



Alpha Ventus Underwater Operational Noise

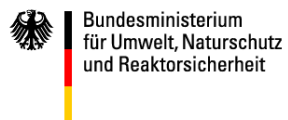
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Flensburg University of Applied Sciences

Gefördert auf Grund eines Beschlusses
des Deutschen Bundestages

Projektträger

Koordination



Contents

- Installations and data collection
- Installation problems
- Signal problems

- Results
 - Mean Sound Level
 - 1/3-octave spectra

- Conclusions
- Acknowledgement



Installations and Data Collection

Installations:

R4 and M7:

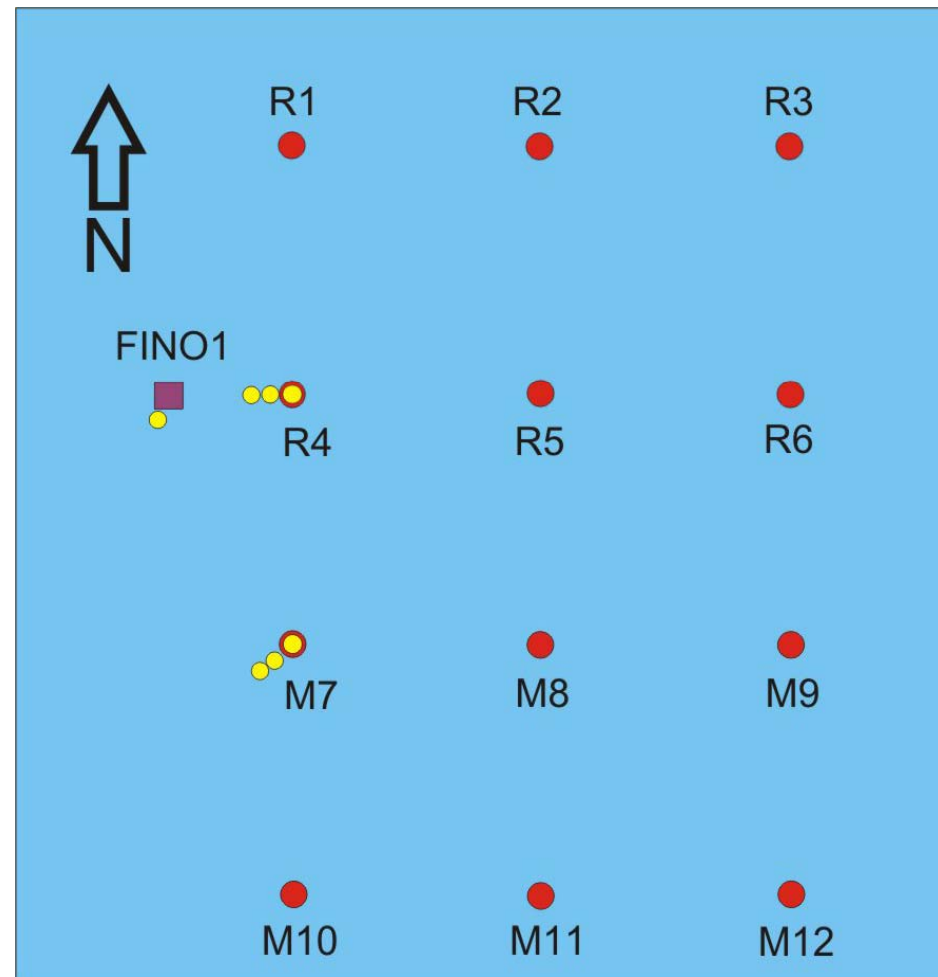
- 2 Hydrophones (75 and 135 m)
- 6 Vibration sensors
- Measuring Computer

Fino1:

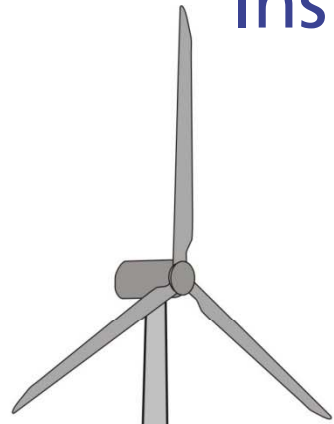
- 1 Hydrophone
- Measuring Computer

Data collection:

- Measurements 3 times a day at
04:00, 18:00, 22:00 UTC
- Sample frequency: 50 kHz
- Measuring time: 300 s



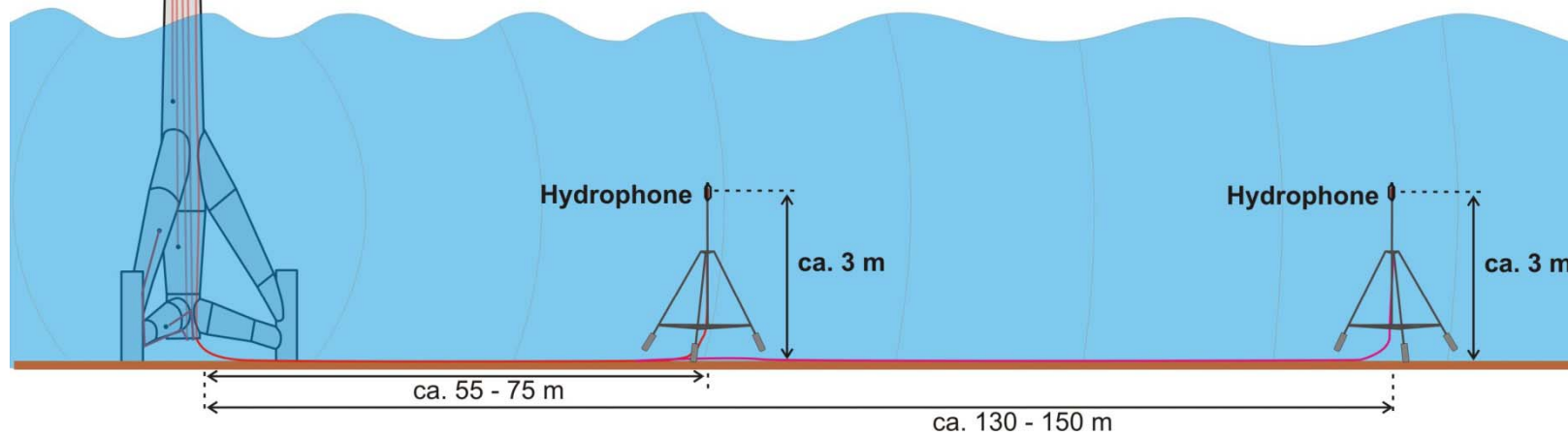
Installations



Vibration Sensor on M7



Installation of Hydrophone at R4



Installation problems

- Delayed erection of alpha ventus
- Adverse weather conditions during installation
(1st hydrophone measurement: 8th September 2010)
- No usable signals from Hydrophones at M7 from the beginning
- Deinstallation of R4 hydrophones 6th October 2010
- Break away of R4 hydrophone cables in December 2010
- Reinstallation of R4 hydrophones not until 21st July 2011
- At same time mains hum at Hydrophone F1-H8106 increases

