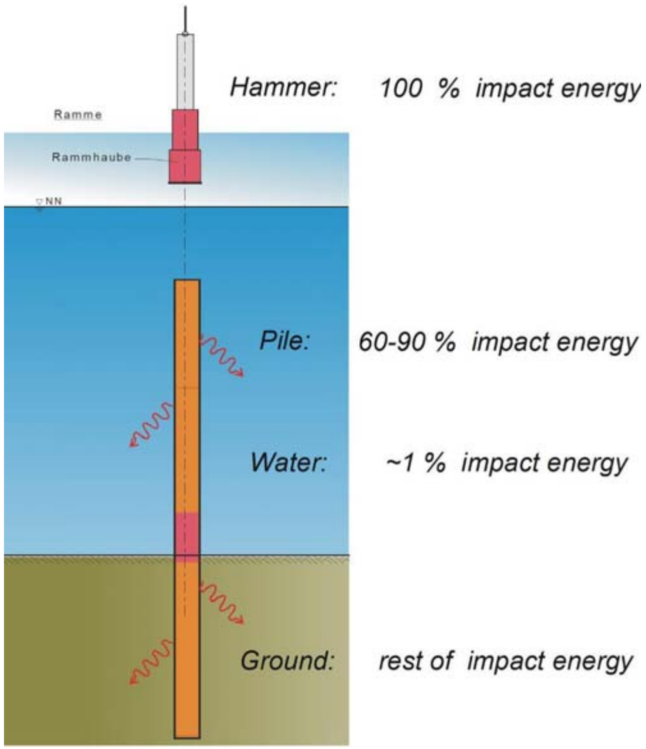
Pile driving underwater noise emissions: potentially harmful to marine life.

Pile driving noise emissions:



- **direct radiation from pile**
- **indirect radiation from the ground nearby**

Proposed noise reduction methods:

Elmer, K.-H.: *Noise Emissions during pile driving of offshore foundations,*
2nd Scientific Confrence on the Use of OWE, ***BMU, Febr. 2007****, Berlin:*

Noise reducing methods and possible amounts of reduction

Primary noise reducing methods:

- *Prolonging the impulse contact time:* *expected* ***10 – 15 dB***
- *Using vibrators for small piles:* *expected* ***15 – 20 dB***

Secondary noise reducing methods:

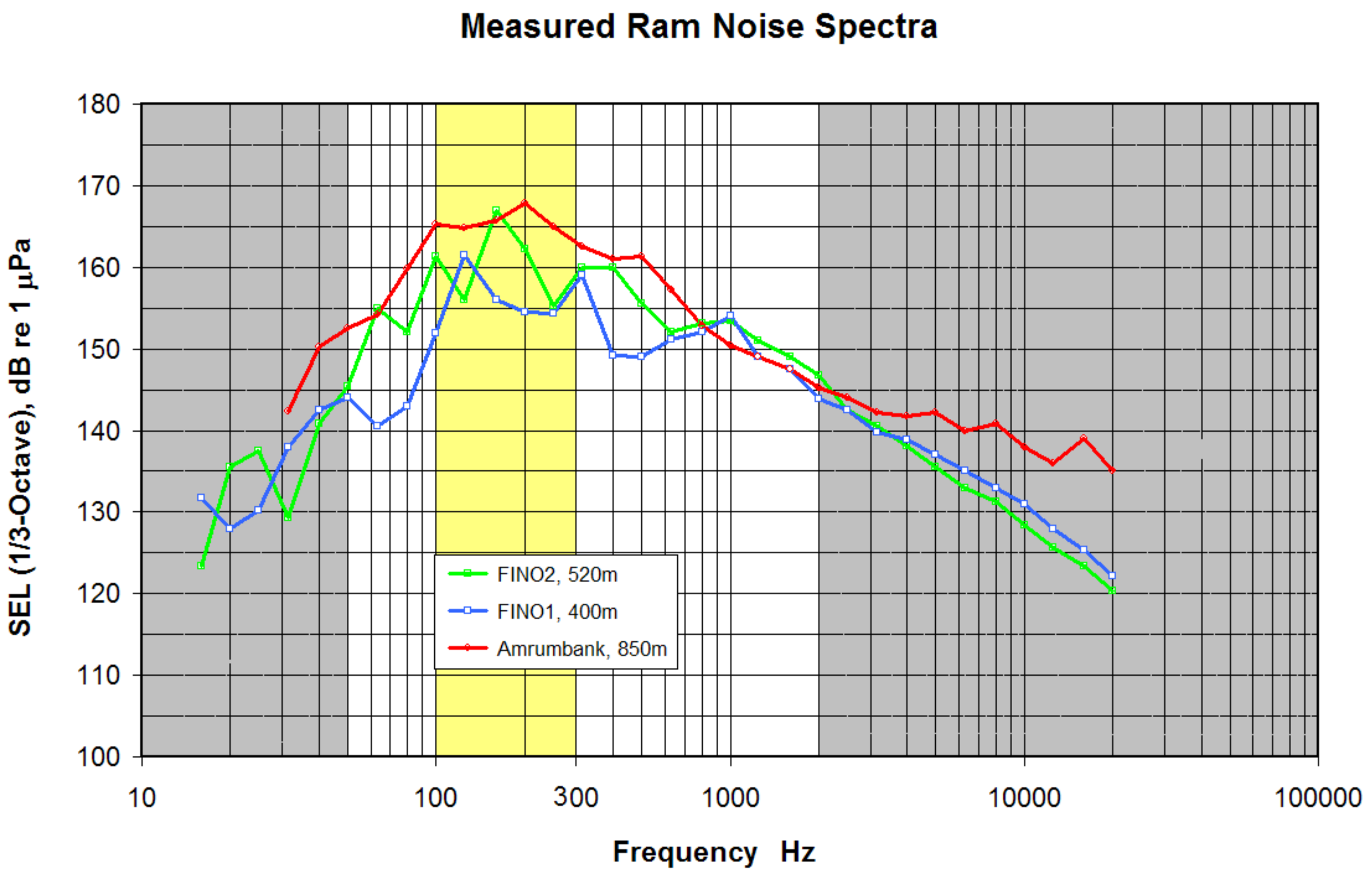
- *Using a curtain of air bubbles around the pile:* *expected* ***10 – 15 dB***
- *Foam-coated tube as noise barrier over the pile: meas./exp.* ***10 – 15 dB***

