Mitigation of noise impact:

The use of soft starts, acoustic deterrents and barrier methods

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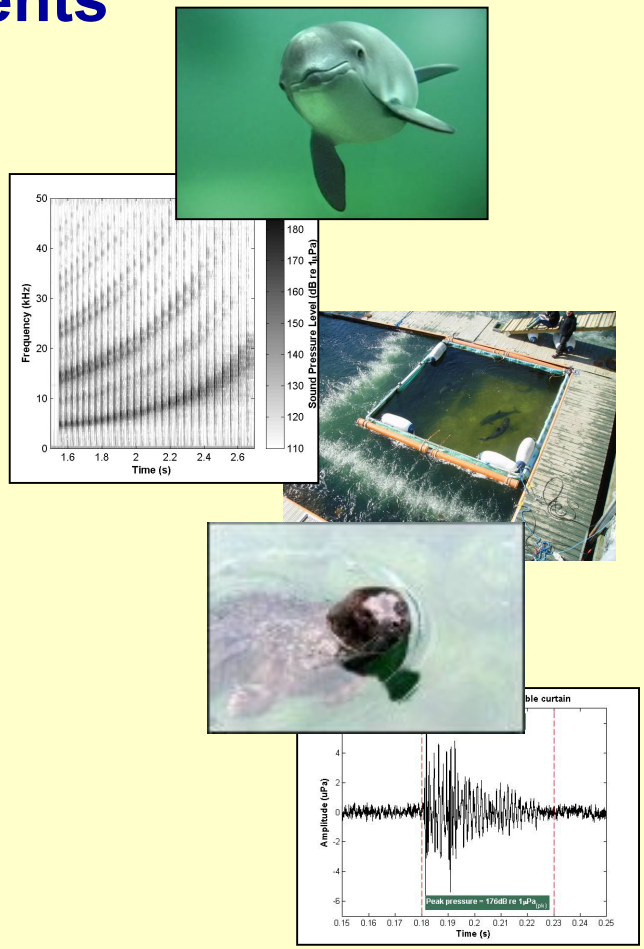

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Loughborough University

Contents:

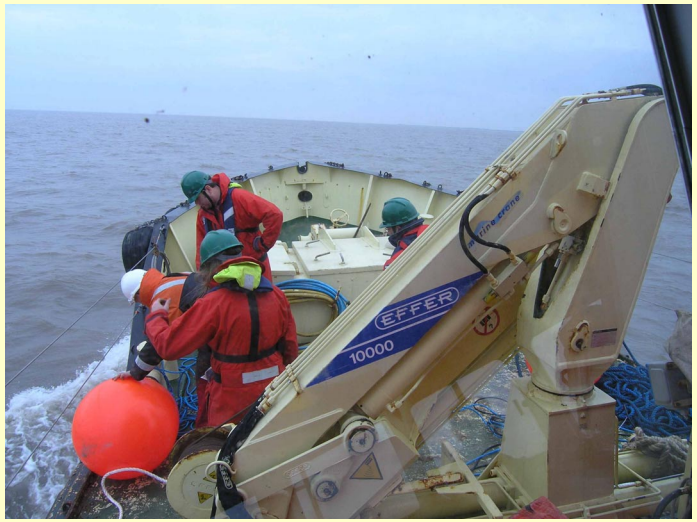
- Introduction to piling noise
- Acoustic field / exposure prediction

Mitigation Methods:

- MMO's (visual and acoustic, PAM)
- Impulsive noise 'soft start', 'slow start'
- Acoustic deterrent technologies
- Barrier methods

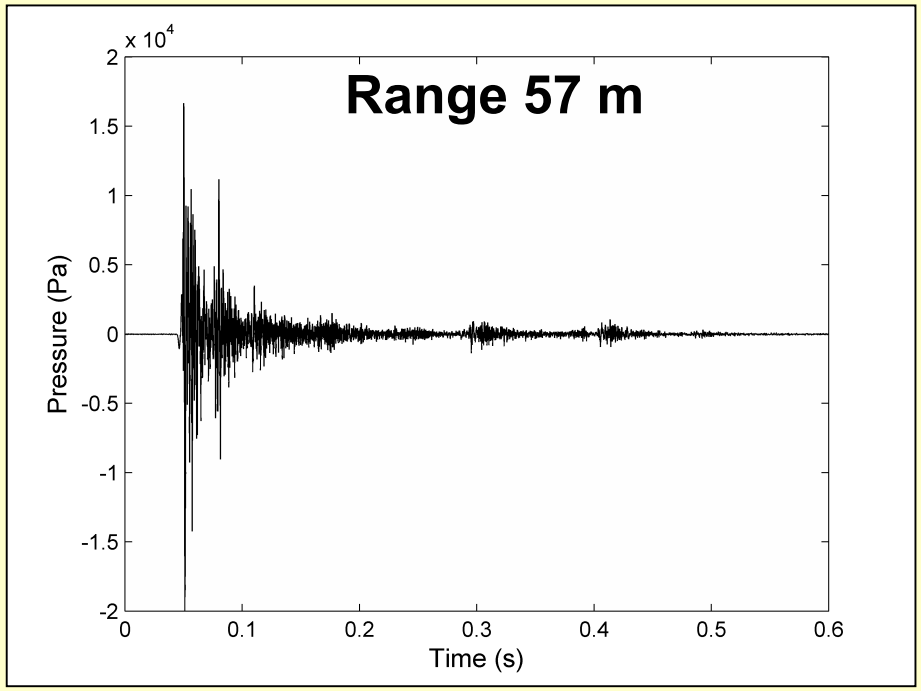
- Conclusions / discussion

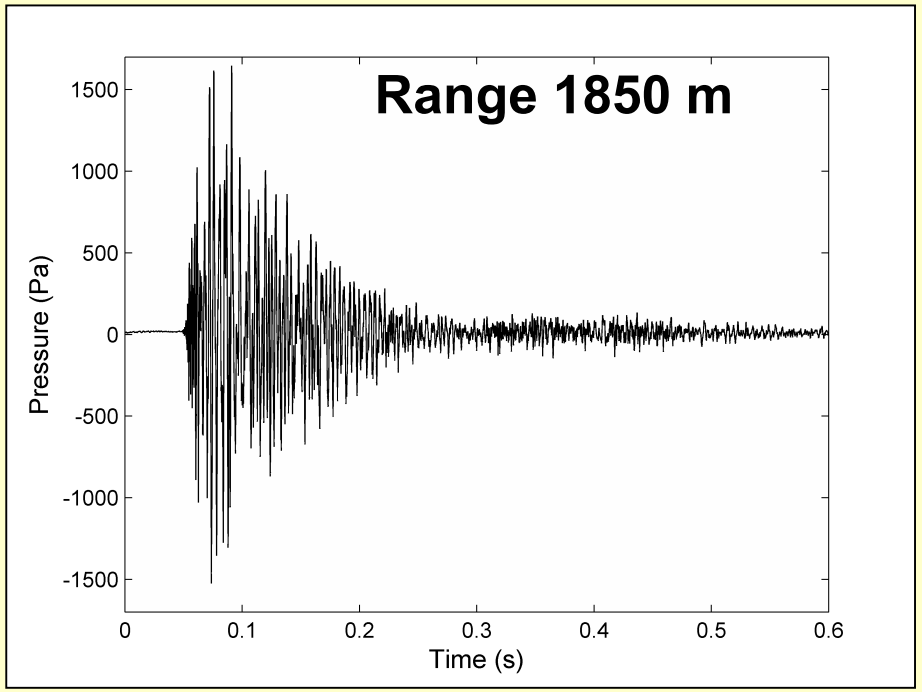
Driven Piling Noise



Piling noise

Single Impact time domain



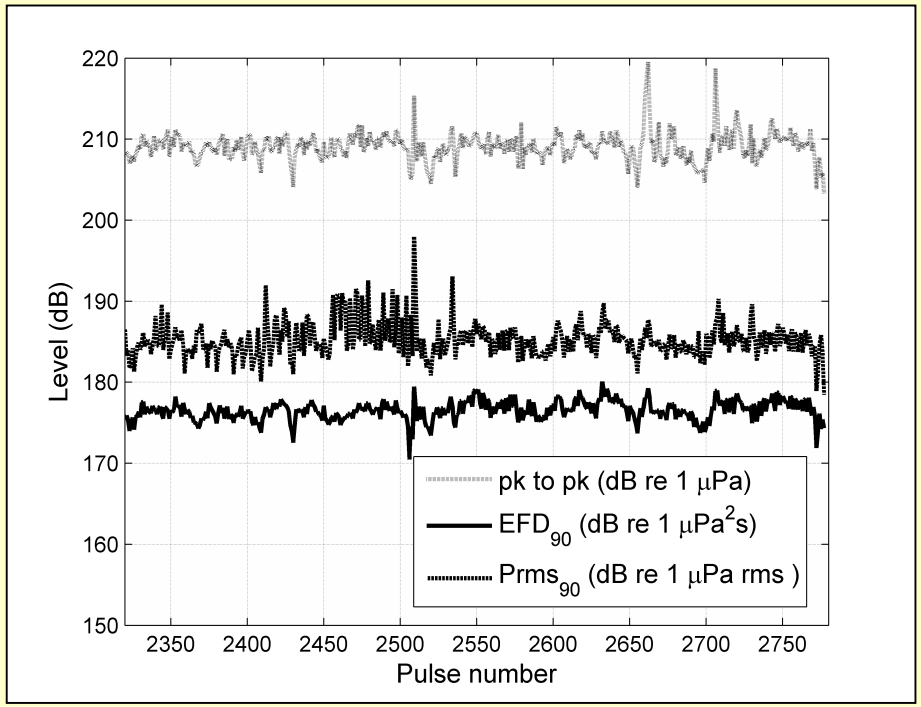


2m diameter driven mono-pile 800 kJ hammer energy

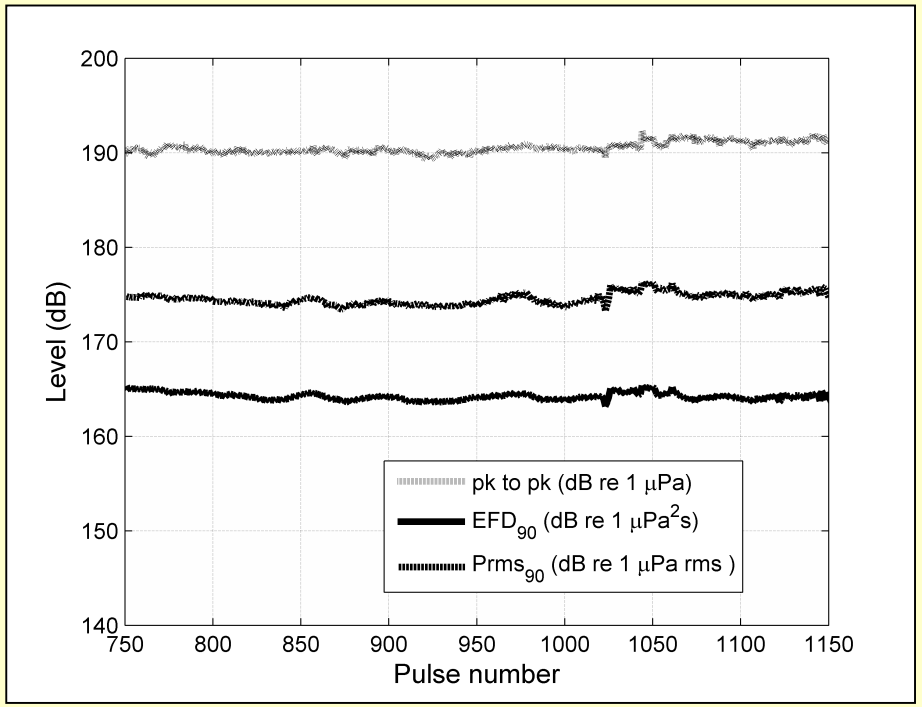
Main piling sequence

$$\mathrm{EFD}_{90} = \int_{t_5}^{t_{95}} p^2(t)\,dt$$

$$\mathrm{P}_{\mathrm{RMS}} = \sqrt{\frac{1}{T_{90}} \int_{t_5}^{t_{95}} P^2(t)dt}$$

