EVALUATION OF RANGE STANDARDS FOR UNDERWATER RADIATED NOISE MEASUREMENTS IN BEAM ASPECT

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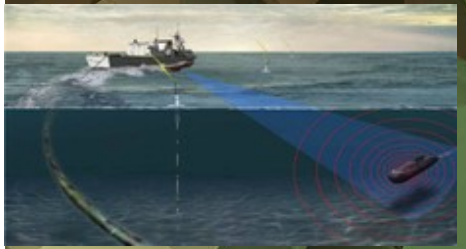
BUNDESWEHR

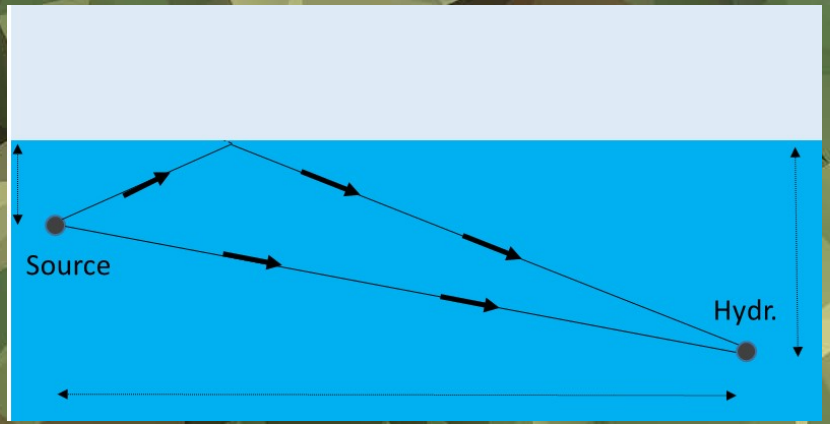
Introduction

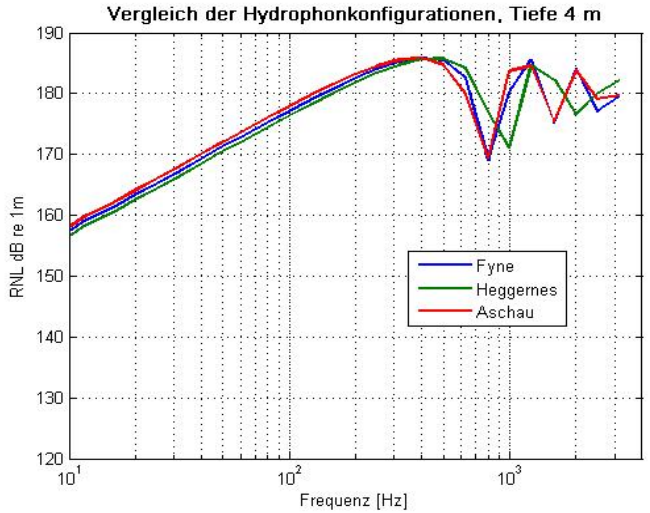
- Data evaluation and analyses of a measurement trial with a small vessel at Heggernes sound range using different standards:
  - The ISO 17208-1 (marine protection)
  - The STANAG 1136 (operational requirements)
- Both standards describe procedures for the determination of underwater Radiated Noise Levels.



Underwater Radiated Noise Level:

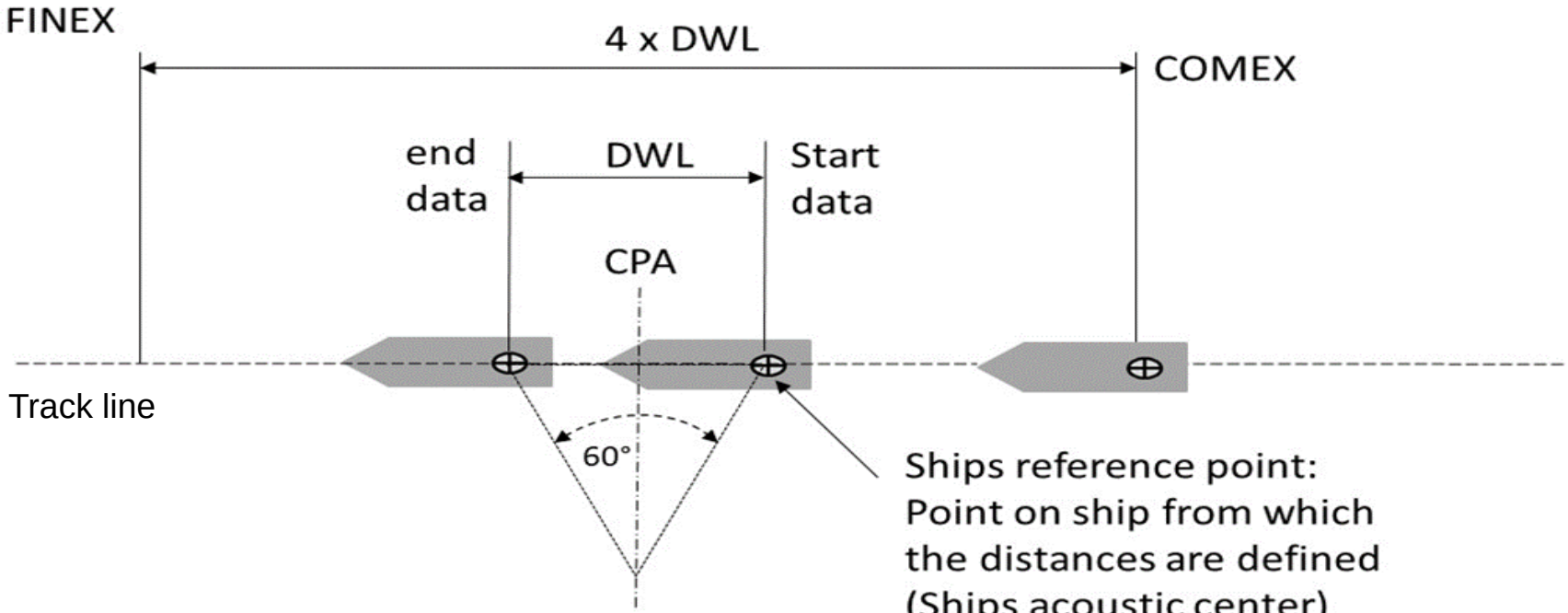
- Underwater Radiated Noise Level (RNL) is defined as the 1/3 Octave RMS Sound Pressure Level measured in the far field and normalized to a reference distance of 1 m by means of spherical propagation correction (20*log (R/R_0))
- The measured Radiated Noise Levels are influenced by Lloyd's mirror effect. It is caused by the pressure release surface reflection.





Standards

Procedure:



Standards

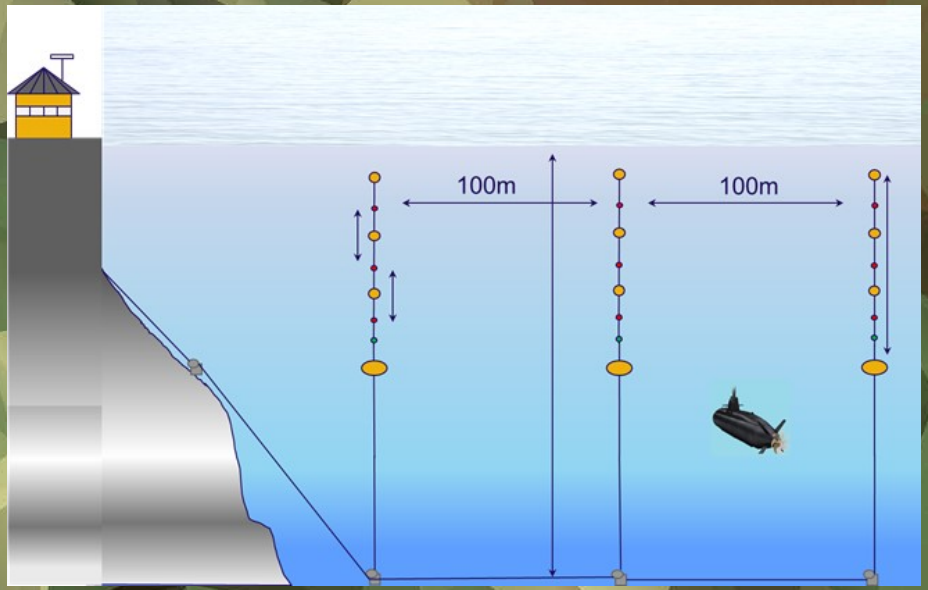
Specification:

Topic	ISO 17208	STANAG 1136	Heggernes
Number of hydrophones	3	1	3x3
Hydrophone depth	@ 15° = 27 m @ 30° = 58 m @ 45° = 100 m	Between 9 m - 36 m	H-up = 30 m H-mid = 62.5 m H-low = 95 m
Data Window Angle (*Data Window Length*)	± 30° (*121 m*)	± 45° (*209 m*)	± 15° (*56 m*)
Distance correction at CPA	Sea surface	Nearest point on the hull	Nearest point on the hull
COMEX Commence exercise	200 m before CPA		400 m before CPA
FINEX Finish exercise	200 m behind CPA		200 m behind CPA