Realized offshore applications of bubble curtains result 10 – 13 dB reductions

- **FINO3 in 2008**
- **„alpha ventus“ in 2009**

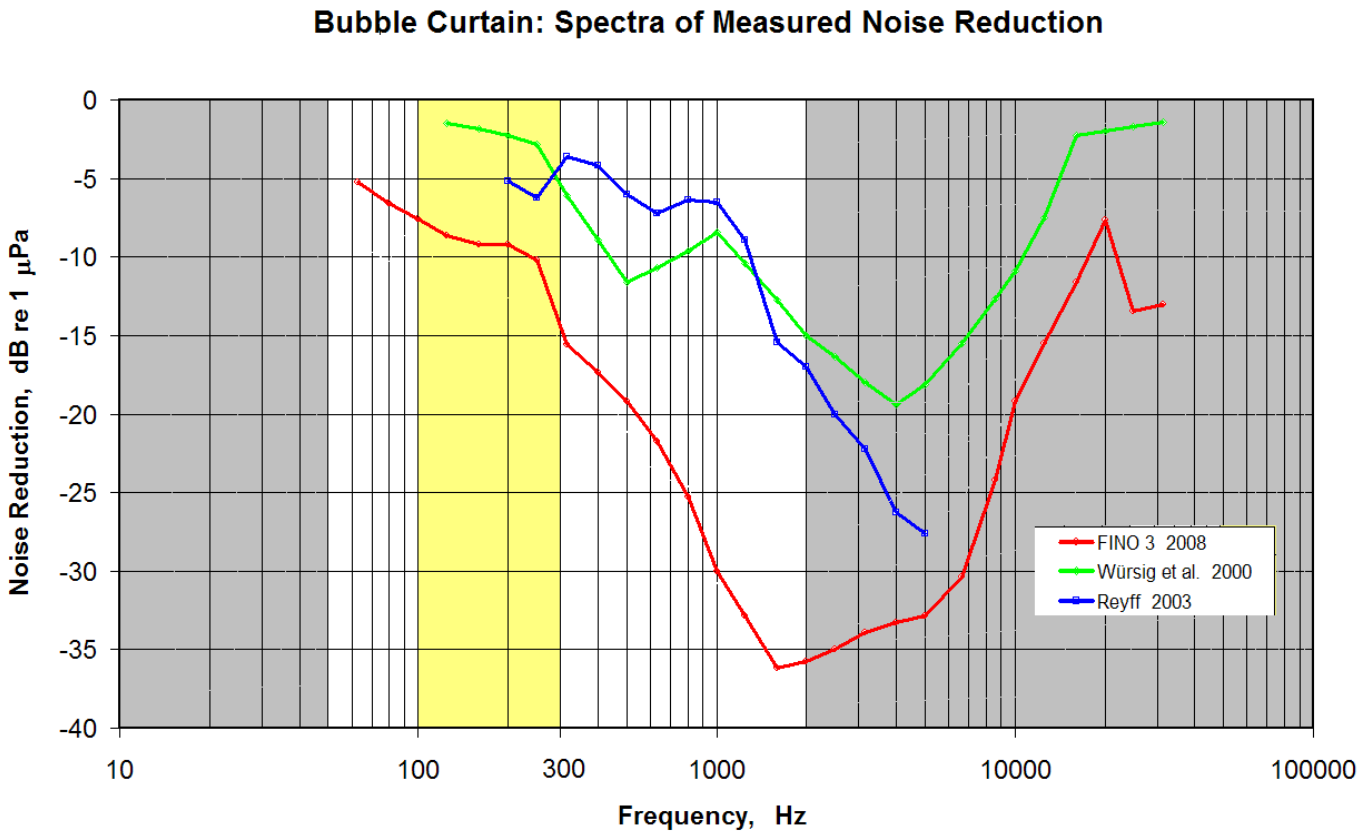
Spectral impact noise of hydraulic hammer:

Important frequency range: 50 Hz – 2000 Hz; Peaks: 100 Hz – 300 Hz



Betke, K.: *Minderung von Unterwassergeräuschen beim Bau von OWEA, FINO3 Workshop, Okt. 2008.*

Unconstrained air bubble curtains (ABC) are a very effective to high frequencies not in the sound level decisive frequency range between: 100 Hz – 300 Hz



Betke, K.: *Minderung von Unterwassergeräuschen beim Bau von OWEA, FINO3 Workshop, Okt. 2008.*
Reyff, JA.:*Underwater sound pressures associated with the restrike of the PIDP pile; Illingw.& Rodk., 2003.*
Würsig,B, *Greene,GR, Jefferson,TA: Development of an air bubble curtain, Mar. Environ. Res.,49,79-93,2000.*

Theory of air bubbles summarized in final BMU report: „SCHALL2“, 2007:

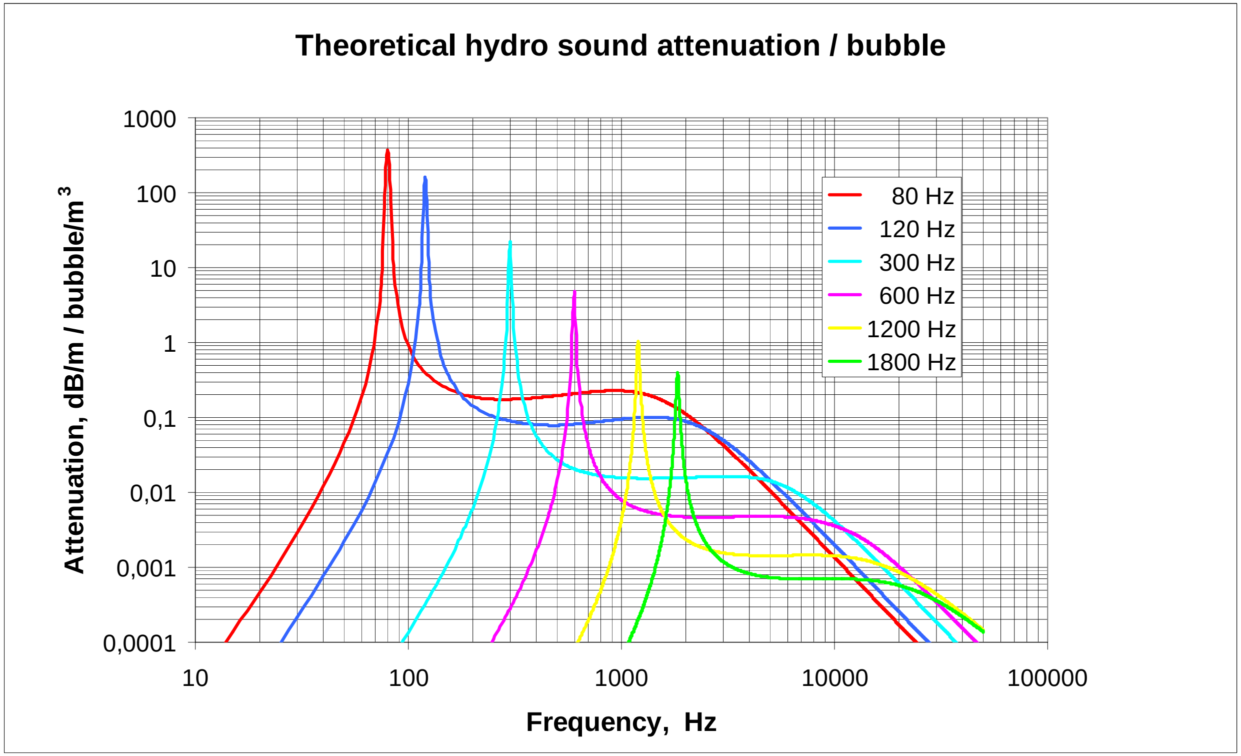
Elmer,K.-H., Betke,K., Neumann,T.: *Standard Procedures for the Determination and Assessment of Noise Impact on Sea Life by Offshore Wind Farms, (in german): „**SCHALL 2“, Final report, BMU 0329947, March 2007.***