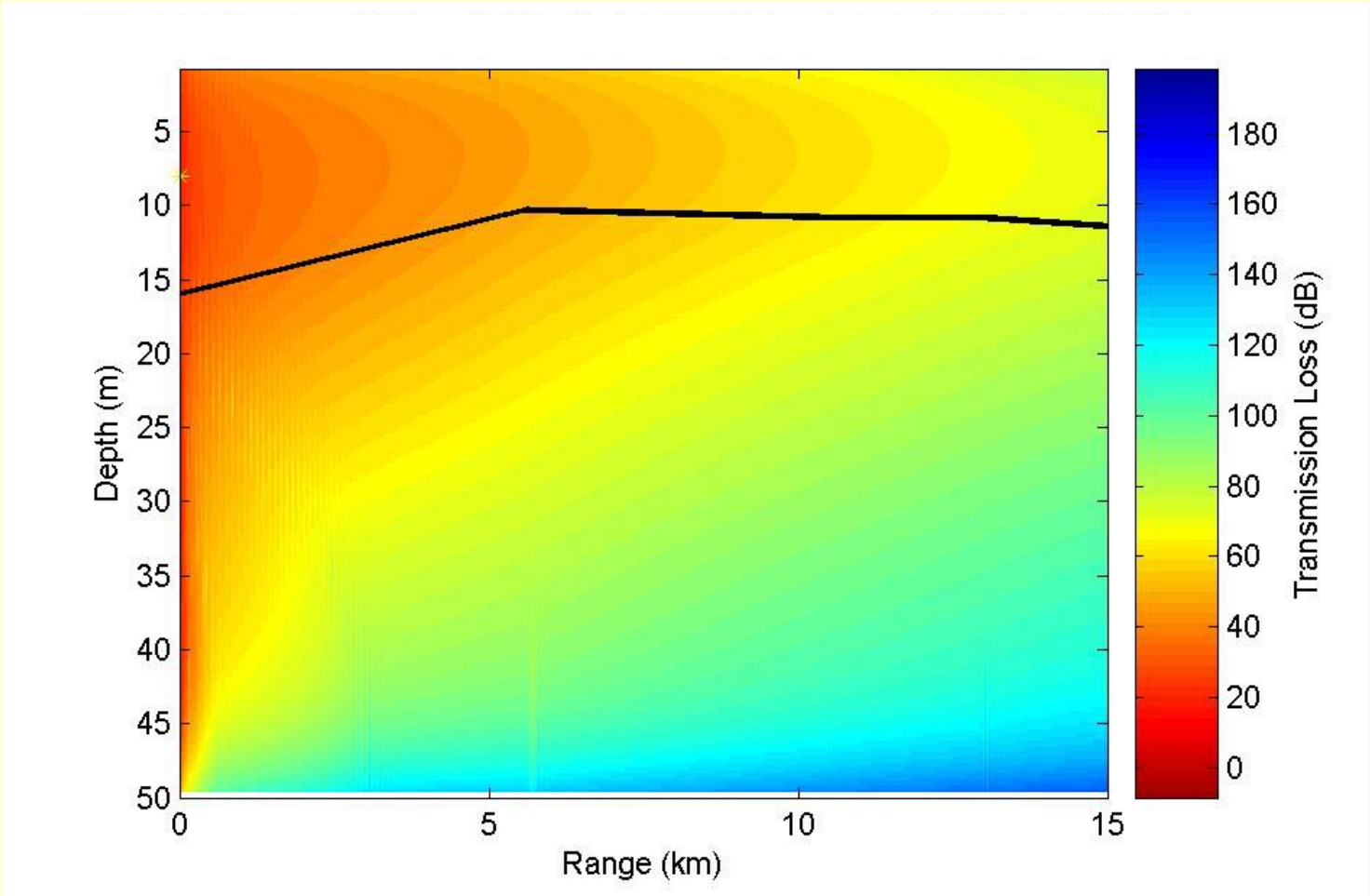


Range 57 m

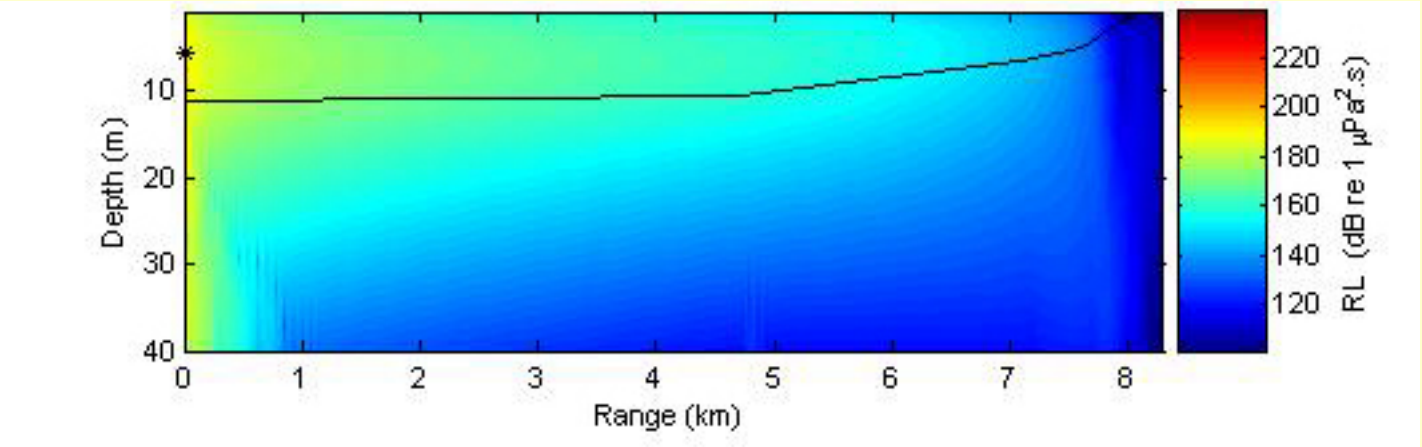


Range 1850 m

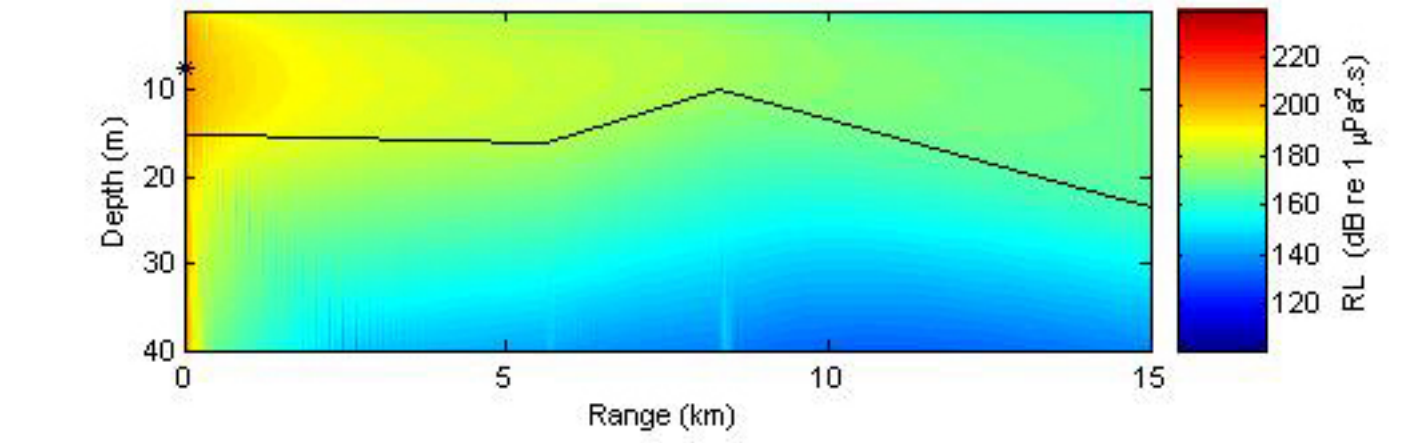
Acoustic field prediction: Transmission Loss



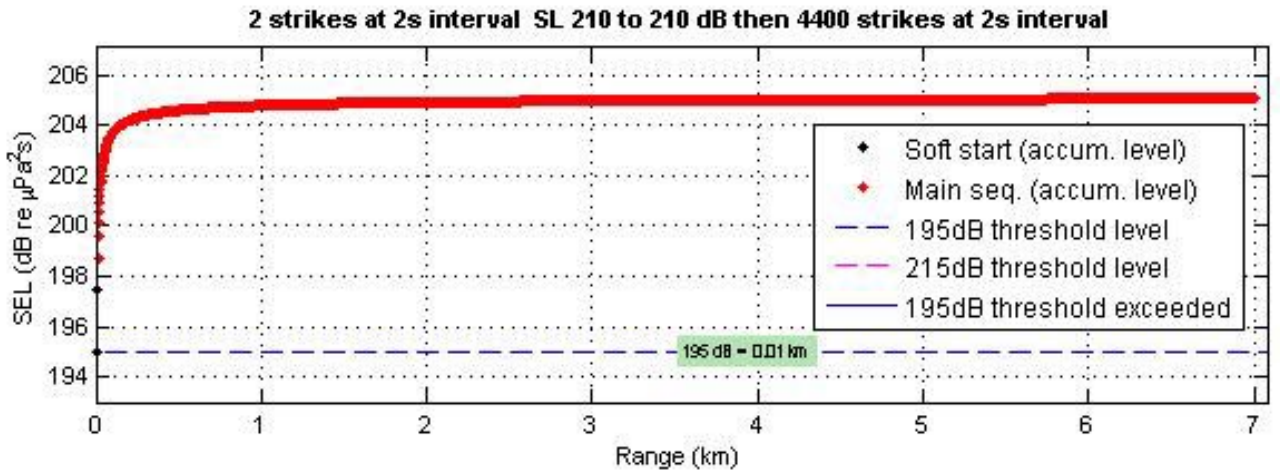
Acoustic field prediction: Received Level

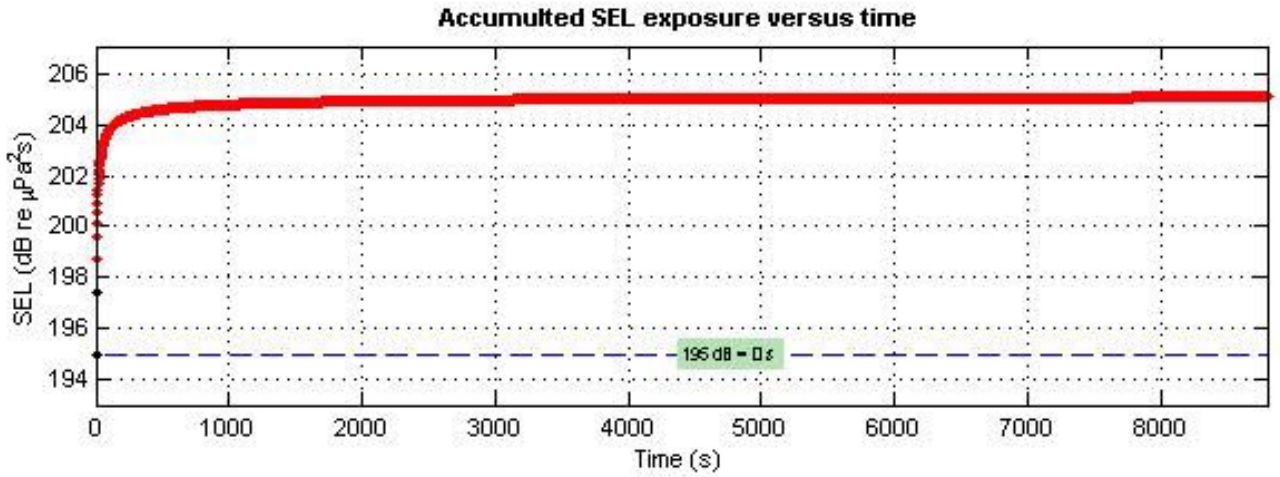


EFD
Source Level
210 dB re 1μPa²s



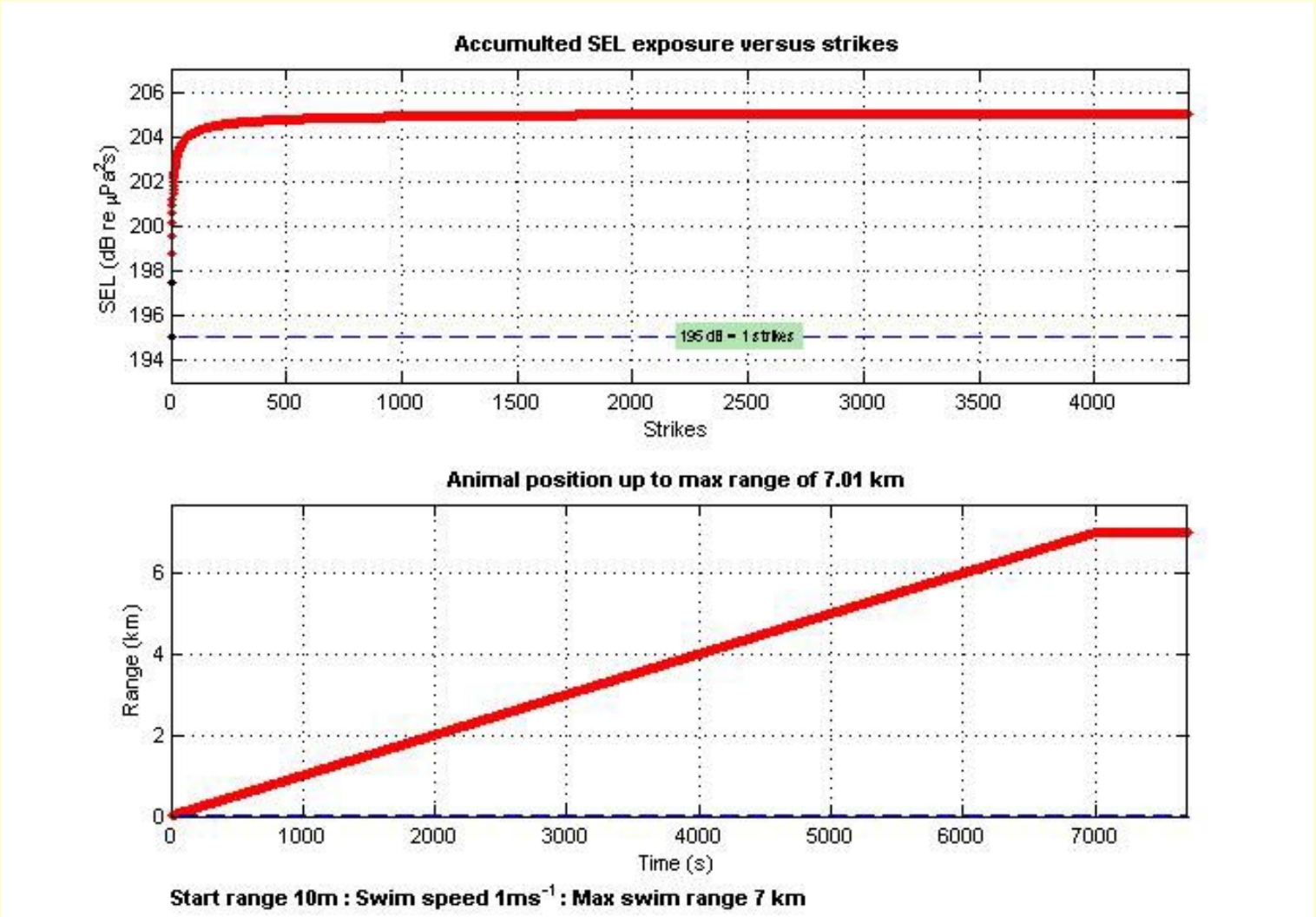
Accumulated exposure model:





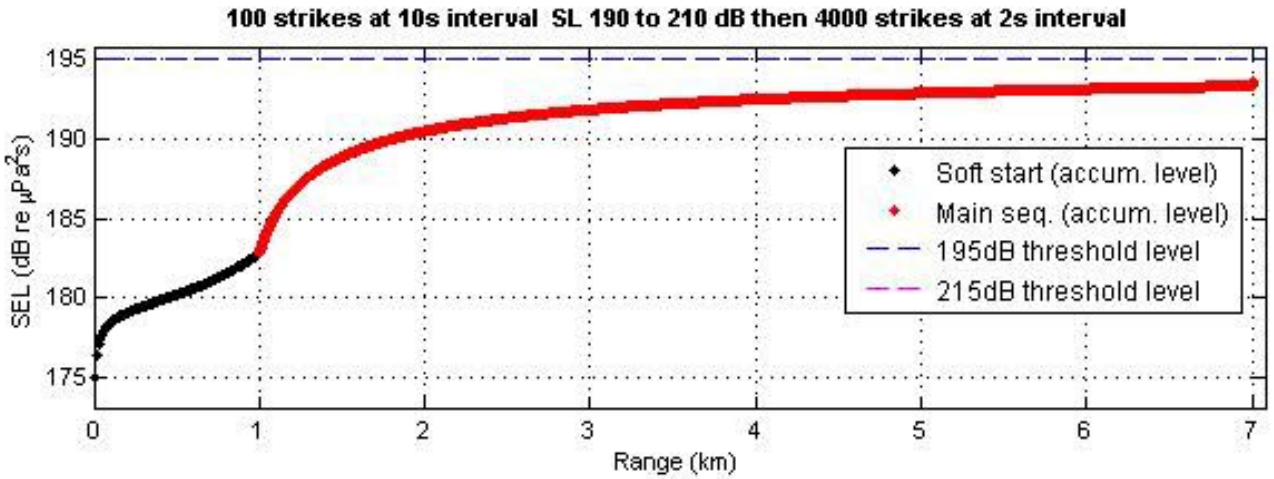
Start range 10m: Swim speed 1 ms^{-1} : Max range 7 km

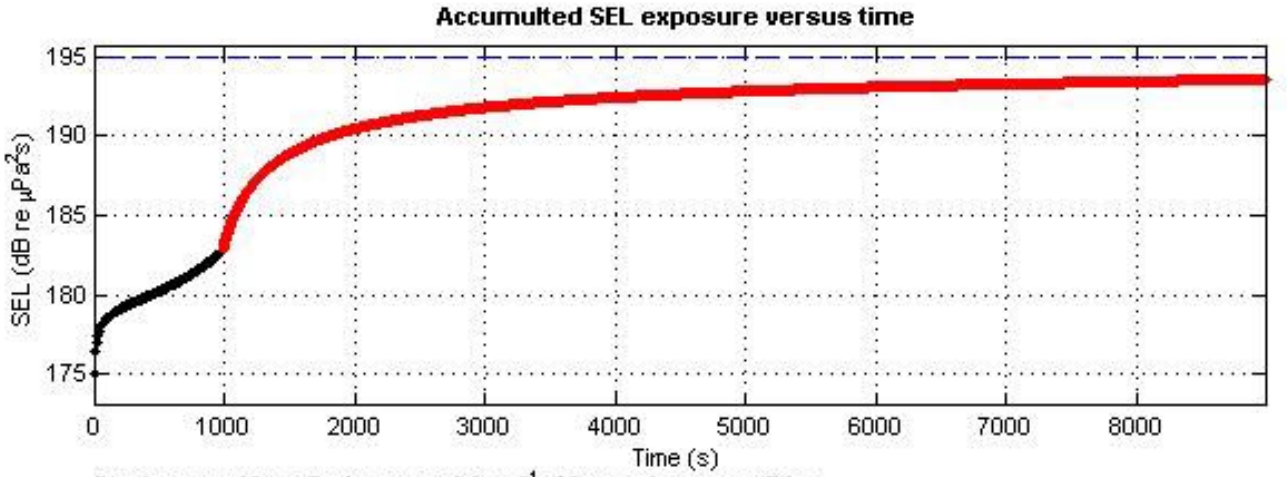
Accumulated exposure model:



Start range 10m: Swim speed 1 ms^{-1} : Max range 7 km

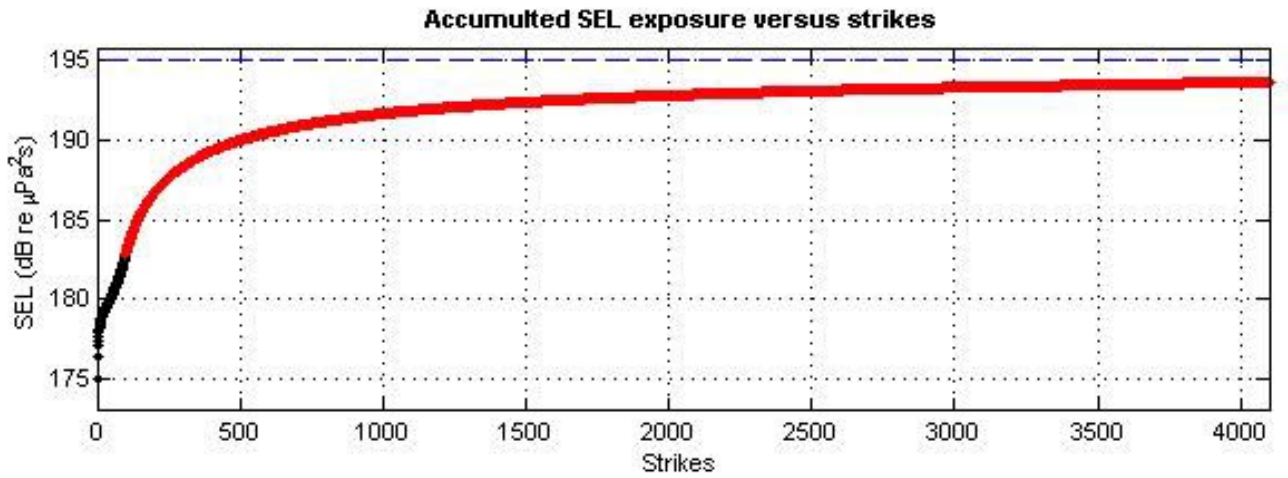
Accumulated exposure model: Soft start

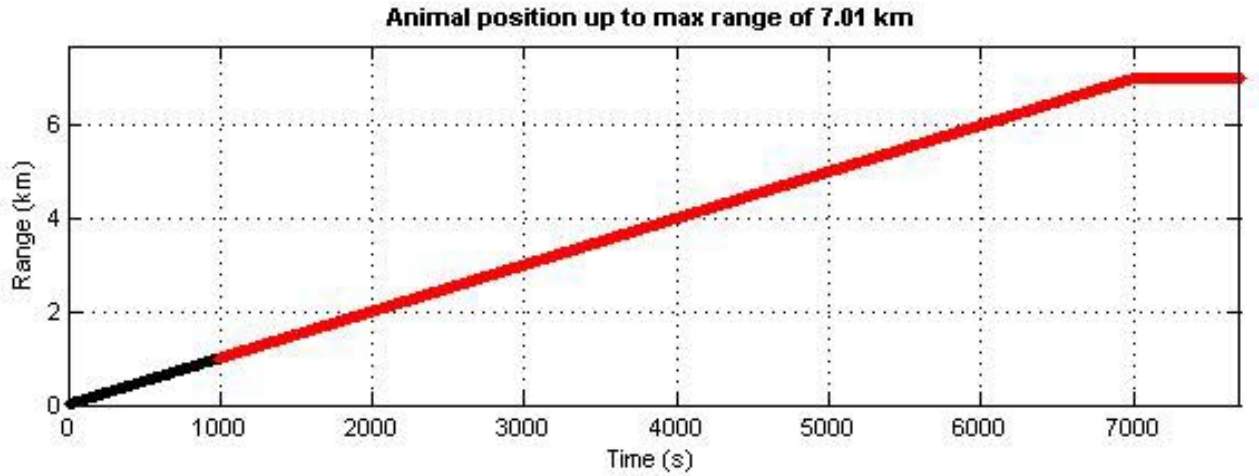




Start range 10m : Swim speed 1ms^{-1} : Max swim range 7 km

Accumulated exposure: Model

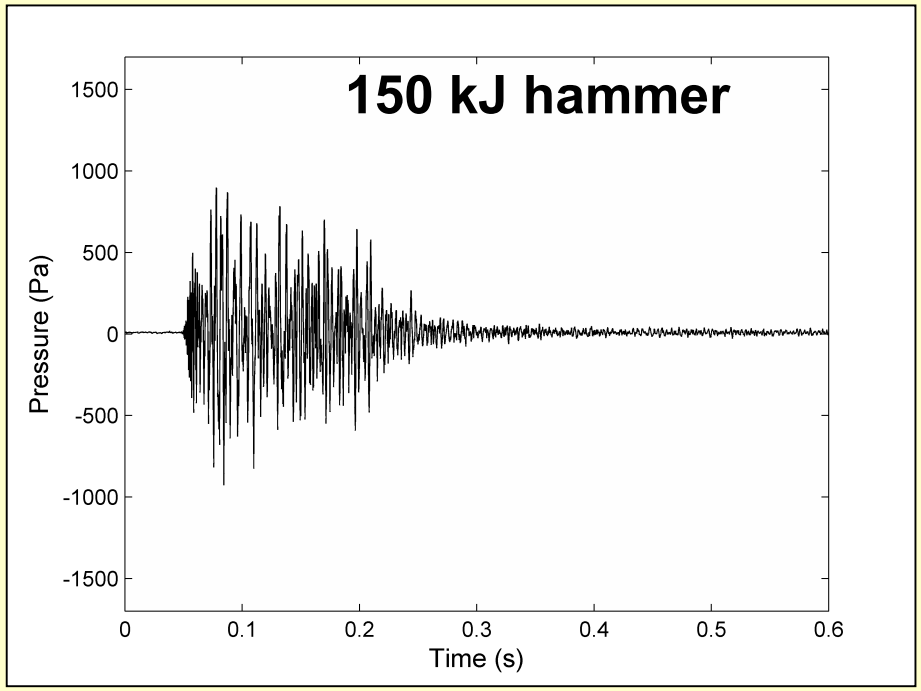


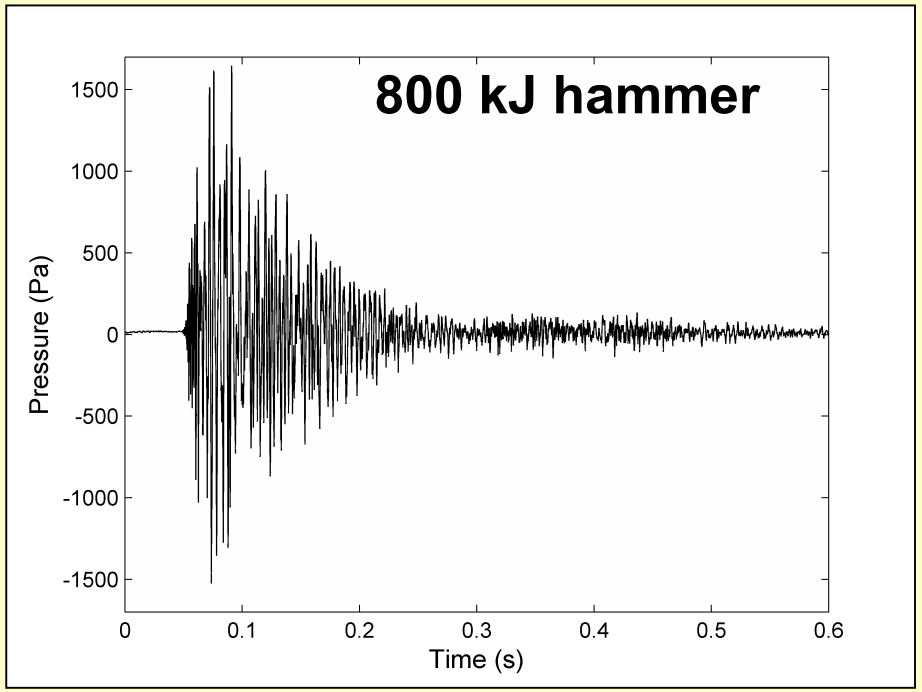


Start range 10m : Swim speed 1ms^{-1} : Max swim range 7 km

Piling noise: ‘Soft start’