Sound Range

Characteristics:

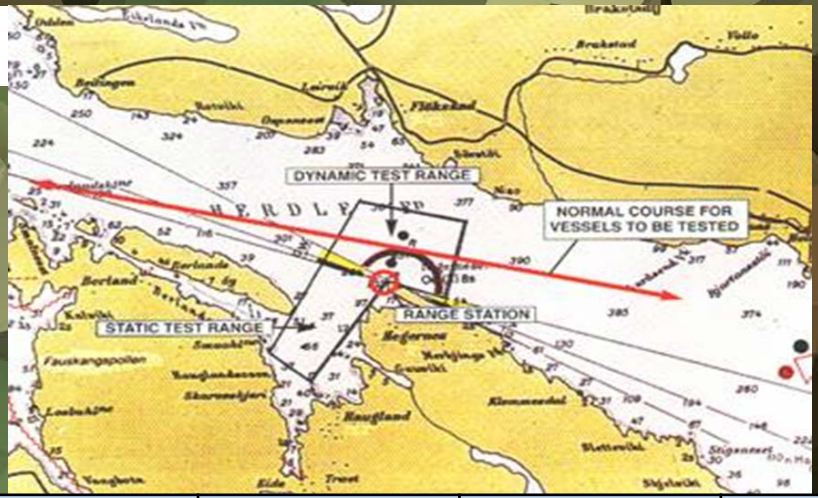
- Deepwater sound range (depth = 385 m)
- Situated in Herdla Fjord (width = 1200 m)
- Bottom fixed hydrophone lines (depth adjustable)
- Measure surface ships & submarines
- Low ambient noise level



Measurement Trial

Runs:

- Two operational conditions
  - 5 kts (below CIS)
  - 12 kts (above CIS)
- Two sailing directions
- Track deviation < 3 m
- Small speed difference between east and west runs

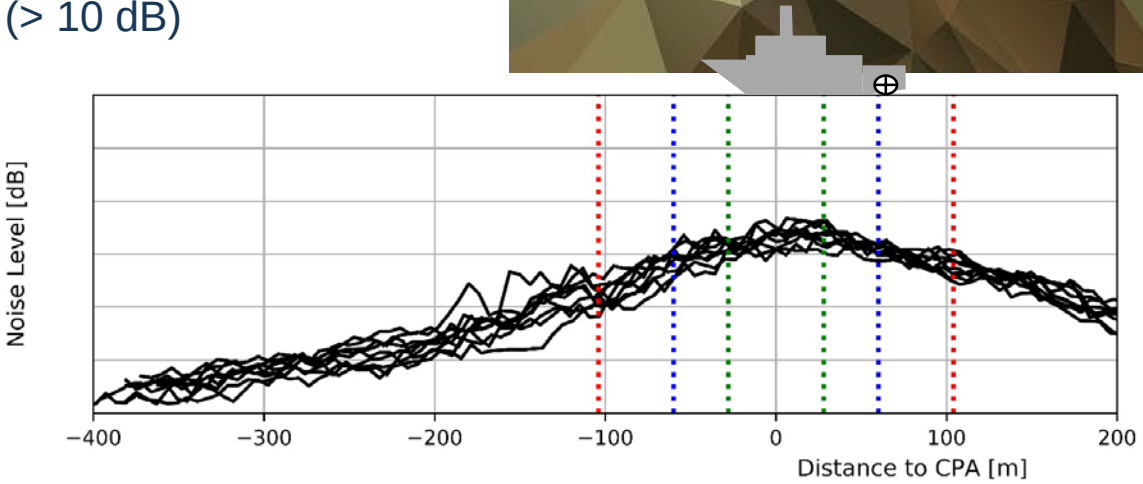


Heading	5 kts	12 kts	Hydrophone location	Aspect
East	6 Runs (4.6 kts / 2.4 m)	9 Runs (11.8 kts / 2.9 m)	North	Port
			South	Stbd
West	7 Runs (5.9 kts / 1.9 m)	10 Runs (12.4 kts / 2.3 m)	North	Stbd
			South	Port