based on: Medwin, H.: *Sounds in the Sea; Cambridge Univ. Press, Cambridge 2005*

Air bubble curtains:

- low frequency reflexions (impedance steps)
- mainly scattering and absorption effects in high frequency range
- extreme resonant effects of small, stable bubbles with high attenuation
- unstable large bubbles with decreasing resonant effects below 1 kHz
- poor effects in lower frequency range (except: constrained ABC)
- air bubbles are uncontrolled, dividing of large bubbles, chaotic movements
- offshore influence of tide current
- compressed air supply is needed

Theoretical sound attenuation of single, resonant air bubbles



Requirements:

- constant shapes of bubbles (spherical)
- steady state resonant exitation

Pile driving reality of ABC:

- dividing and chaotic movement of large bubbles
- short impact loads from pile driving

➔ **No benefit from very high attenuation potential of large bubbles with low frequencies**

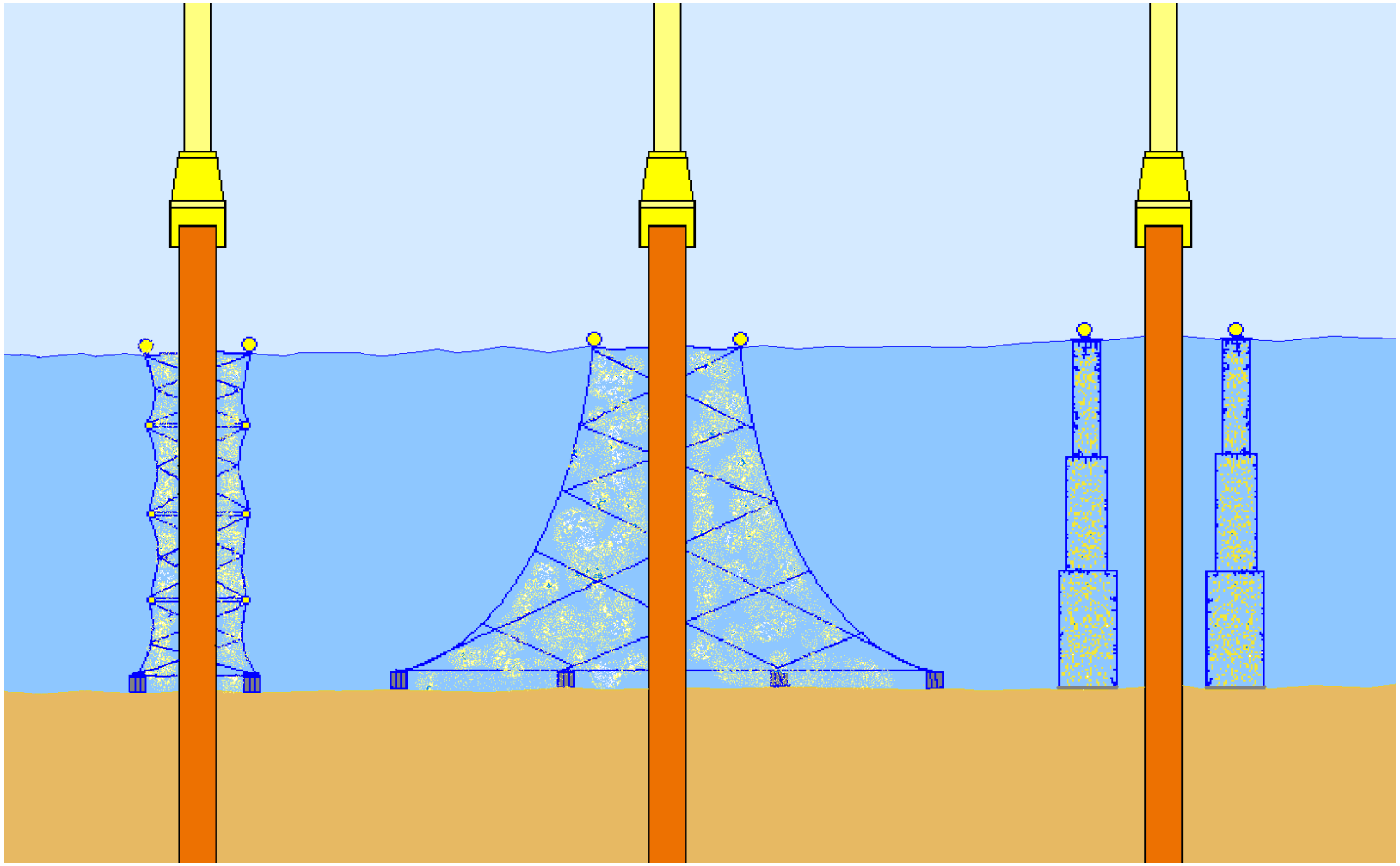
New „Hydro Sound Dampers“ overcome disadvantages:

shape stability and resonant effects even in lower frequency range

Hydro Sound Dampers:

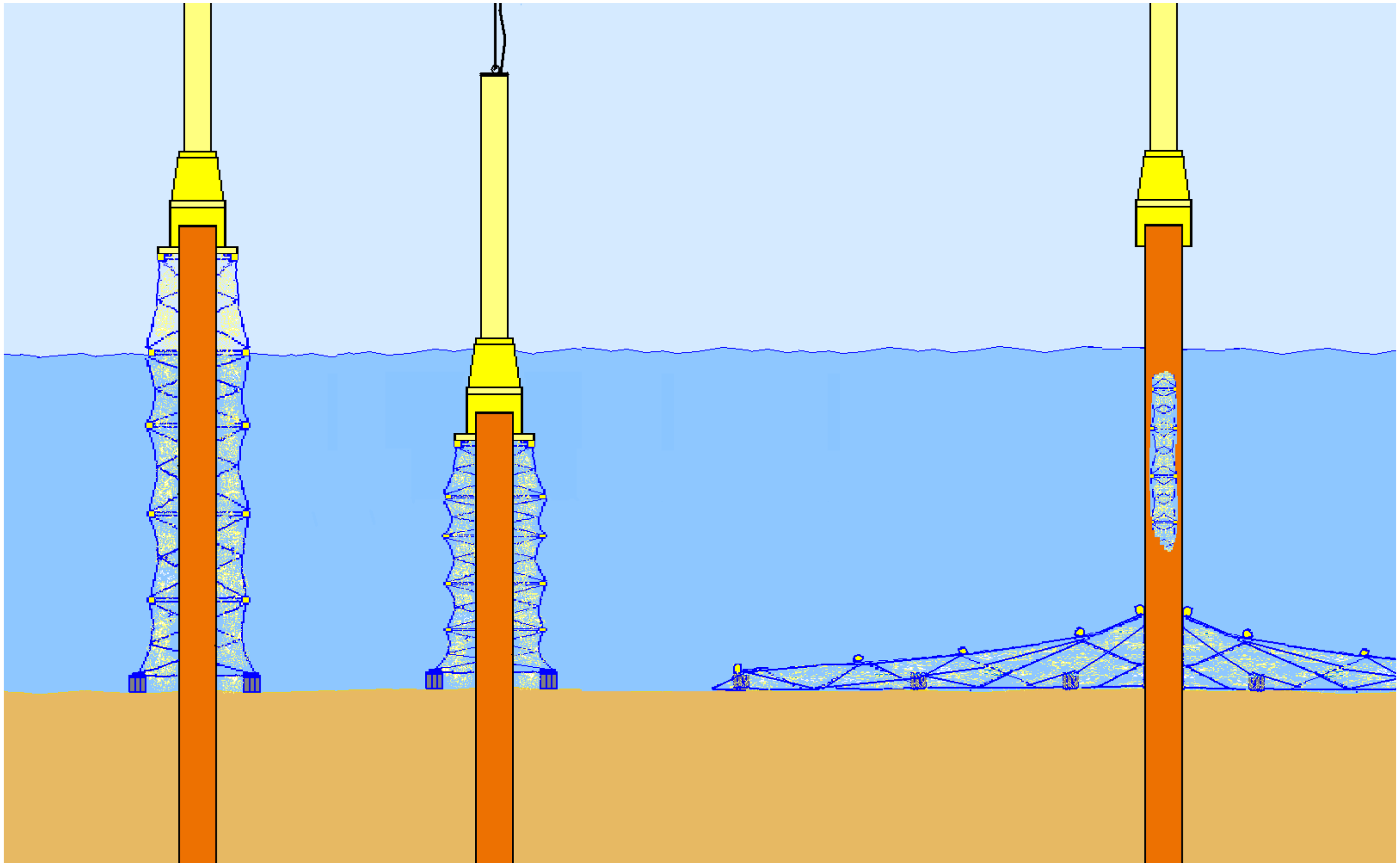
- using gas filled envelope bodies (balloons) instead of free bubbles
- scattering, absorption and additional material damping effects
- allow extreme resonant effects in decisive frequency range 100 – 300 Hz
- fully controlled elast. balloons, fixed to fishing nets or frames
- number, size, damping rate and distribution are controlled / designed
- only small offshore influence of tide current
- no supply with compressed air is needed
- easy adaptable to diffent applications

Offshore applications of „Hydro Sound Dampers“, HSD



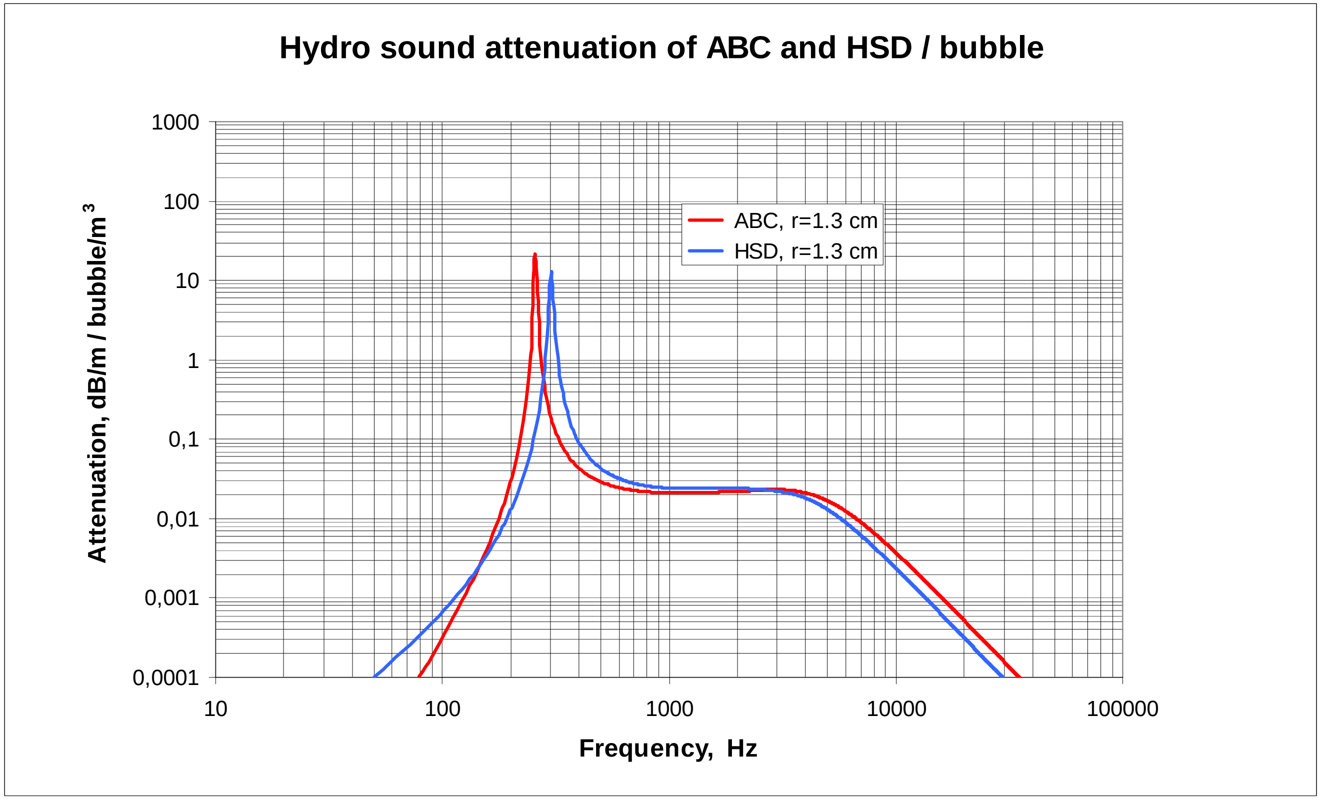
staggered HSD-grid **large fishing net with HSD** **telescopic HSD-frames**