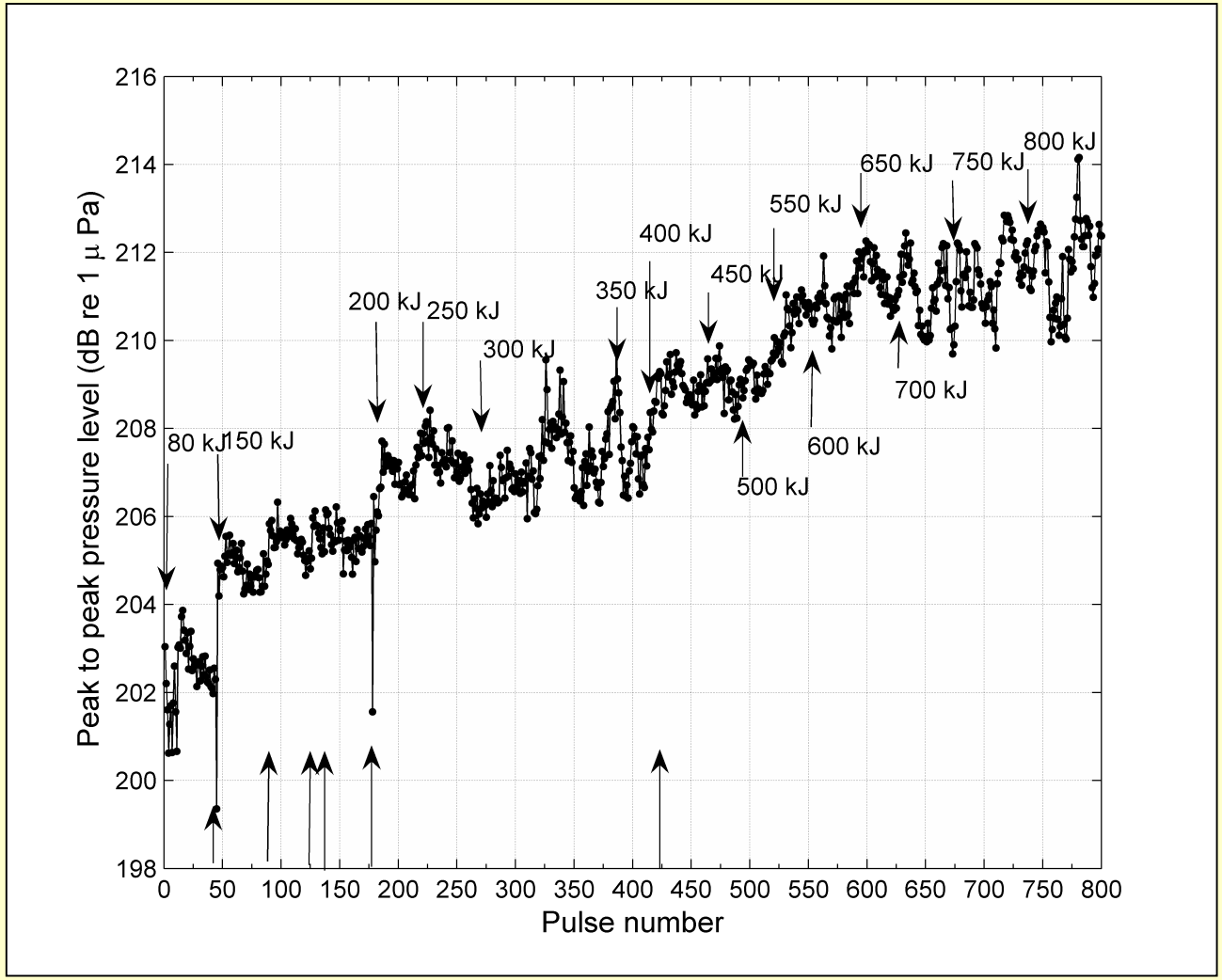
Single Impact time domain





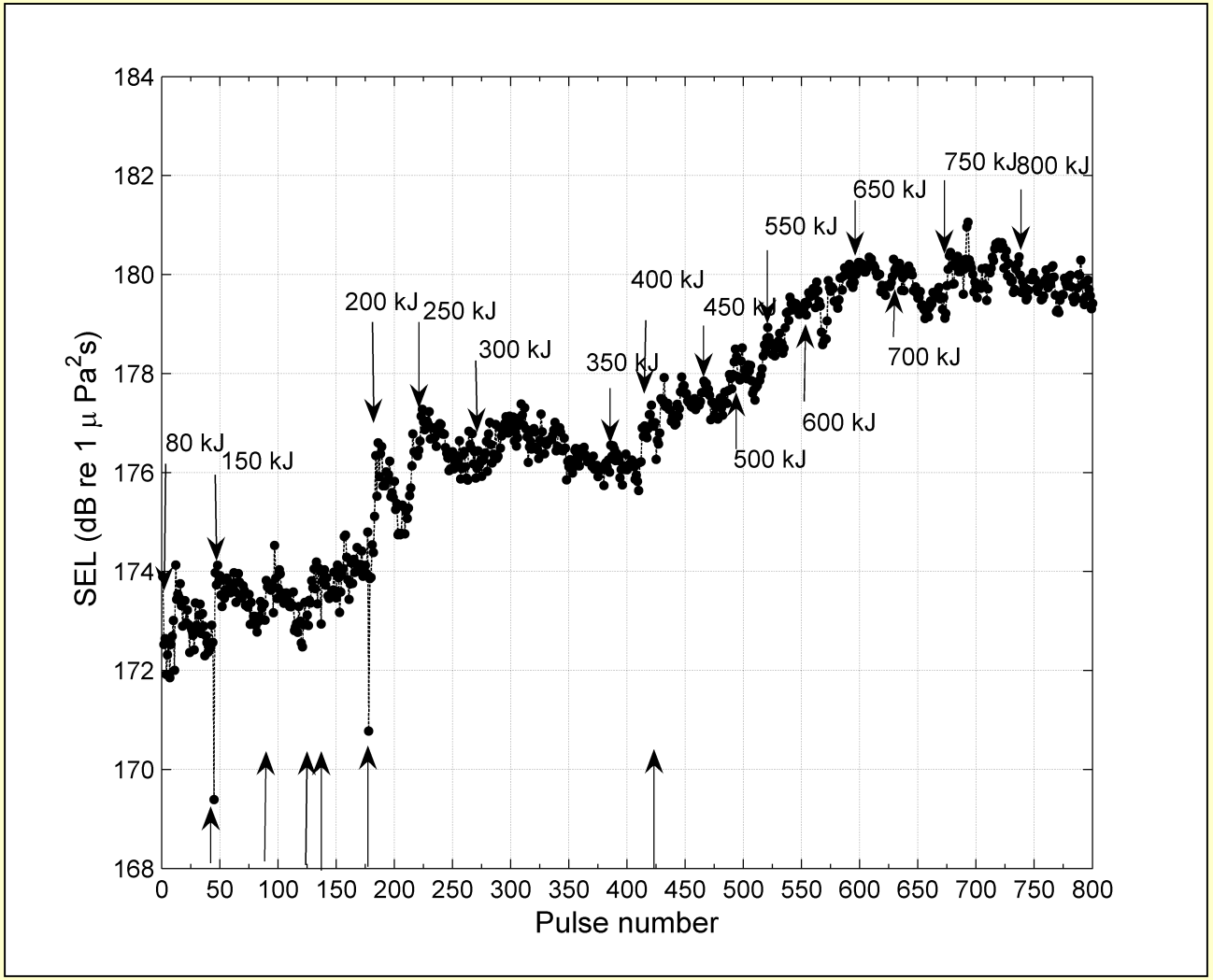
2m diameter driven mono-pile range 1850 m

Single Impact pulse peak-to-peak pressure during ‘soft start’



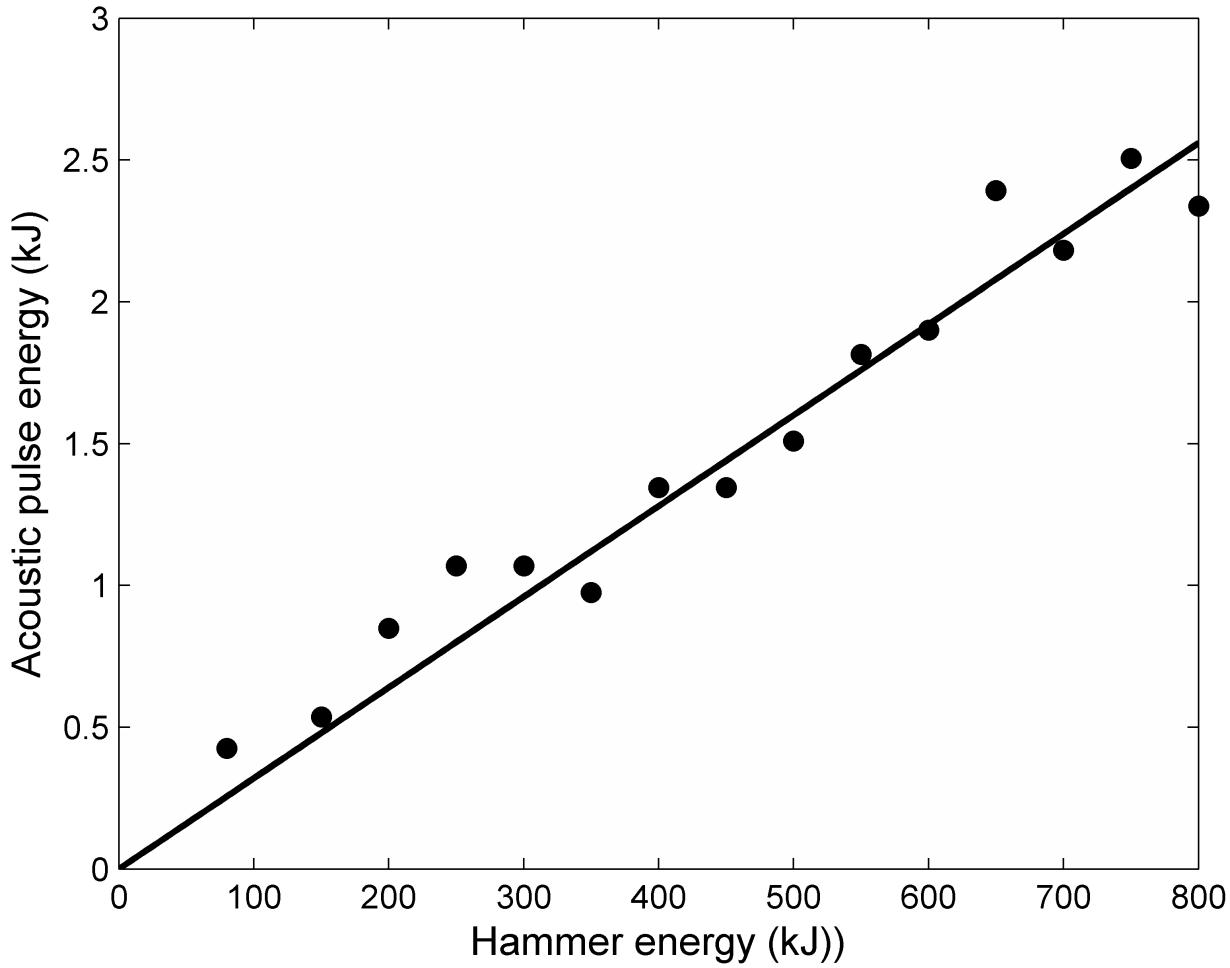
Range: 1850 m

Single Impact pulse EFD increase during ‘soft start’



Range: 1850 m

Acoustic pulse energy versus hammer energy



Acoustic Deterrents

CAAD's

Estimated losses:
£1.8 - 4.8 million annually
Ross-on-Wye Cons. Soc (1988).

Cetacean Acoustic deterrents: Pingers.