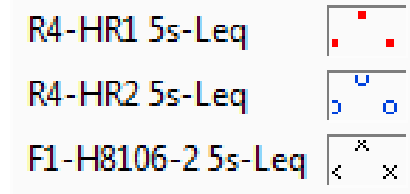
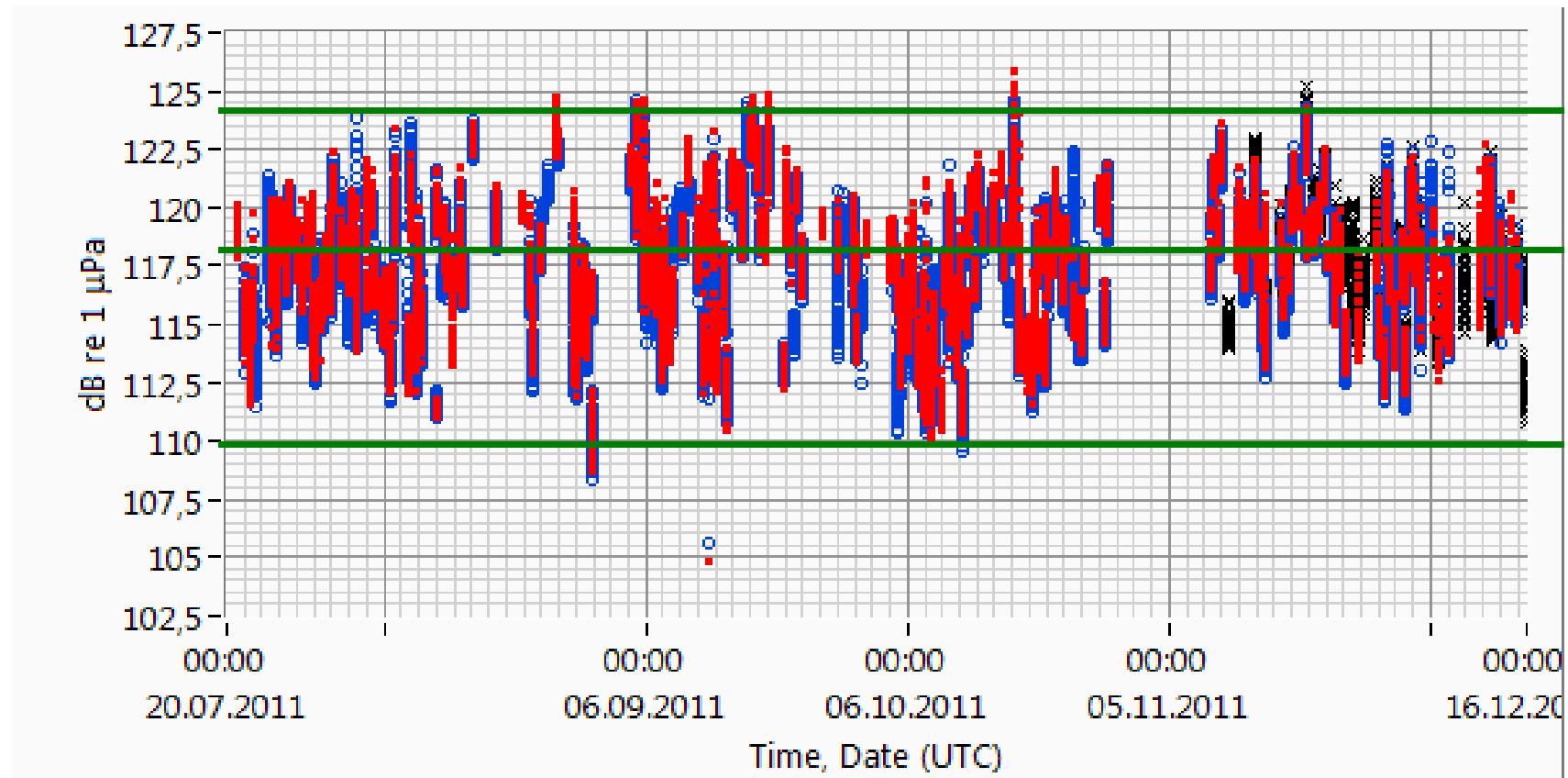


Signal problems

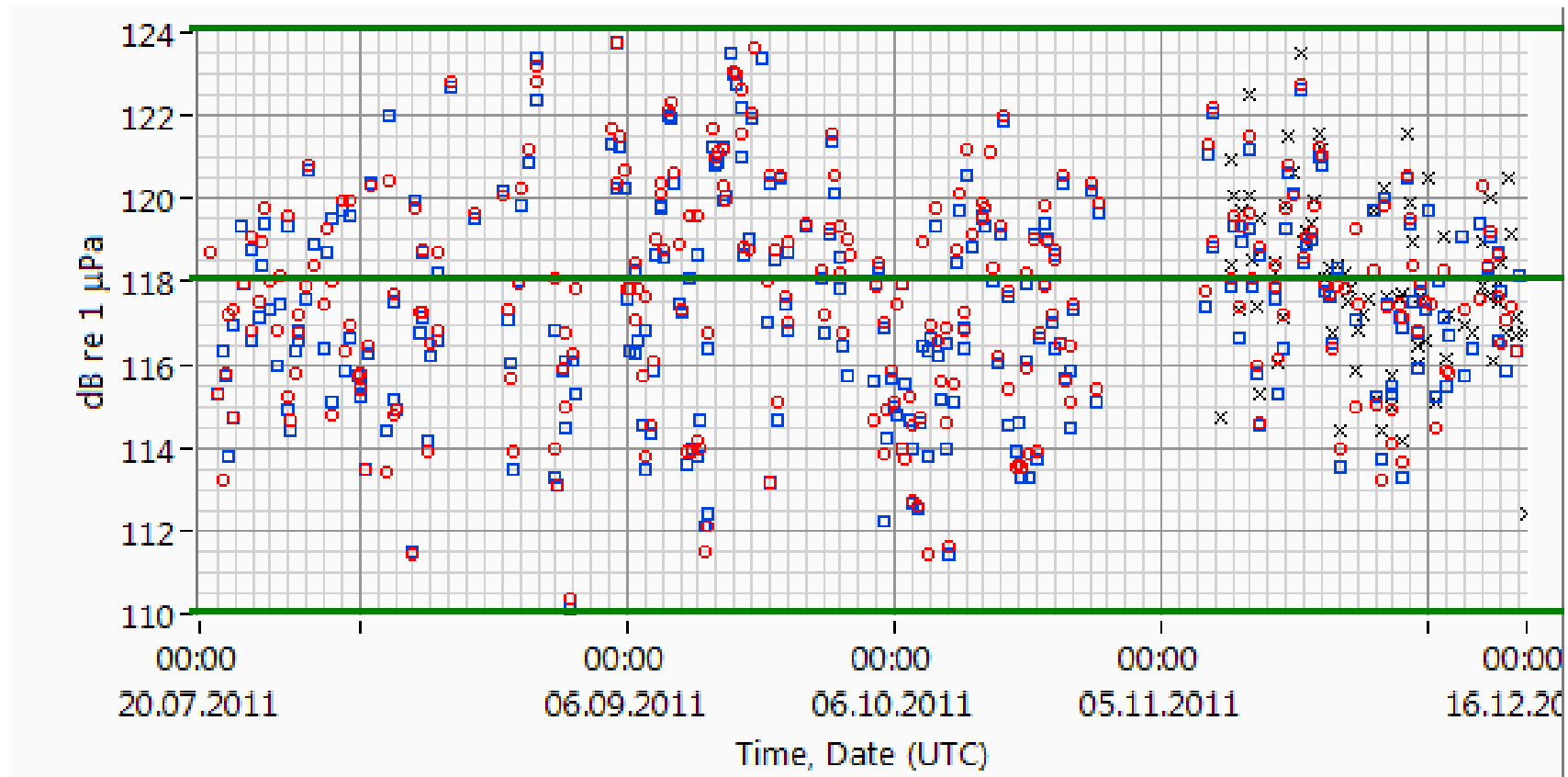
- Ship & work noise
 - Ramming noise from Bard and BW2
 - Sonar signals
 - Anchor chain noise
 - Flow separation at hydrophones (strong tide flow and wave induced flow)
 - Crosstalk from inverter and scour sonar R4
 - Mains hum on Fino1 hydrophone
 - Local noise & mechanical interaction at hydrophones from marine animals
-
- -> Manual optical and acoustical control and selection of each measurement
 - -> Bandpass filtering 10 Hz – 3 kHz
 - -> Manual correction of mains hum influence on Fino1-H8106 hydrophone data