Offshore applications of „Hydro Sound Dampers“, HSD



HSD-grid fixed to piling frames **HSD-net: ground covering and inside of pile**

Sound Attenuation of a single air bubble and a single hydro sound damper

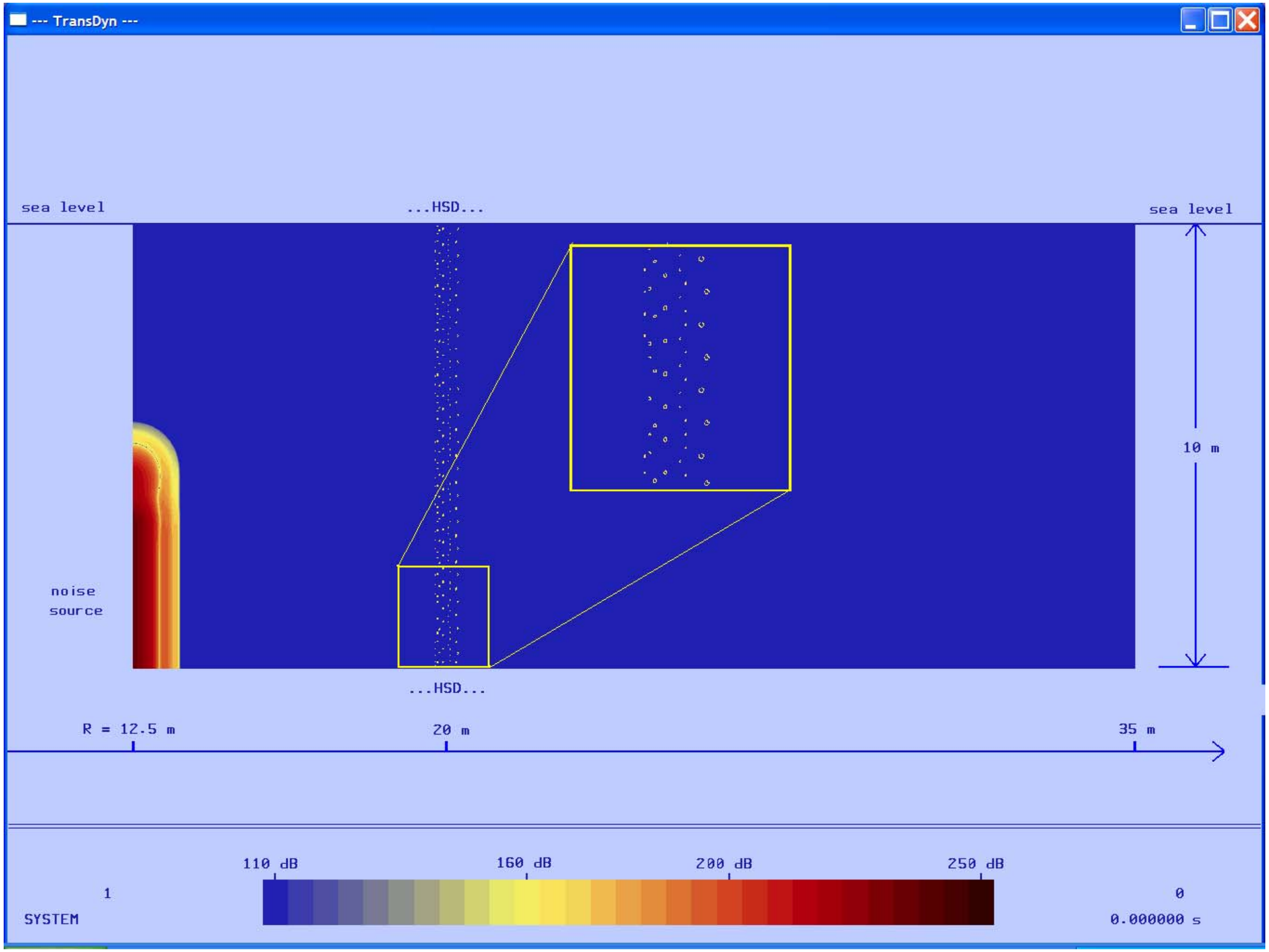


Comments:

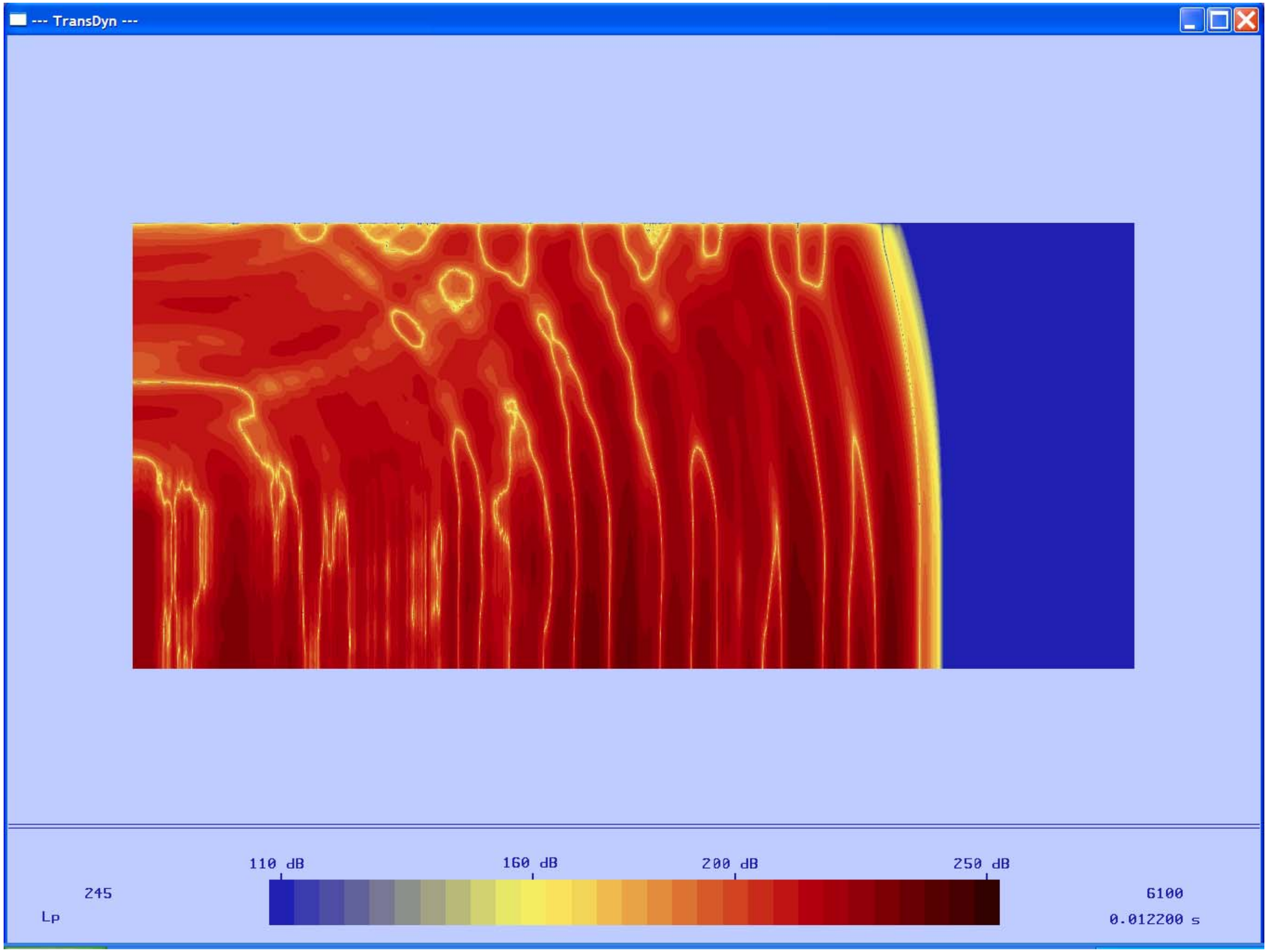
A constant shape of an air bubble with 250 Hz resonant frequency is not real, but HSD.
Increased stiffness from envelope material and additional inside pressure cause higher resonant frequencies of HSD.

Numerical example of HSD noise reduction:

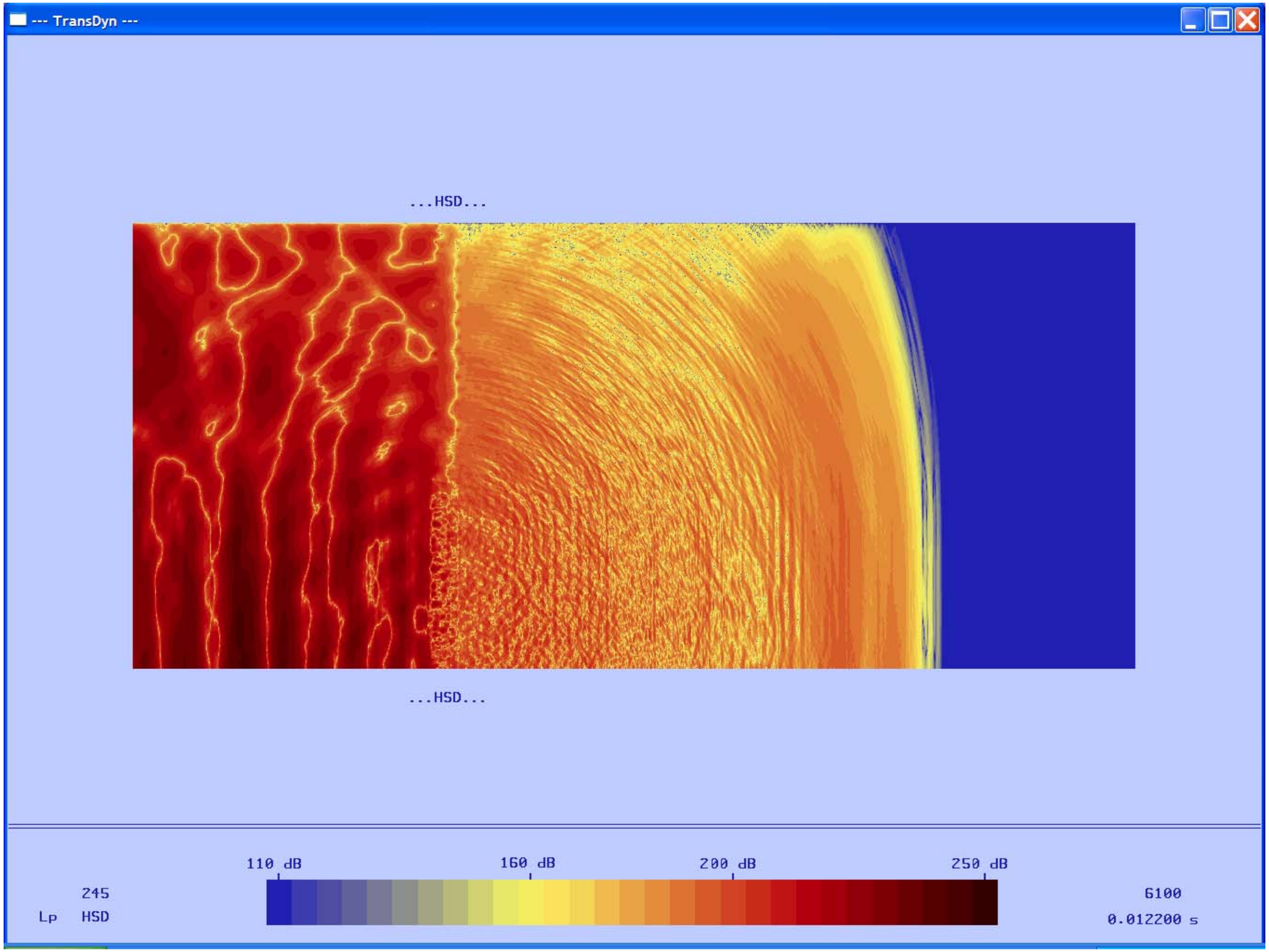
pile: 12.5 m distance (on left side)
load: measured sound pressure