Measurement Trial

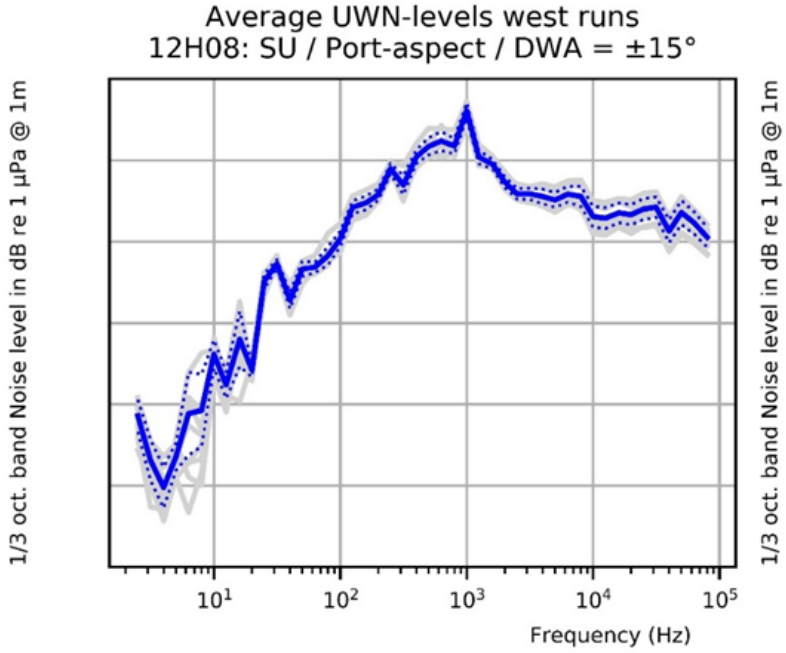
Signal to noise ratio (100Hz-10kHz):

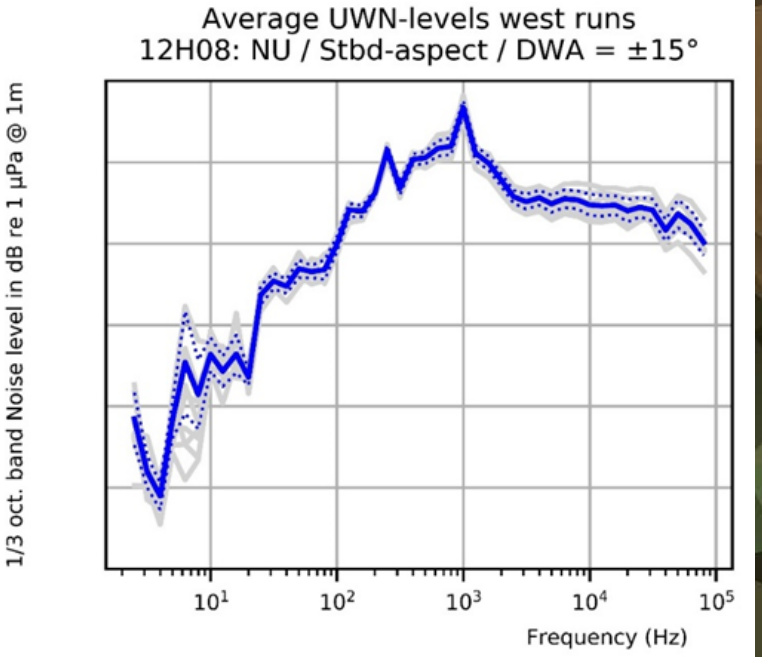
- Reproducible conditions and noise levels
- Maximum levels inside all DWL's
- Sufficient signal to noise ratio (> 10 dB)