5-s Sound Level (5-s Leq) 2011



Measured Mean Sound Levels 2011 (300s Leq)



○ R4-HR1

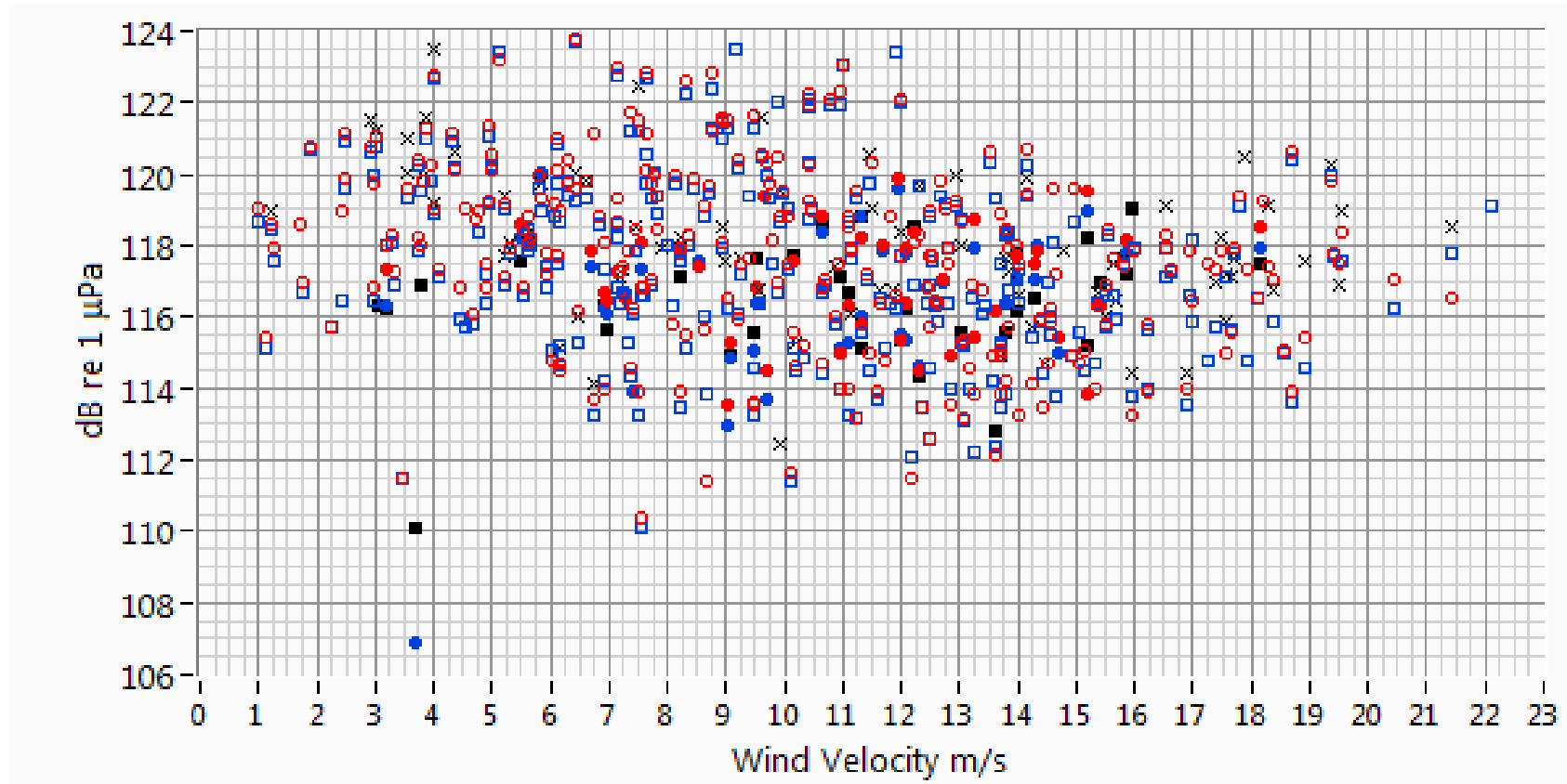
□ R4-HR2

× F1-H8106-2

Energetic mean 2011: R4-HR1: 118.4 dB; R4-HR2: 118.2; F1-H8106-2: 118.5



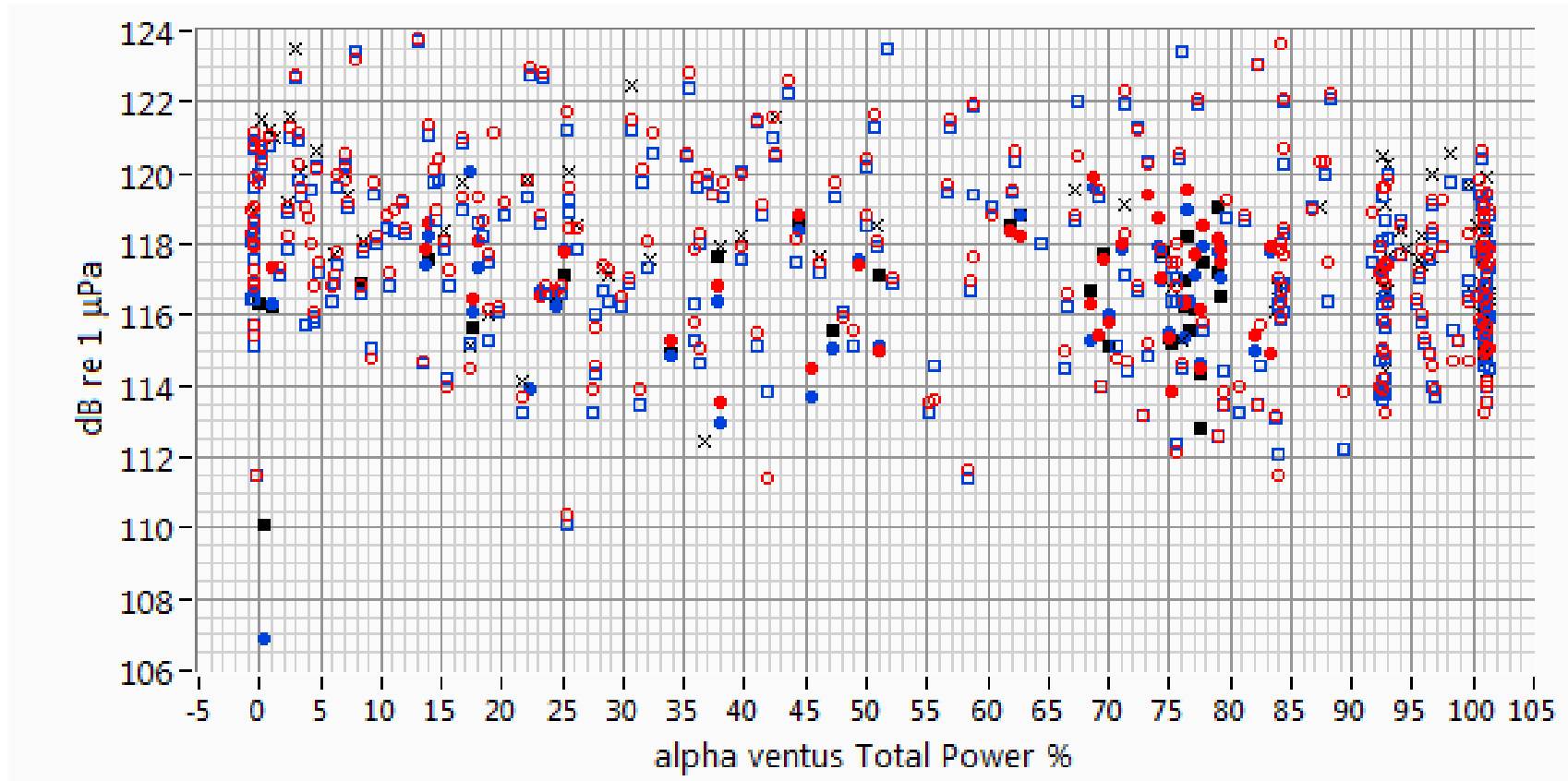