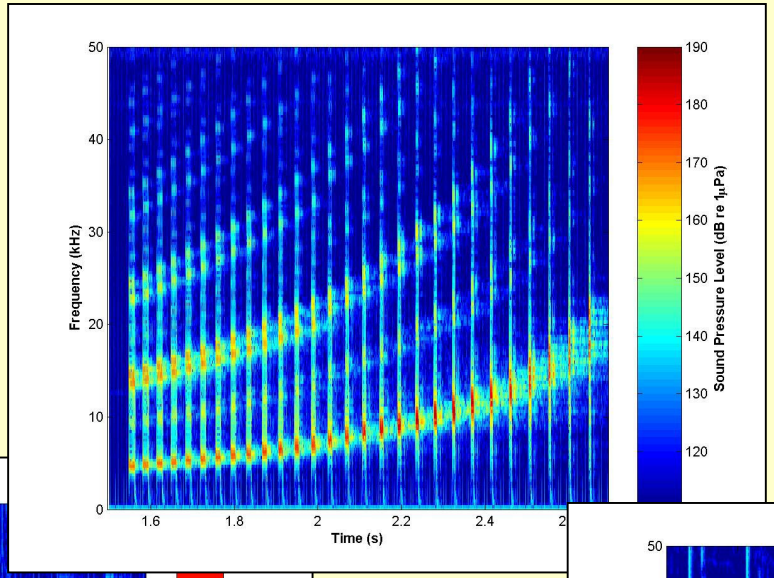
Widespread testing for prevention of accidental by-catch & predation

Manufacturers

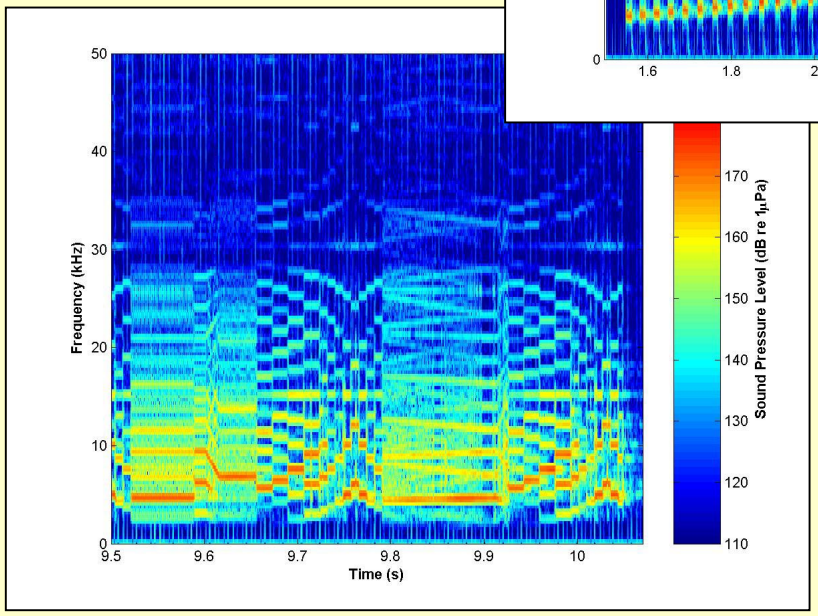
AIRMAR	**(dB Plus II)**	**AQUATEC**	**Aquamark, etc.**
ACE AQUATEC	**(Silent Scrammer)**	**DUKANE**	
TERECOS	**(Type DSMS – 4)**	**FUMANDAE**	

Acoustic Deterrents

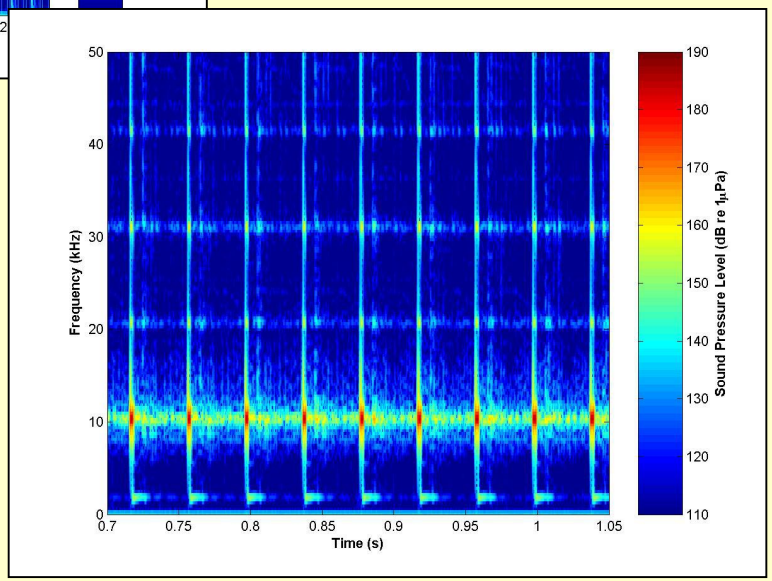
ACE AQUATEC (Silent Scrammer)



TERECOS (Type DSMS-4)



AIRMAR (dB Plus II)



AQ528 for Pair-Pelagic Trawls

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Remote activation by an u/w acoustic link as required – Transmits randomly timed 256 ms frequency sweeps SL 165 dB re 1 μPa at 1m.

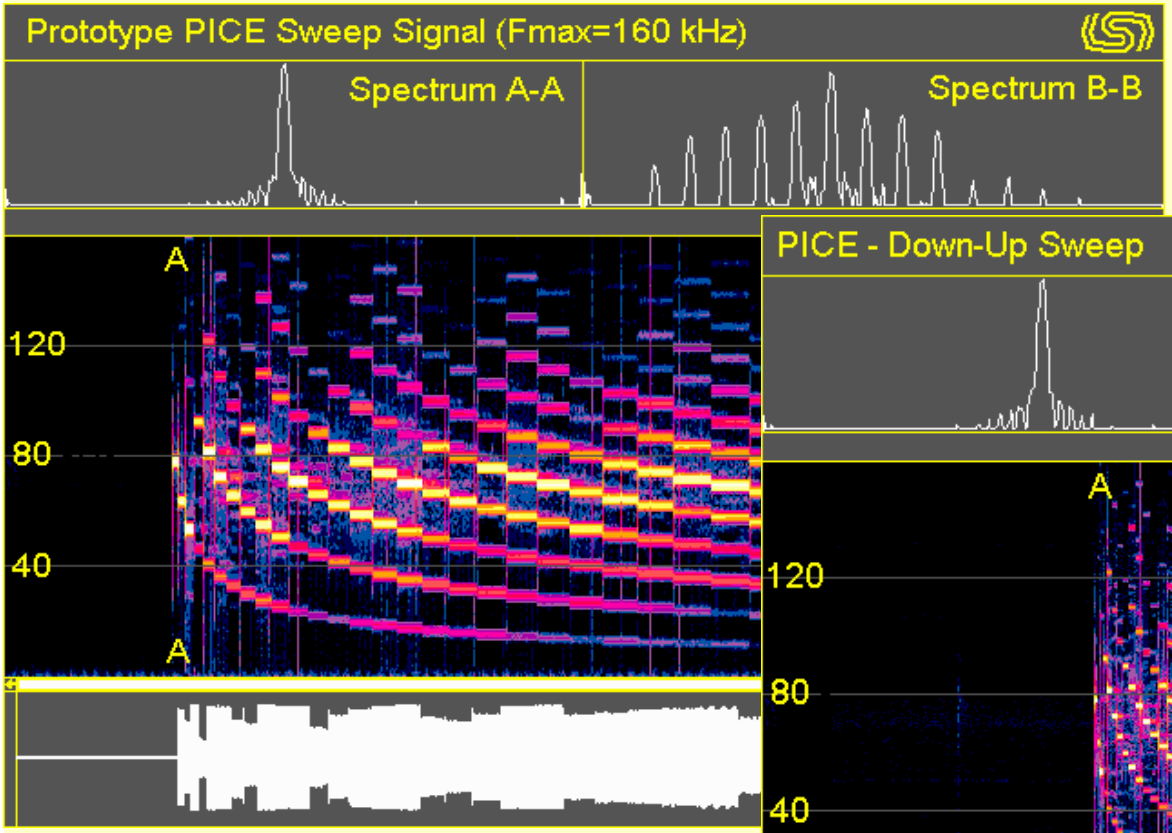
Wideband Acoustic Deterrents

AQUAmark100 - wideband device SL 145 dB re 1 mPa at 1m. Meets Danish (Type 1) regulations introduced in August 2000.

AQUAmark200 devices were also tested during 2001 in the French 'Thonaille' fishery and reduced dolphin bycatch by 87.5%

AQUAmark100 & 200

PICE / AQUAmark100 acoustic deterrent

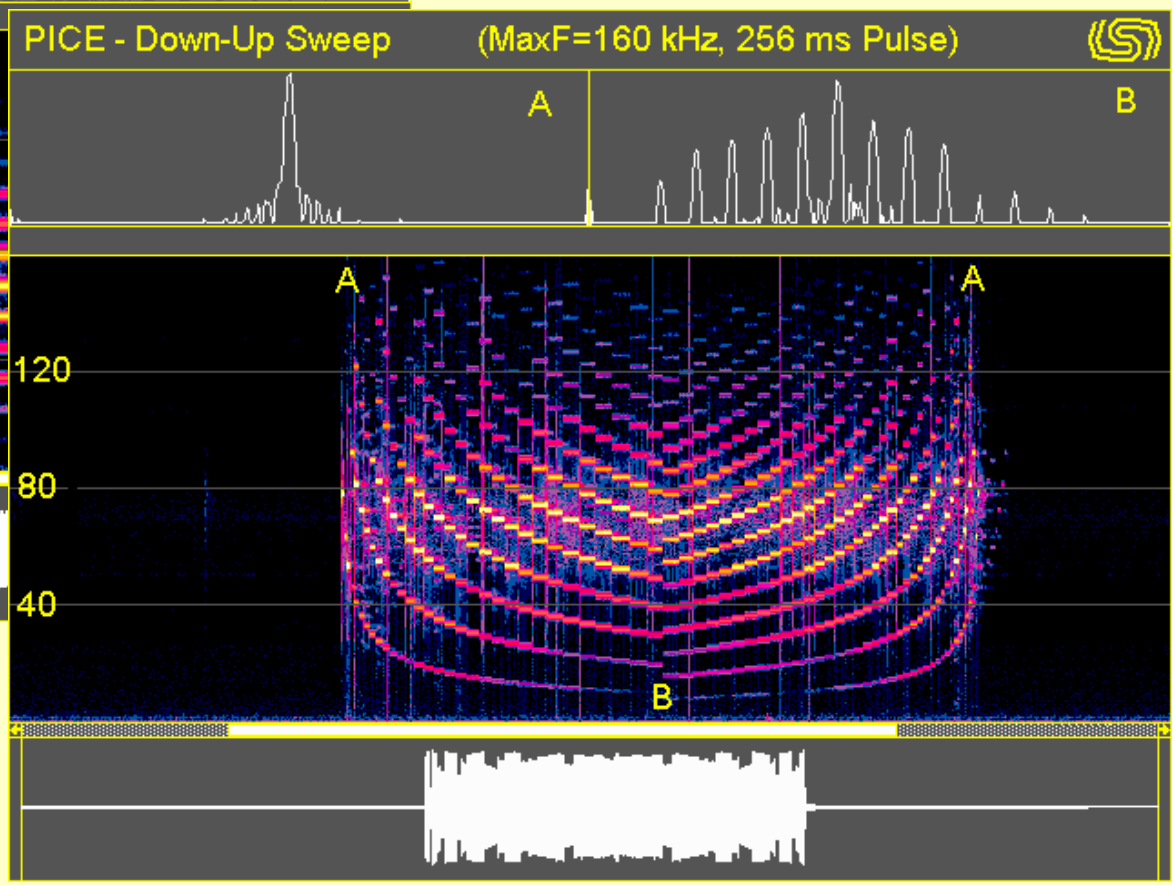


Pulse Length = 256 ms

Peak Source Level ~145 dB re 1 μPa at 1m

8 wide-band signal variations

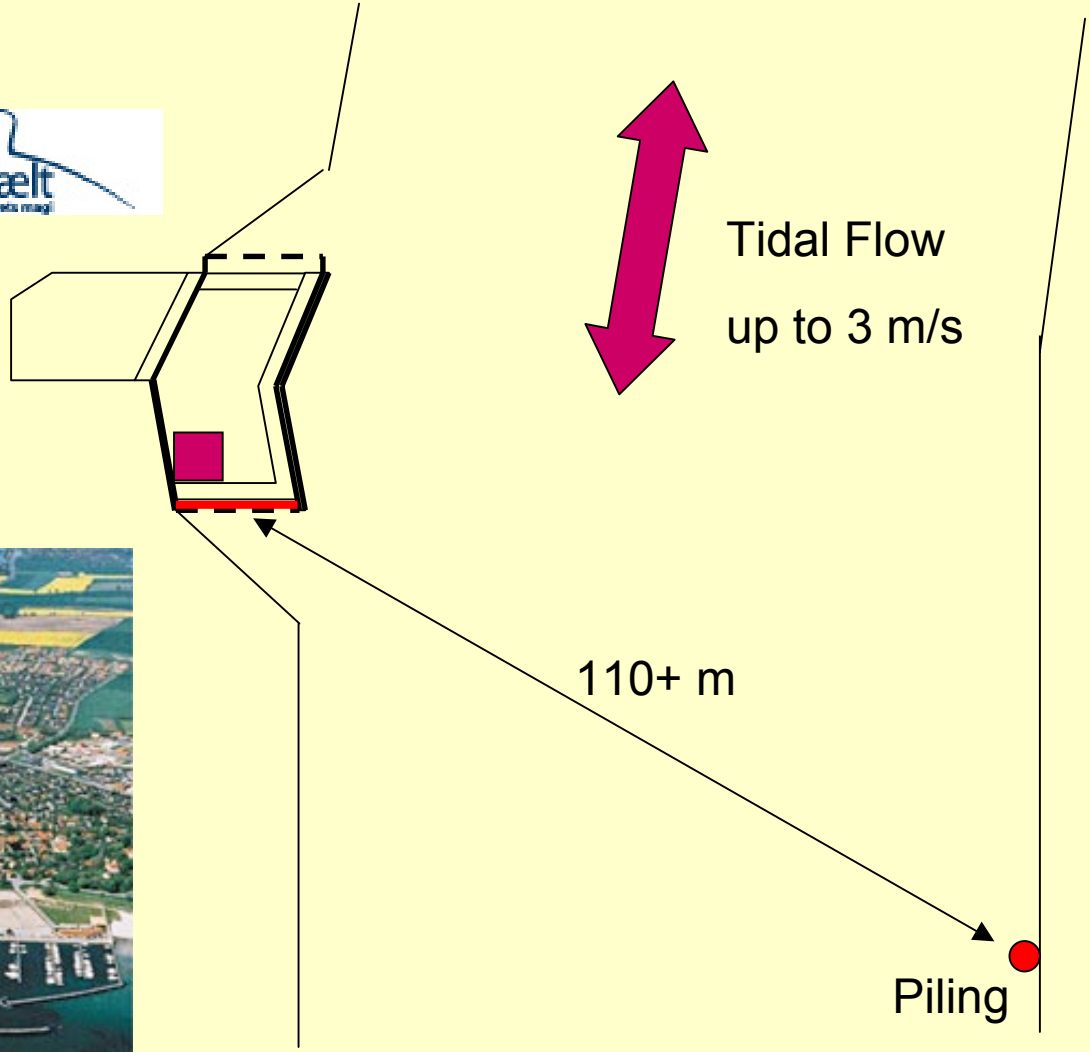
Pseudo-random inter-pulse timings from 5 to 30 secs