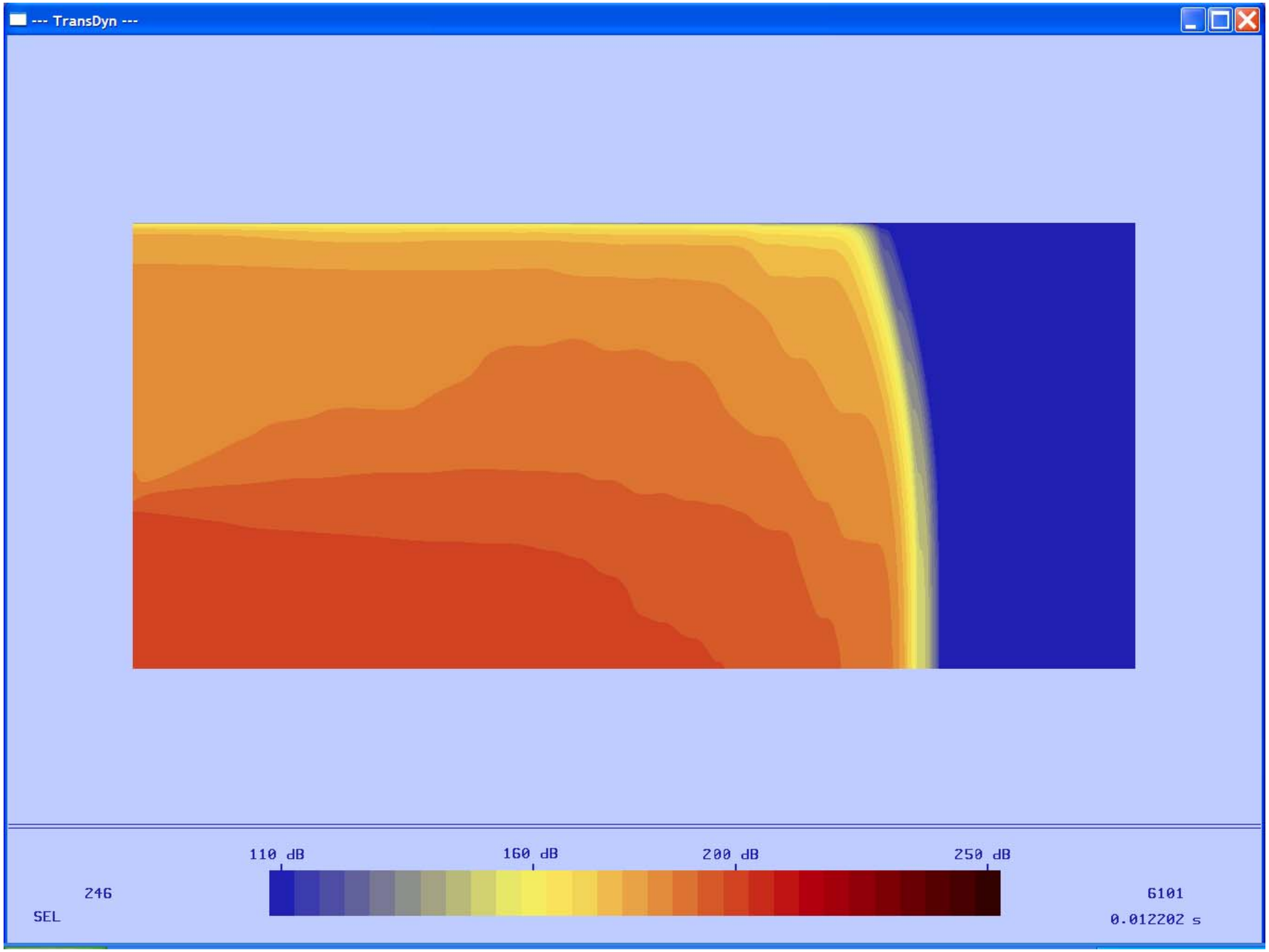
Distribution of hydro sound pressure level L_p; freezed at time t = 0.0122 s