Sound Level (300s Leq) vs. Wind Velocity (2010 + 2011)



○ R4-HR1 2011 □ R4-HR2 2011 ✕ F1-H8106-2 2011
● R4-HR1 2010 ■ R4-HR2 2010 ■ F1-H8106 2010



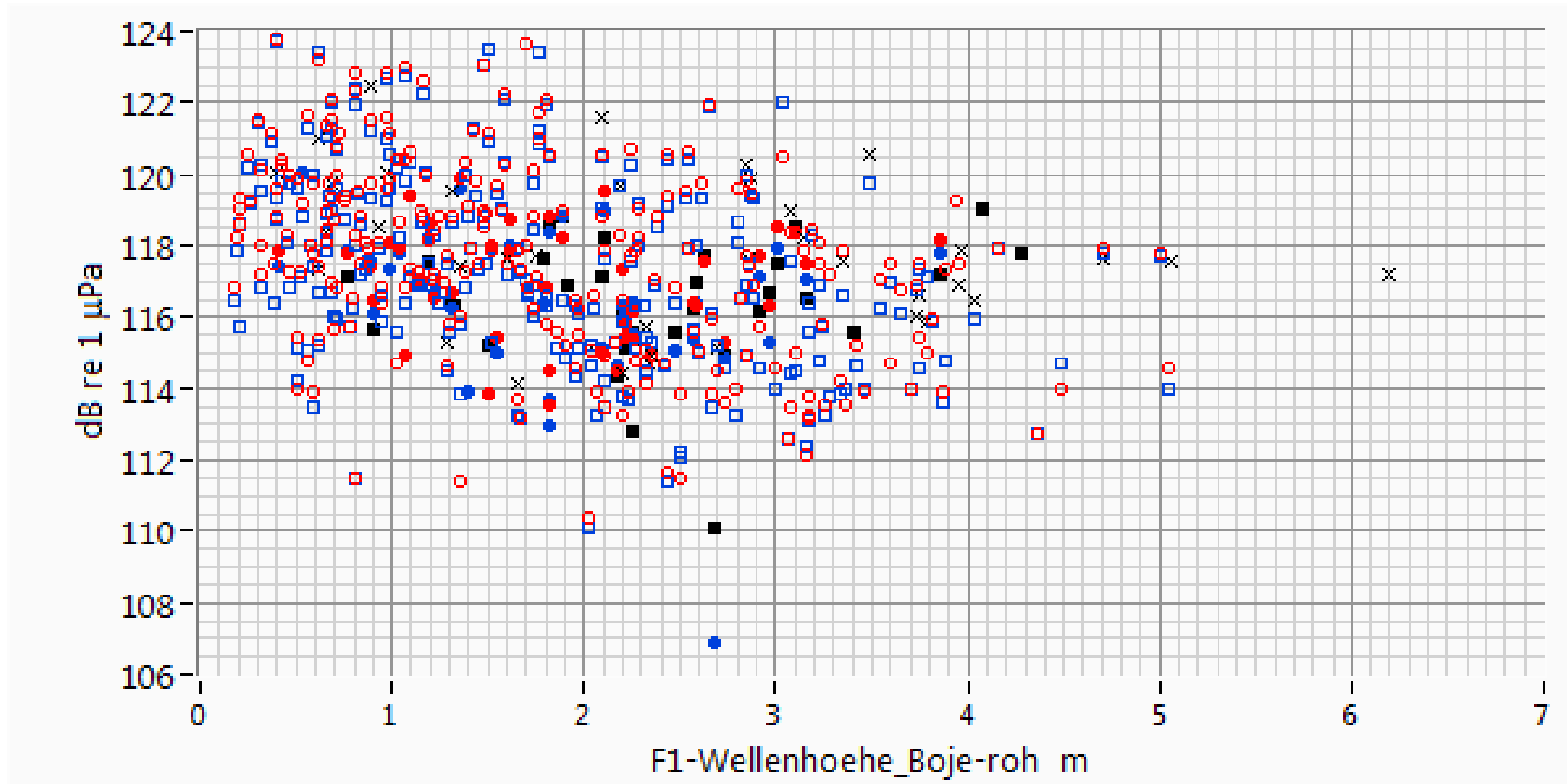
Sound Level (300s Leq) vs. Total Power alpha ventus %