Battery Life typically exceeds 2 years

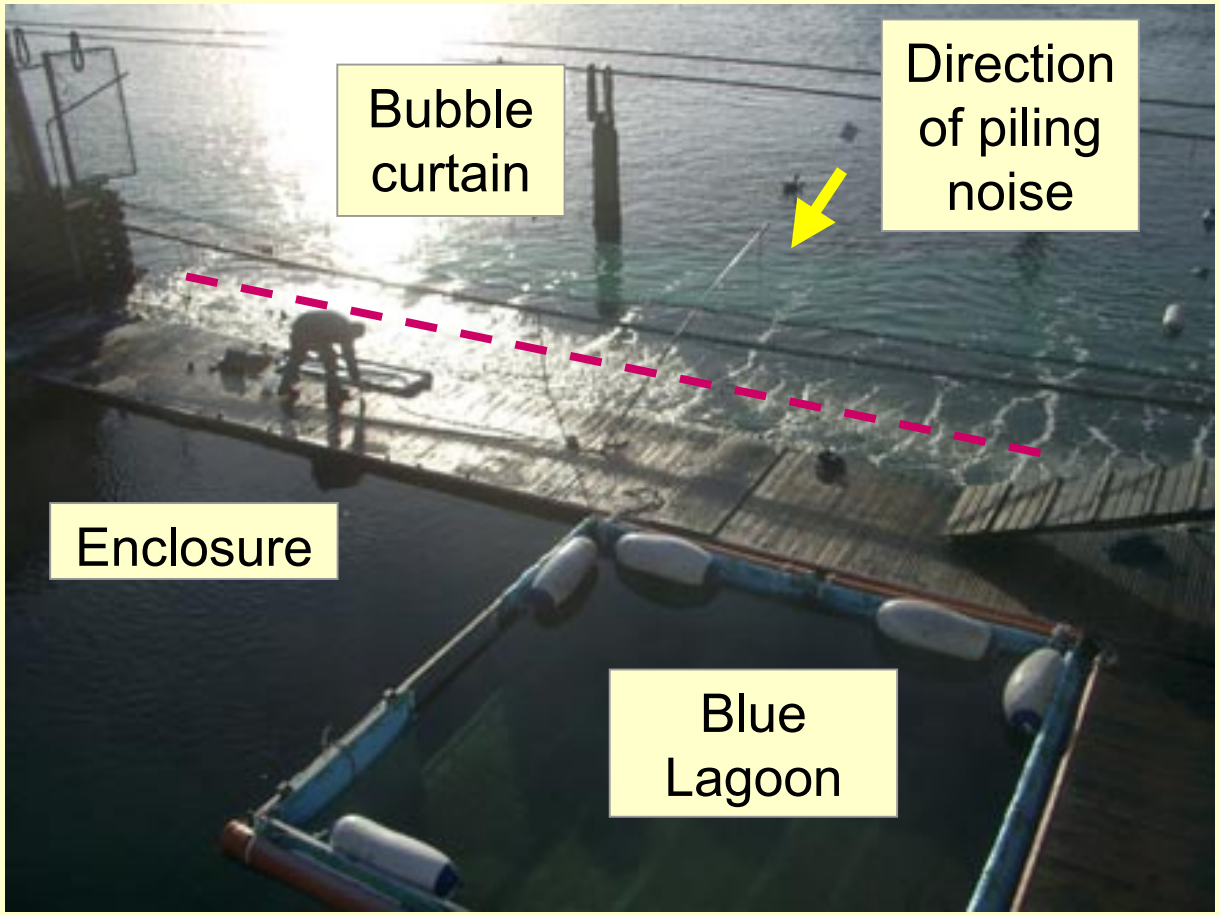
Barrier Methods

Kerteminde Harbour



Fjord & Baelt centre

Bubble curtain deployment



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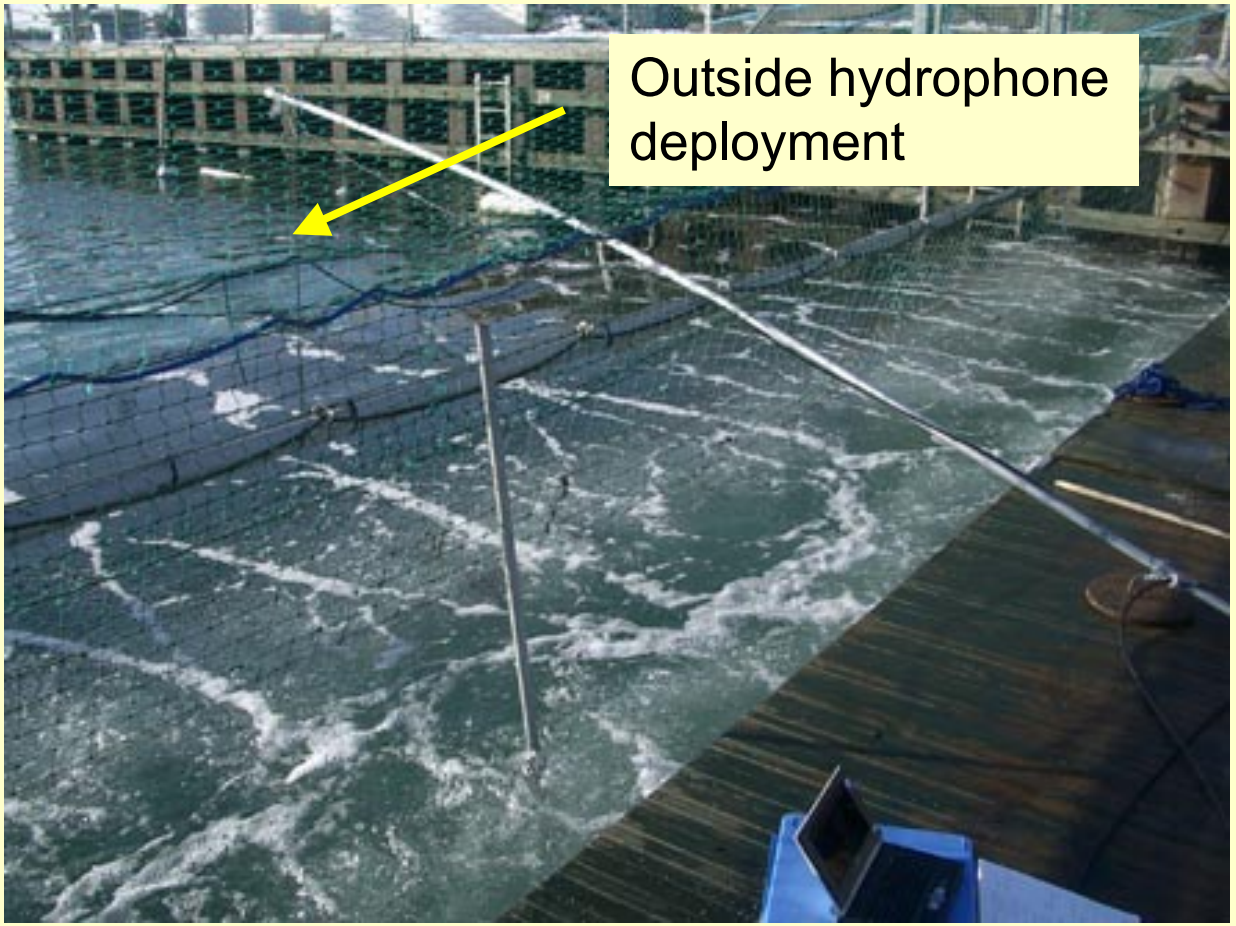
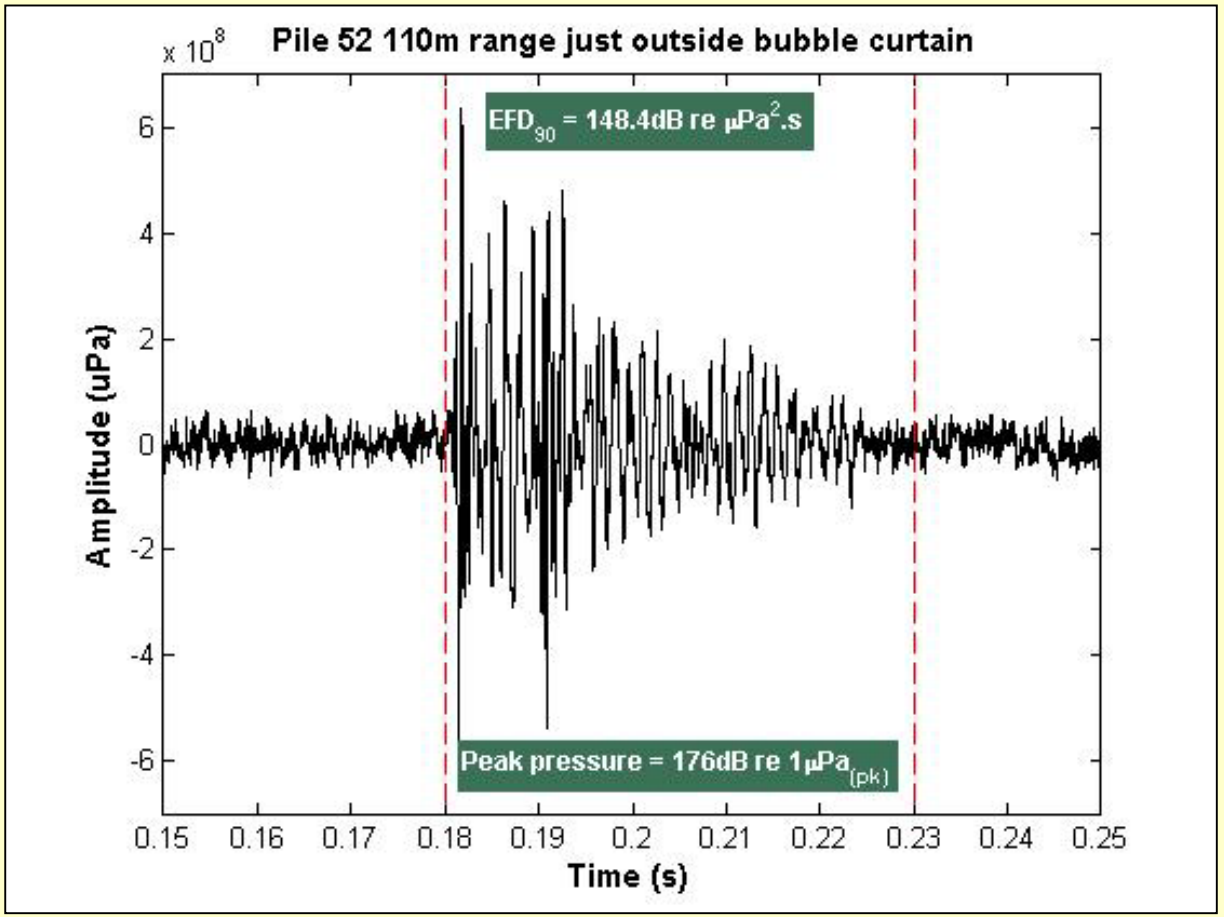
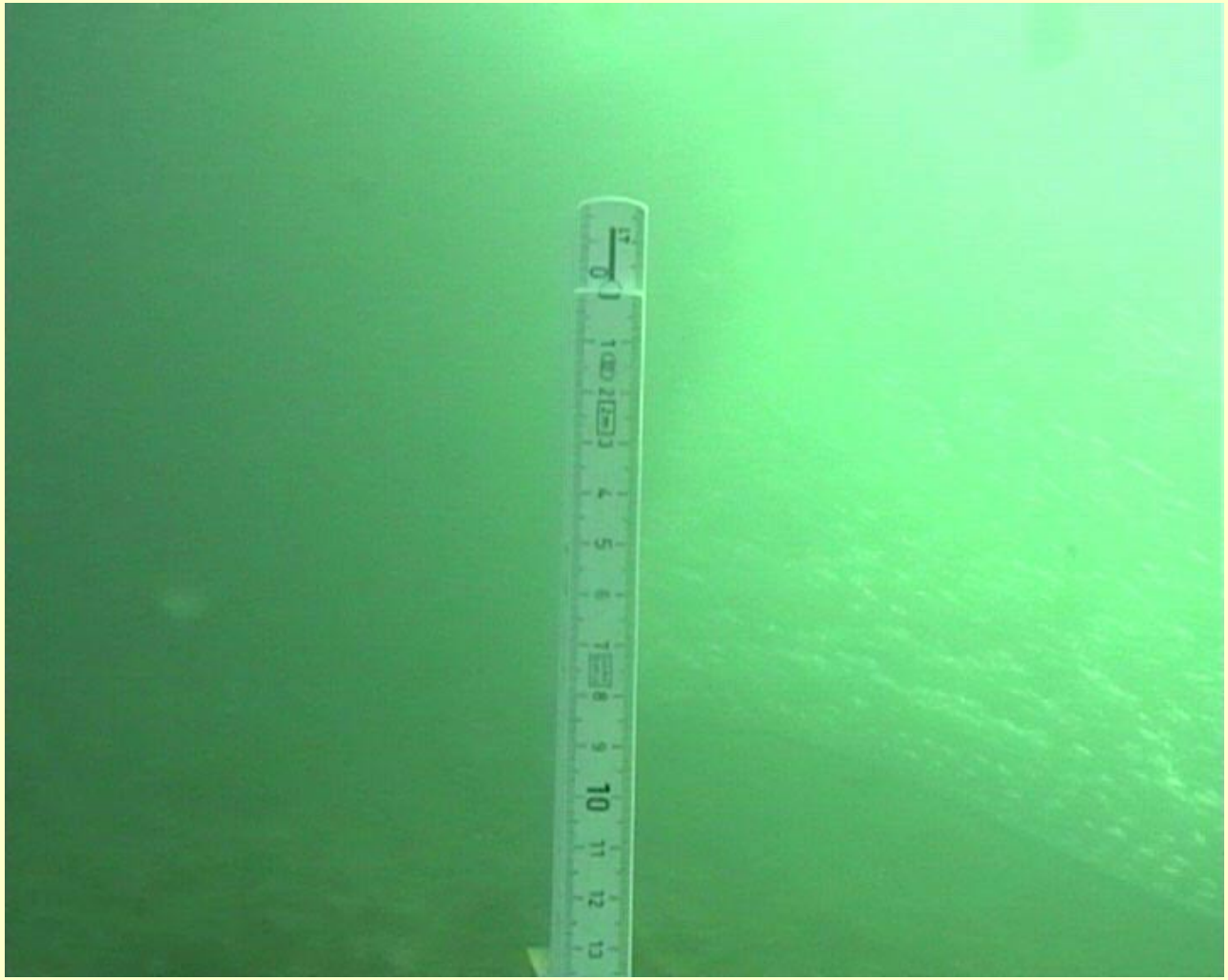
Hydrophone Deployment