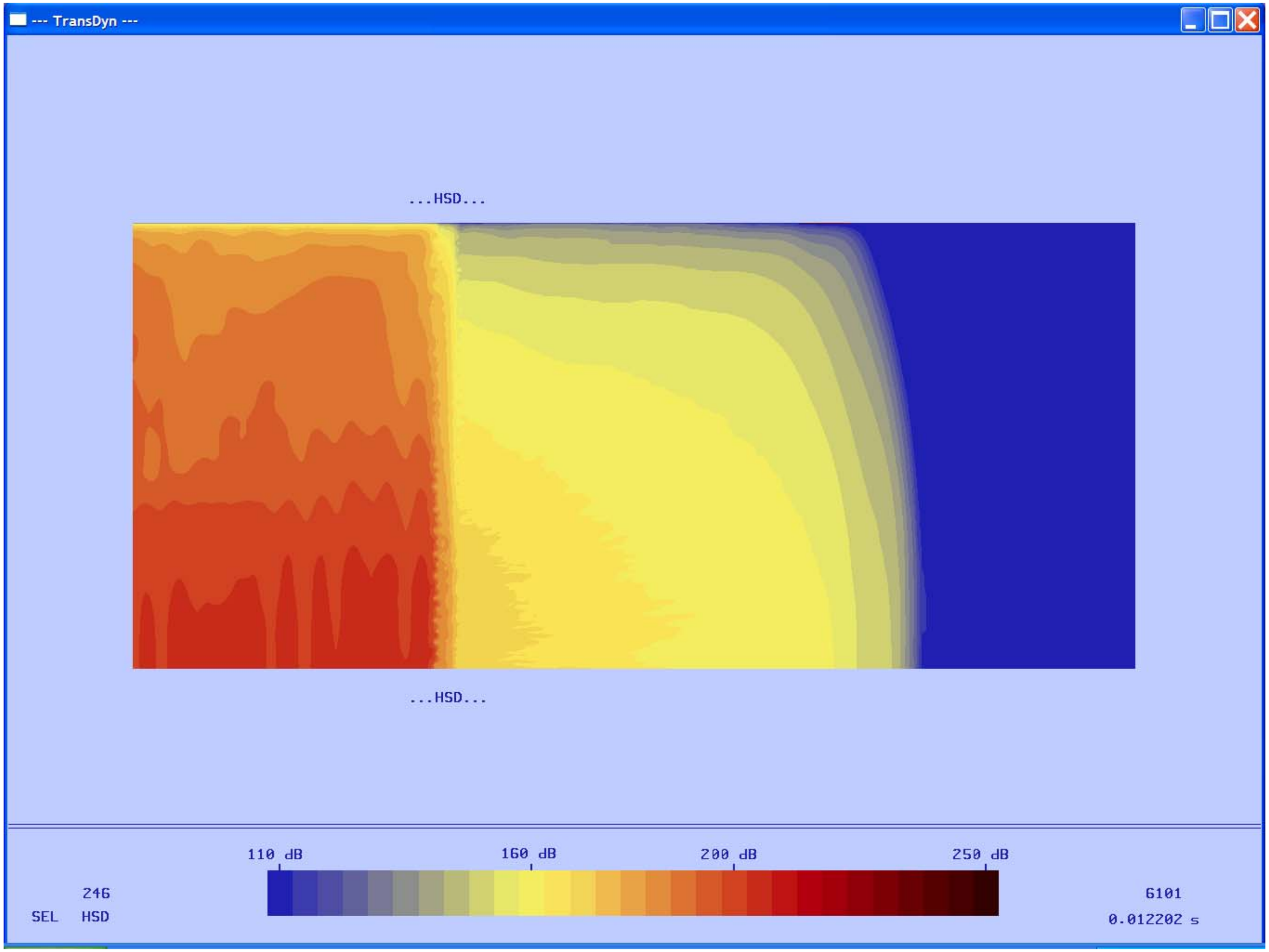
Distribution of hydro sound pressure level L_p; HSD noise reduct.: > 30 dB



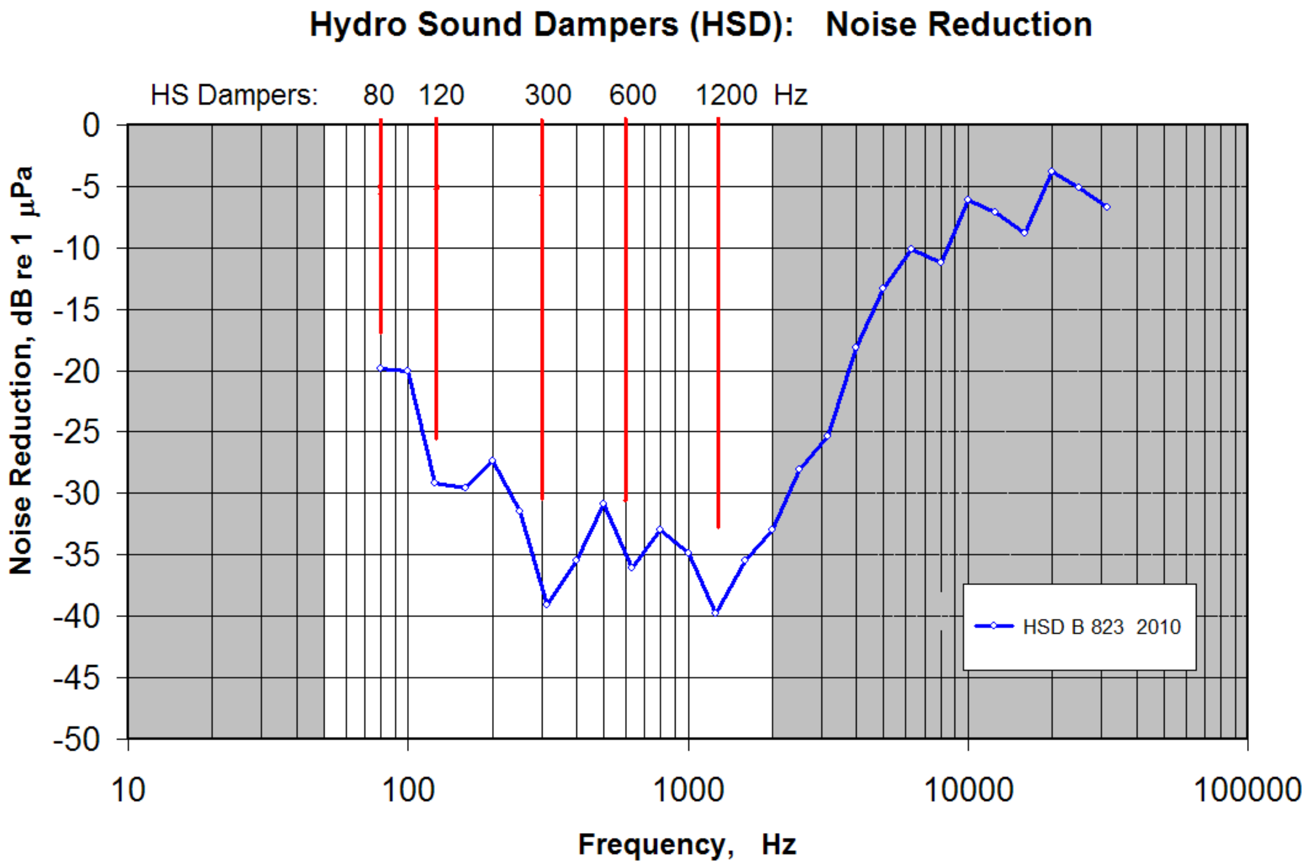
Distribution of single event level SEL; freezed at time t = 0.0122 s



Distribution of single event level SEL; HSD noise reduct.: 23 dB - 30 dB



Spectrum of calculated SEL reduction using Hydro Sound Dampers



„Hydro Sound Dampers“

Summary:

- **balloons instead of free bubbles**
- **allow high attenuation effects between 50 Hz – 5000 Hz**
- **possible resonant effects in SEL decisive frequency range: 100 – 300 Hz**
- **fully controlled HSD, fixed to fishing nets or frames**
- **only small offshore influence of tide current**
- **no supply with compressed air is needed**
- **easy adaptable to diffent applications:**

  inside pile, covering ground, operating OWT and underw. explosions
- **not expensive (construction, transport, installation)**
- **applied for a patent**
- **next steps: testing, optimization and offshore applications of HSD**