- | | | |
|---------------|---------------|-------------------|
| ○ R4-HR1 2011 | □ R4-HR2 2011 | × F1-H8106-2 2011 |
| ● R4-HR1 2010 | ■ R4-HR2 2010 | ■ F1-H8106 2010 |



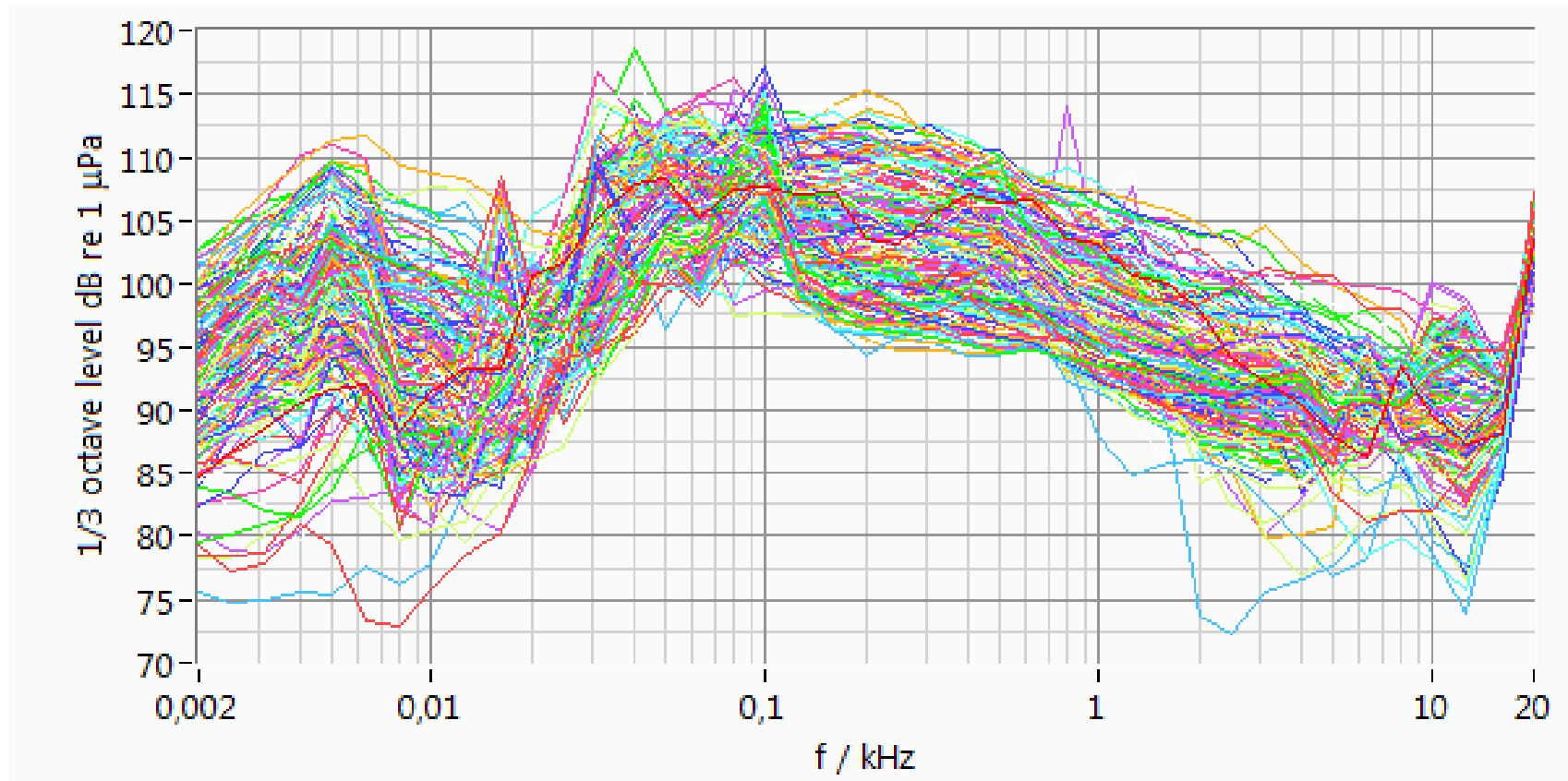
Sound Level (300s Leq) vs. Wave Height



- | | | |
|---------------|---------------|-------------------|
| ○ R4-HR1 2011 | □ R4-HR2 2011 | × F1-H8106-2 2011 |
| ● R4-HR1 2010 | ■ R4-HR2 2010 | ■ F1-H8106 2010 |