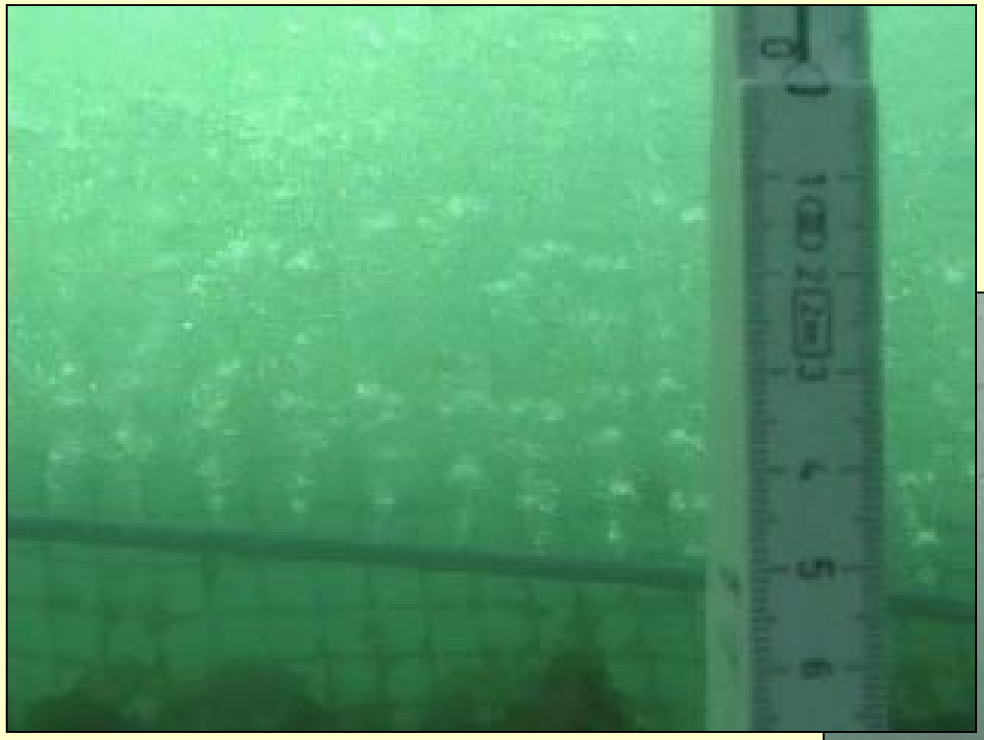
Piling noise

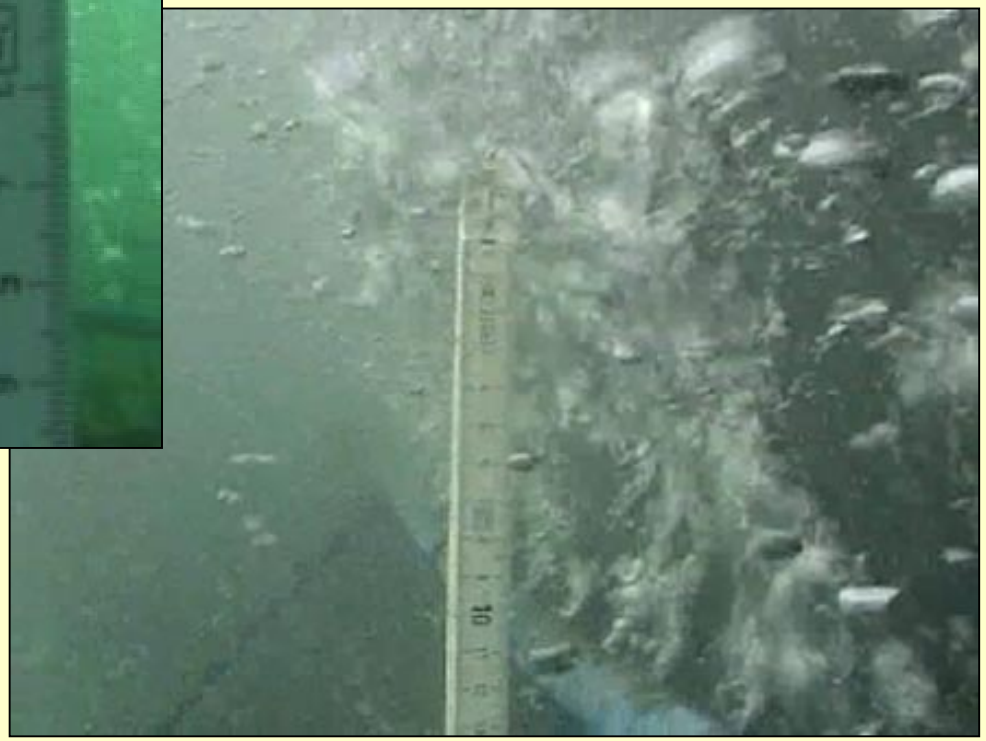


Bubble curtain

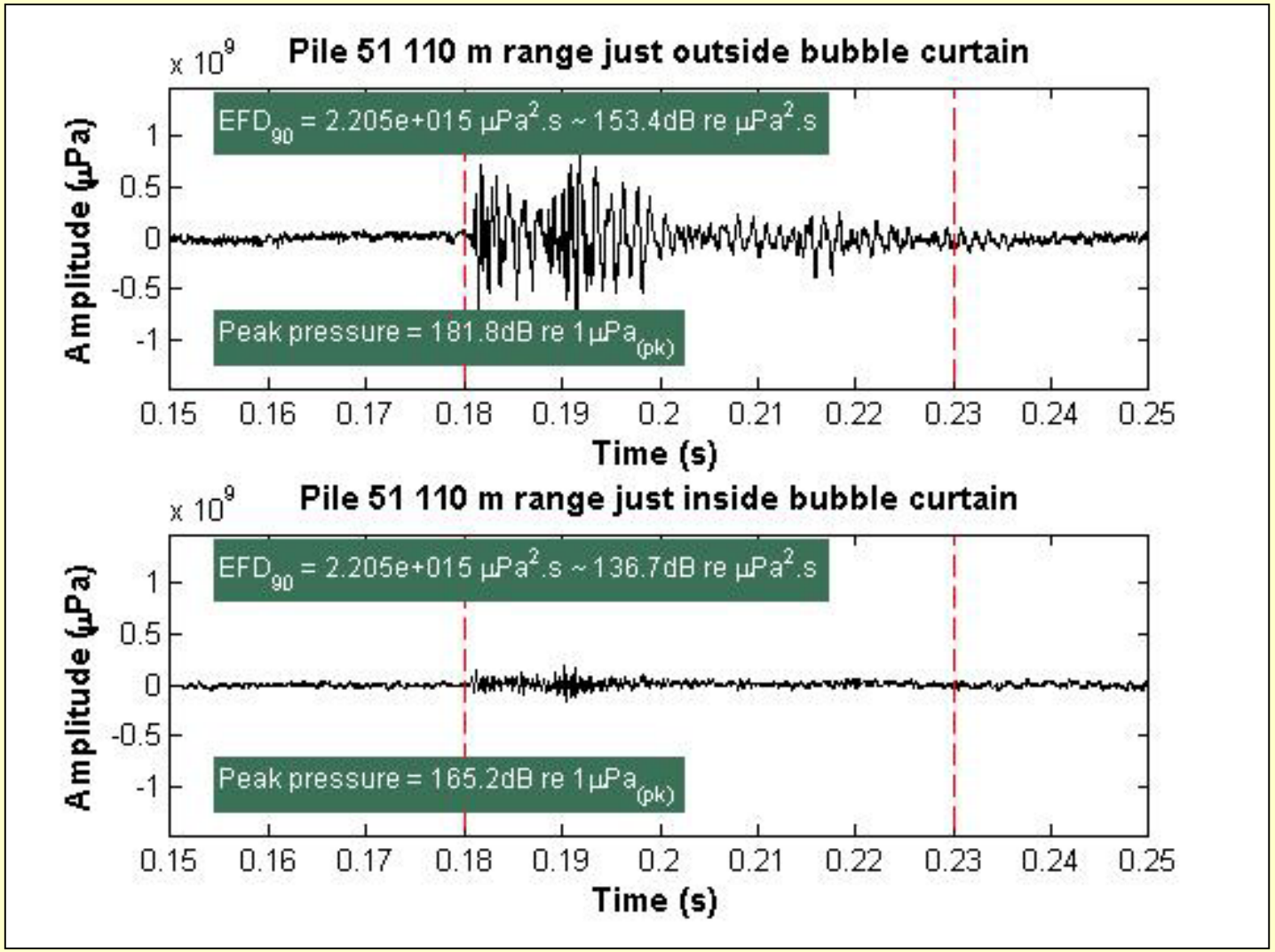


Bubble curtain



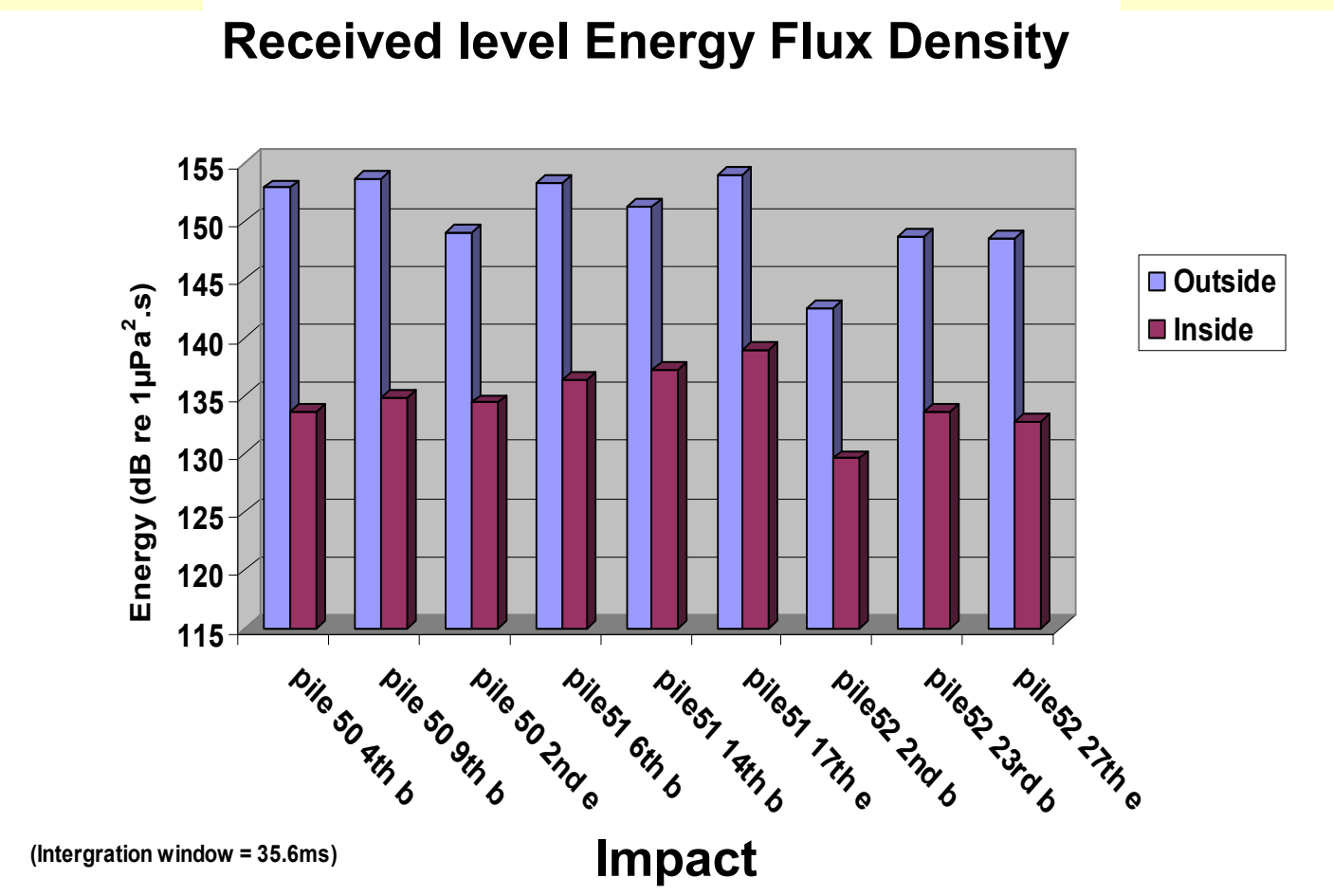


Inside / outside bubble curtain comparison



~16 dB reduction in energy and peak level

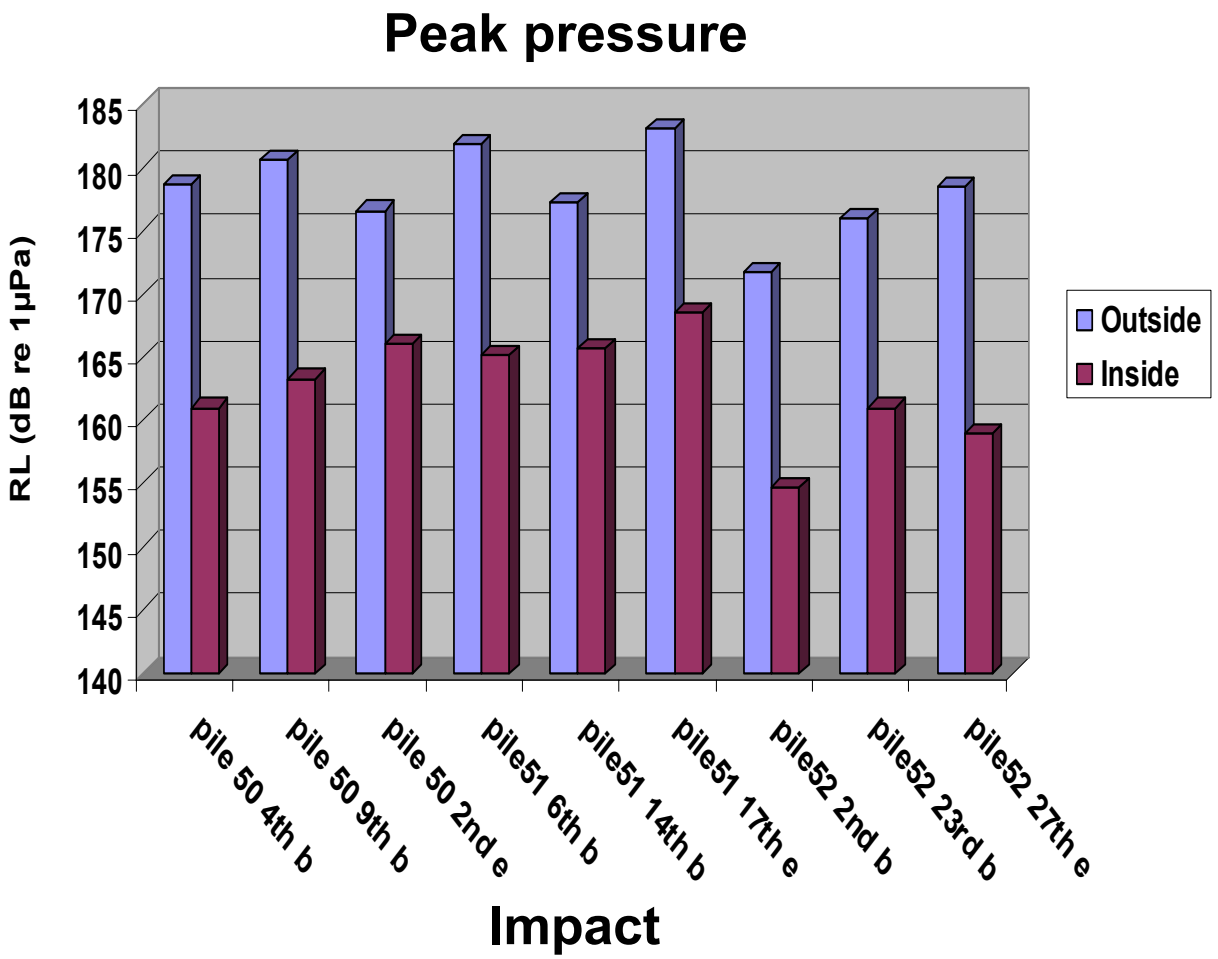
Energy Flux Density comparison



13-18 dB reduction in energy and peak level

Mean EFD 150.5 dB re 1µPa^2.s

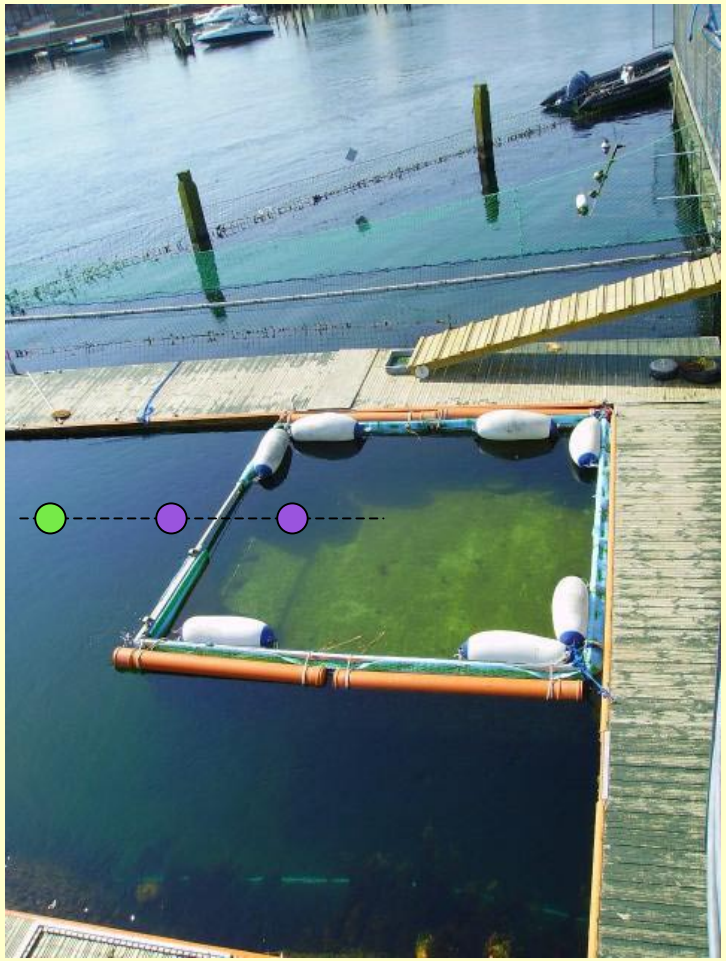
Peak pressure comparison



Mean peak level outside bubble curtain 178.2 dB re 1µPa (pk)

11-19 dB reduction in energy and peak level

Blue lagoon

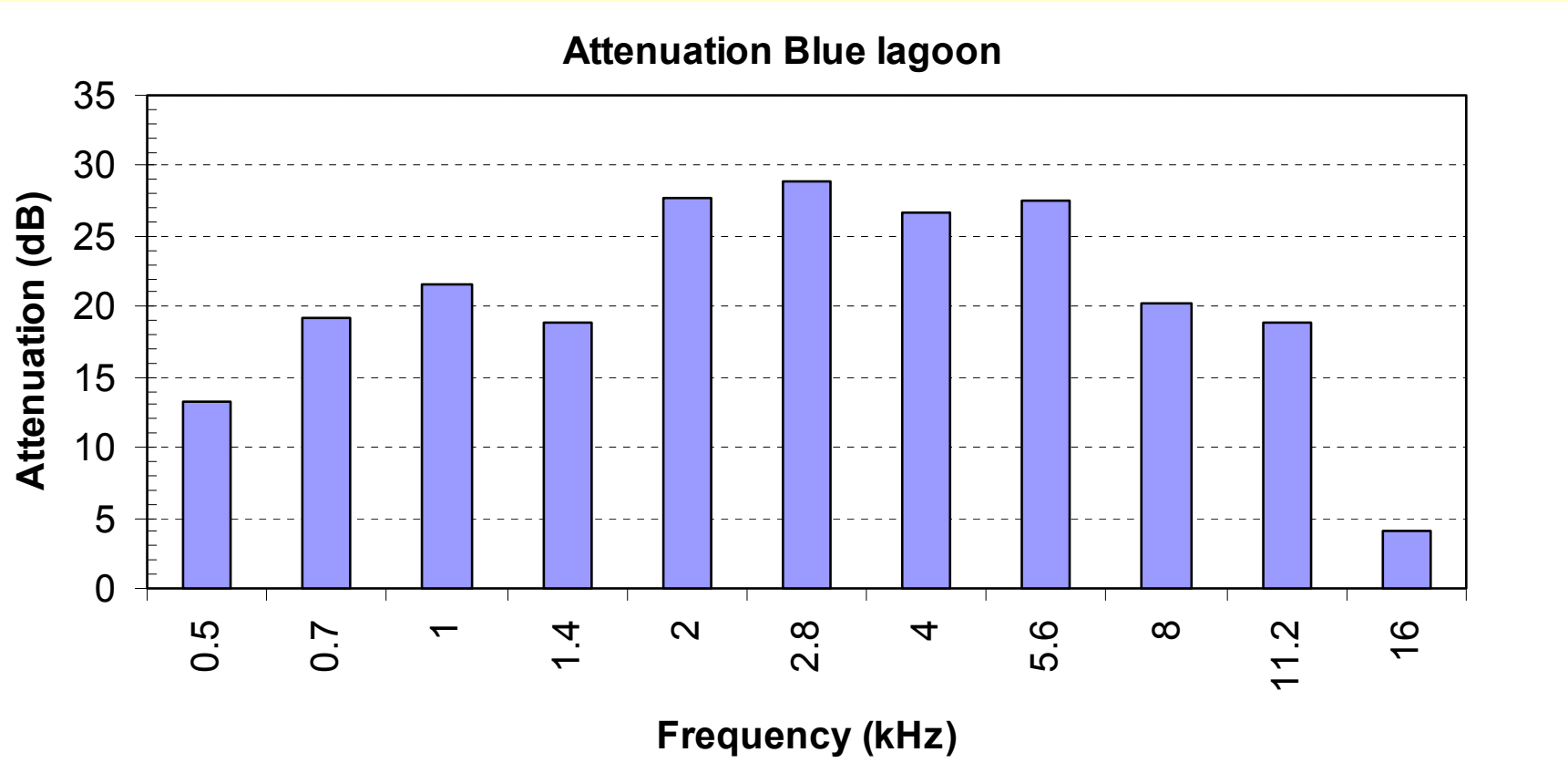


Closed cell foam lined floating pen

Comparison was made
door open / door closed
&
receiver inside / outside

Tone burst source in
range 500Hz – 160 kHz

Attenuation in Blue Lagoon



Air gun trial

Conclusions / Discussions

A linear increase acoustic energy was observed with increasing hammer energy. This may allow at risk species to move way from an area before full power is used reducing individual and total exposure levels. Similarly acoustic deterrents may exclude animals for at risk areas.

Reductions of a specific type of piling noise and was achieved in terms of both the peak signal and the equivalent energy flux density with attenuations ranging from of 11 to 19 dB in signal peak and 13 to 18 dB respectively using a bubble curtain.

Similarly the closed cell foam lining on a floating pen, did provide a degree of acoustic protection from a nearby airgun source with attenuation levels of greater than 18 dB for frequency from 700 Hz up to 11.2 kHz for tonal signals.

These methodologies in conjunction with MMO and PAM individually or collectively can help reduce marine species exposure to anthropogenic noise sources.

Acknowledgments

Fjord & Bælt Centre, DK, Mat Amundin, Kolmårdens Djurpark SE, Harderwijk Zeedierenpark, NL, Aquatec Subsea Ltd, The Bord Iscaigh Mhara, Ireland, Sea Fish Industry Authority, Hull, Klaus Lucke, Keil University, Victoria Todd, Appin Scientific Ltd., Tim Leighton, ISVR, Kerteminde Harbour master and local council, piling construction company. Steve Robinson, Justin Ablitt NPL. LU staff, Gordon Leonard & Simon Dible.

Thank you