1/3-Octave spectra Hydrophone R4-HR1
Full frequency range 2 Hz – 20 kHz

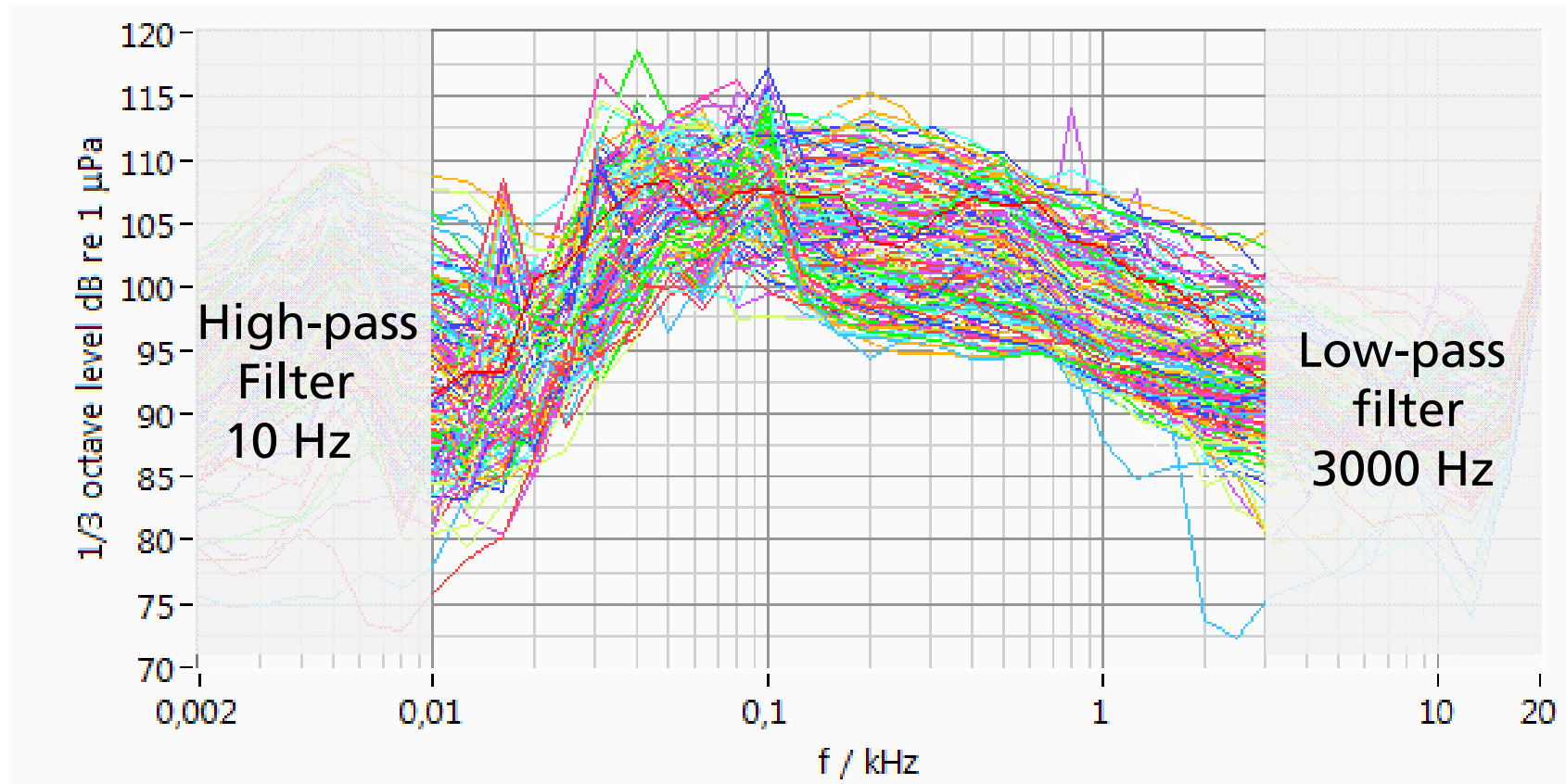


All 235 selected measurements (300 s)



1/3 Octave spectra Hydrophone R4-HR1

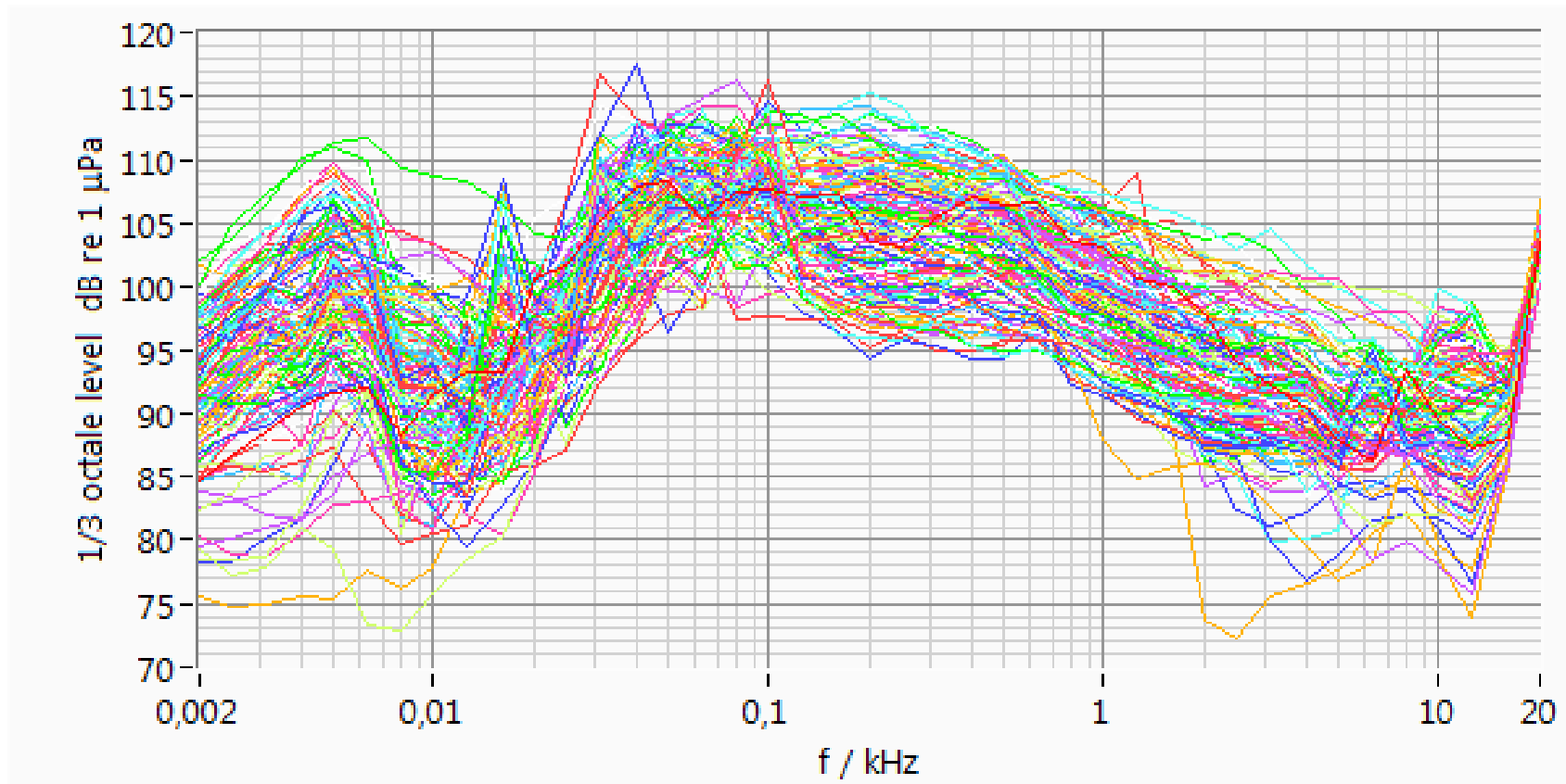
Filtered frequency range for the calculation of the mean values



All 235 selected measurements (300 s)



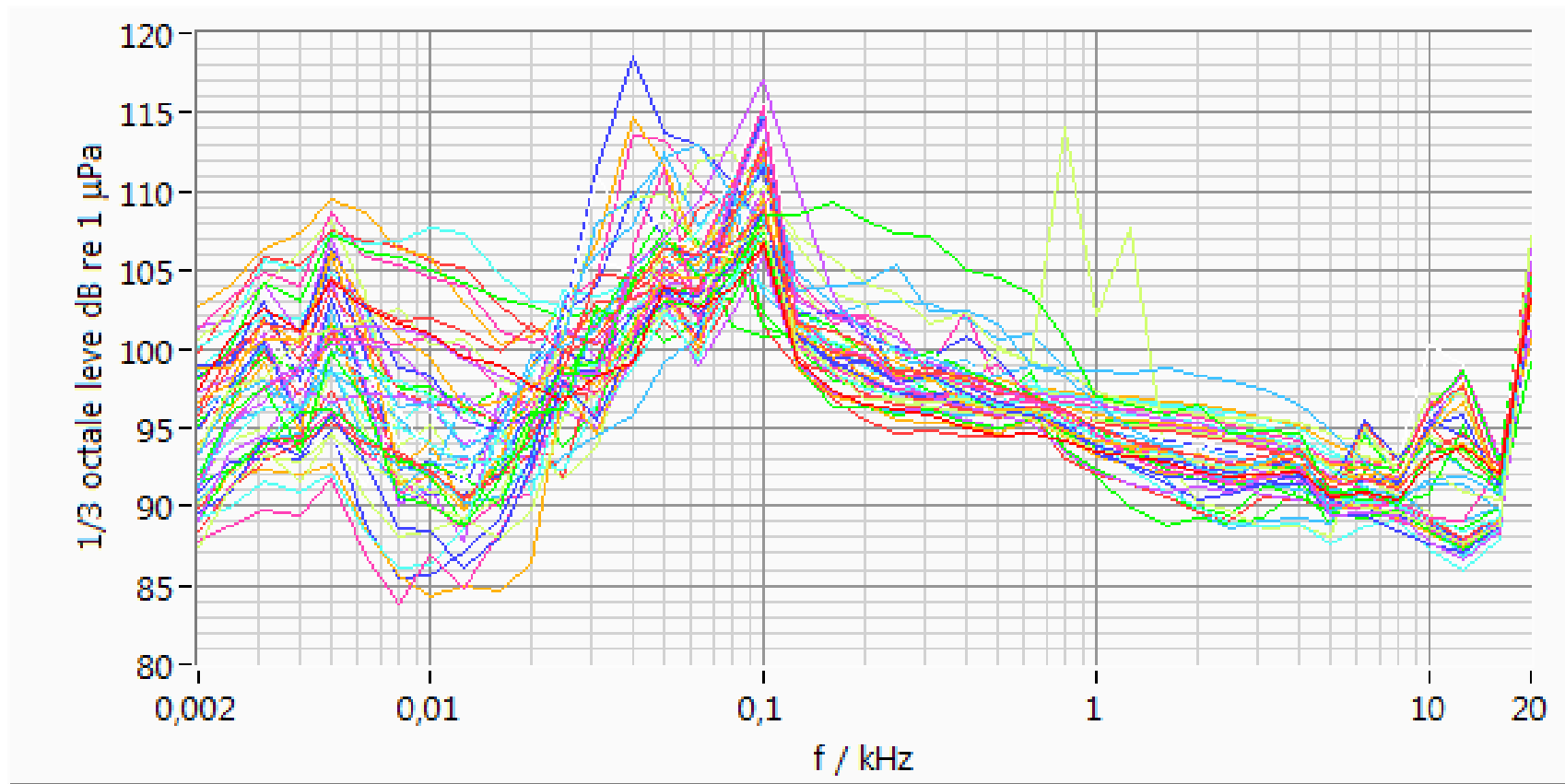
1/3-Octave spectra, Hydrophone R4-HR1



Only measurements at wave heights < 2.5 m, (151 measurements)



1/3-Octave spectra Hydrophone R4-HR1



Only measurements at wave heights > 2.5 m,
(53 measurements, power on)



Conclusions

- The underwater operational noise of alpha ventus wind farm at about 100 m distance is in the order of magnitude of the background noise
- 2011 on the perimeter of the wind farm a mean value over all measurements of 118 dB re 1 μ Pa was measured, minimum distance to type Repower approx. 100 m, type Multibrid approx. 800 m (energetic mean, wind farm noise and background noise)
- The local underwater noise level in the region of alpha ventus wind farm **decreases** with increasing wave heights
 - Fewer ships in and around the wind farm means lower local background noise
 - Higher transmission loss for noise because of higher air entrainment



Acknowledgment

This project was sponsored by the Federal Ministry for the Environment (BMU) and Project Management Juelich (ptj).



Special thanks to the colleagues from DEWI (German Wind Energy Institute), BSH (Federal Maritime and Hydrographic Agency) and Windtest for installation and maintenance of the sensors and the measuring equipment.



1 yd = 0.9144 m

⇒ ΔL_{wa}

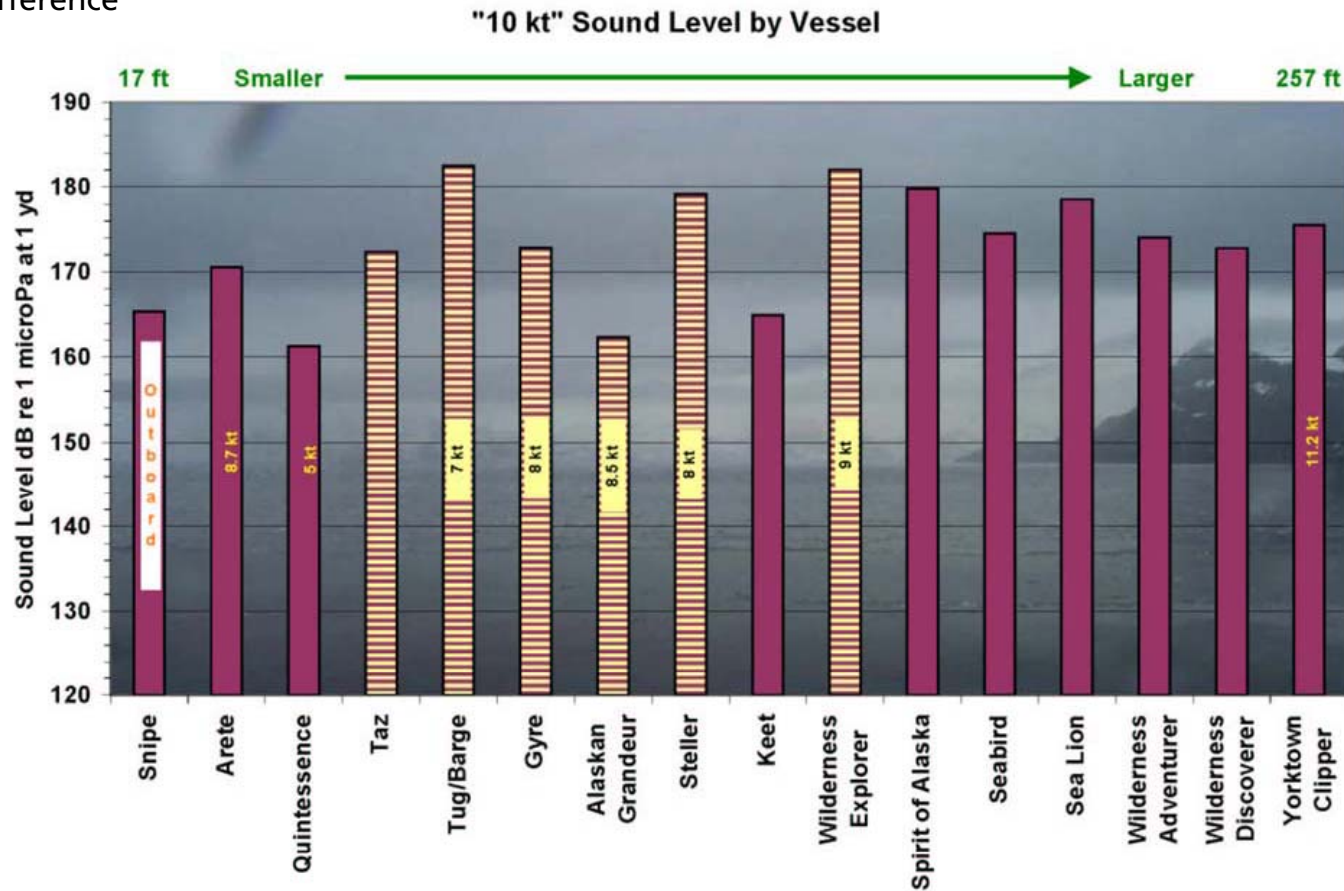
= $15 \cdot \log(1\text{yd}/1\text{m})$

= -0.6 dB

no difference

Transmission loss 14 km: $TL = 15 \cdot \log(14,000\text{m}/1\text{m}) = 62 \text{ dB}$

Vessel in 14 km distance, e.g. $180 - 62 = 118 \text{ [unit dB]}$



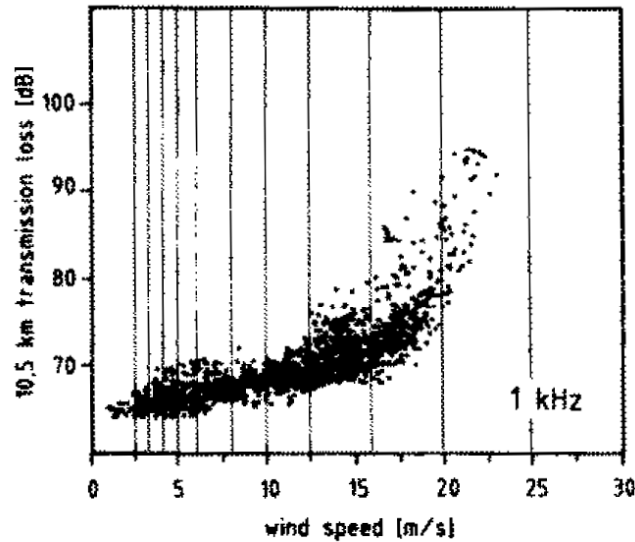
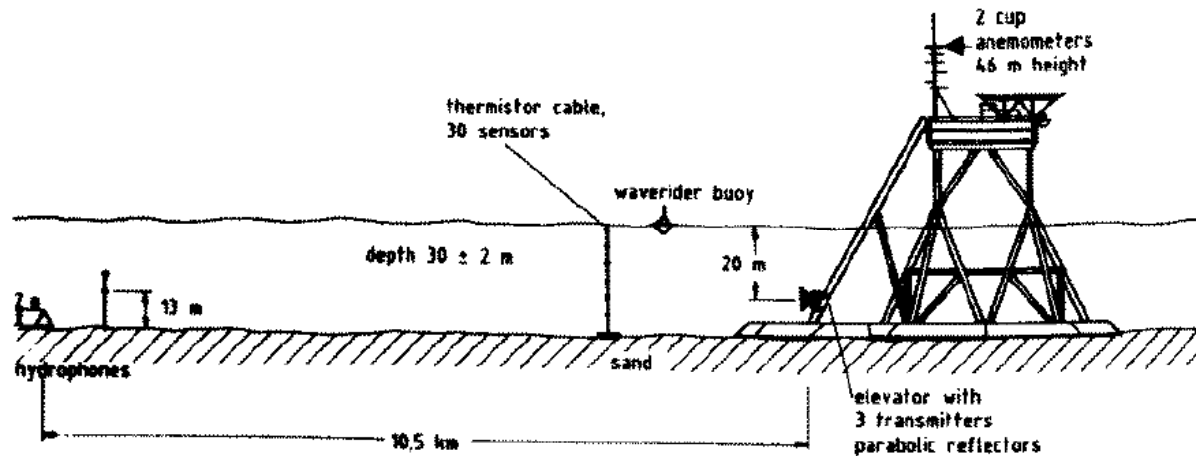
Background
at
alpha ventus
← 118 dB re 1 μ Pa

Source Sound Level Lwa: Kipple, B., Chris Gabriele, B. (2004): Glacier Bay Watercraft Noise – Noise Characterization for Tour, Charter, Private and Government Vessels. Naval Surface Warfare Center – Detachment Bremerton Technical Report NSWCCD-71-TR-2004/545 June 2004



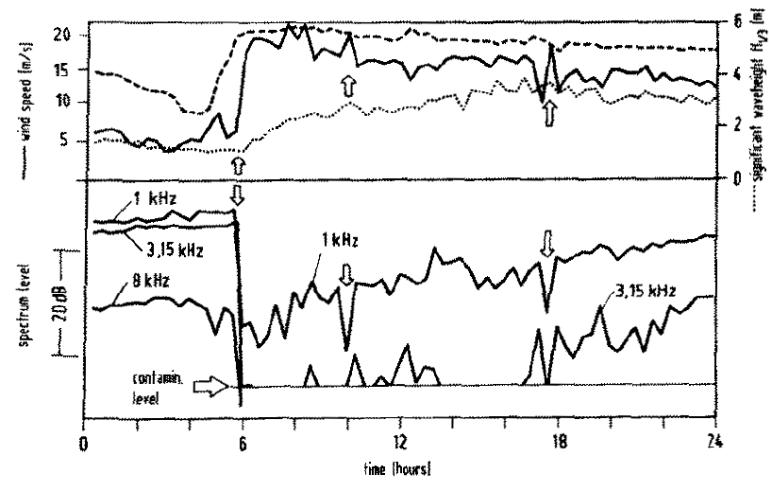
Wille, Geyer (1988) FWG Forschungsanstalt Bundeswehr Wasserschall Geophysik Kiel
 Transmission loss, 10 km, 30 m depth, bottom: sand, increases with wind (and waves)

Right:
 Measurement setup
 Loudspeaker
 10.5 km
 Hydrophone



Left:
 Versus wind speed:
 Transmission loss
 10.5 km, 1 kHz
 Each dot 10 min average

Right:
 Wind jump
 Meteorological front
 Versus time:
 Wind speed
 Three 1/3 Octave bands:
 1 kHz, 3.15 kHz
 8 kHz in result too low to show



Source: Wille, P.C., Geyer, D. (1988): Simultaneous Measurements of Surface Generated Noise and Attenuation (FWG = Member Project Committee)

at the fixed Acoustic Shallow Water Range "Nordsee". in Kerman, B. R.: Sea Surface Sound. Kluwer Academic Publishers, Dordrecht