Measurement Trial

Underwater Radiated Noise Levels

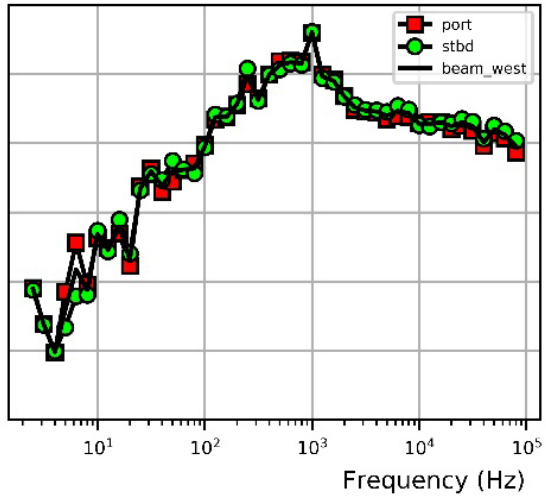




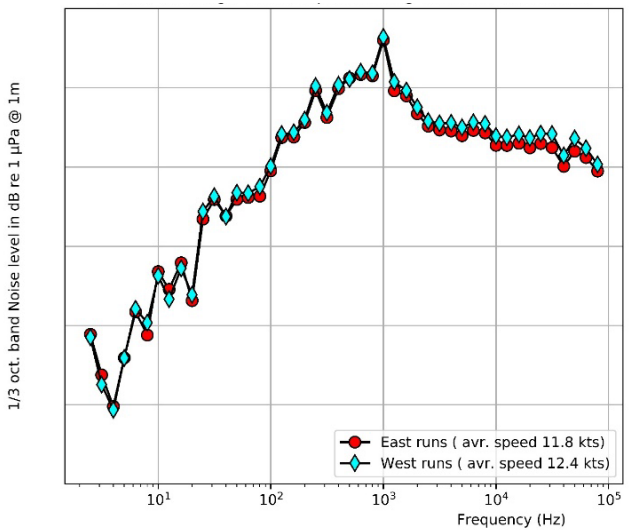
Measurement Trial

Effect of aspect angle and heading:

Port and Stbd aspect levels are almost equal

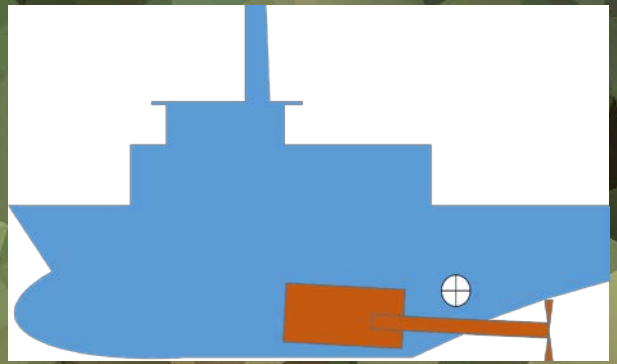


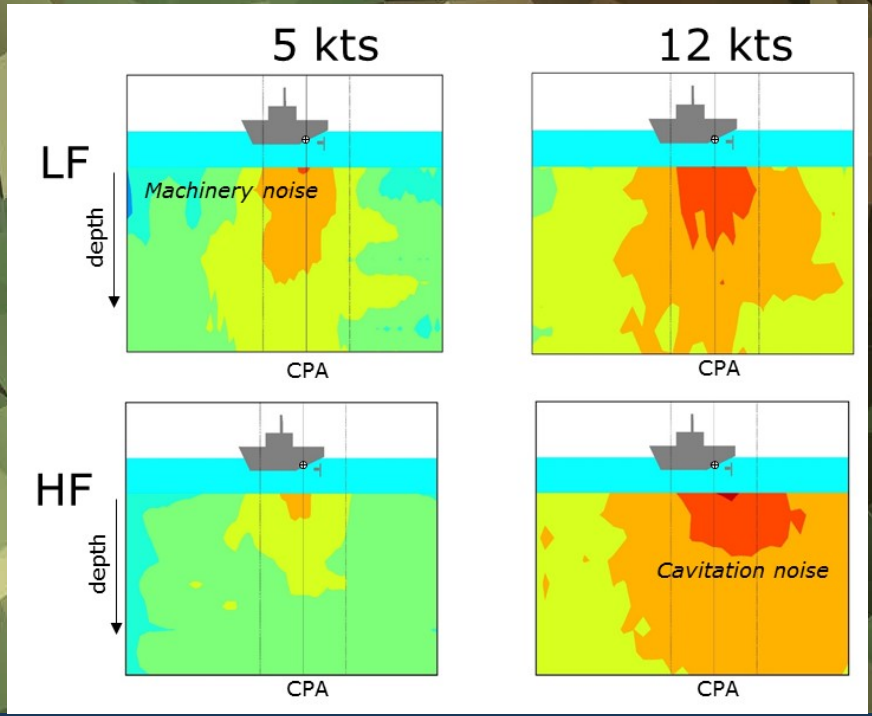
West runs are faster and produce more noise in the higher frequency bands



Measurement Trial

Acoustic reference position:

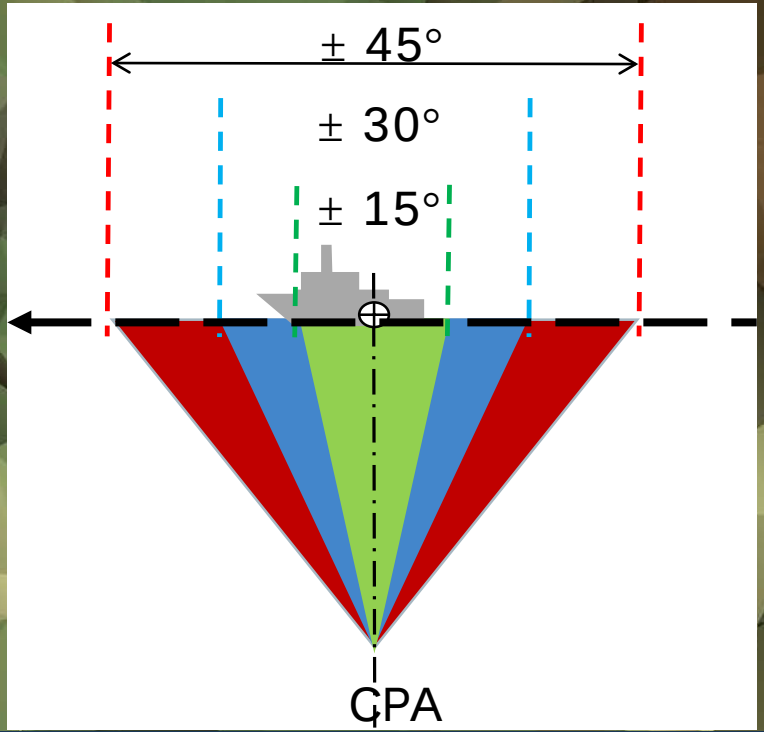




Comparison of range standards

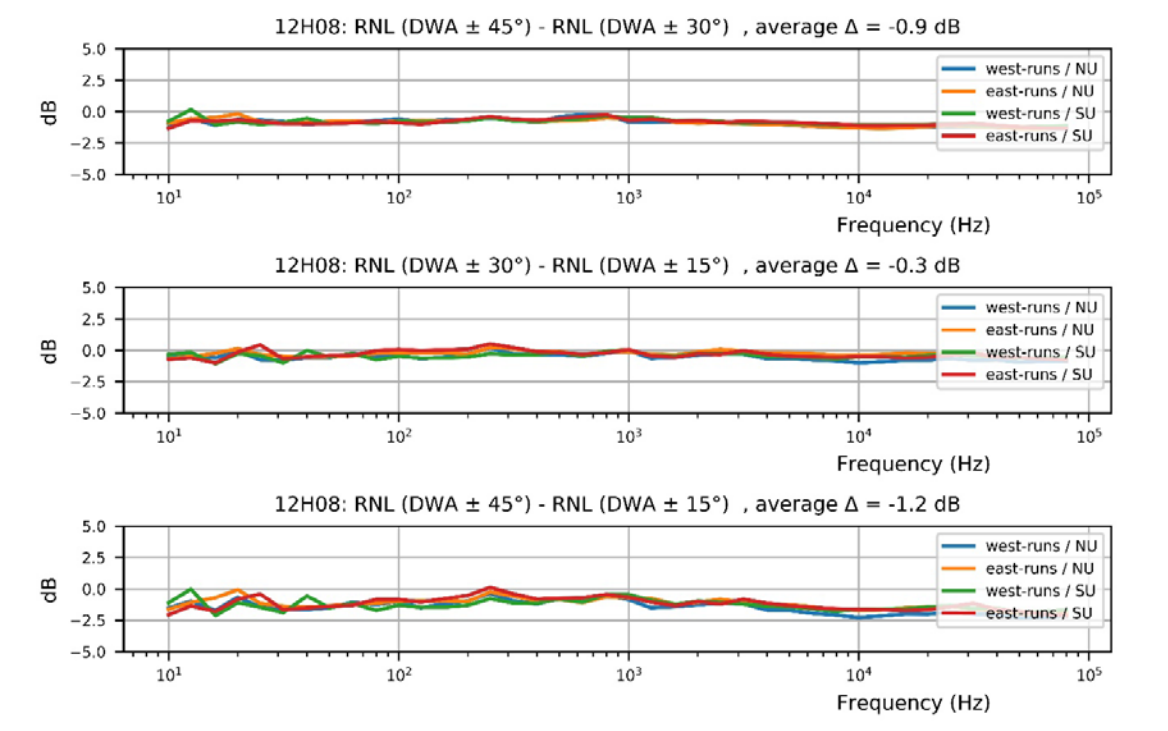
Data Window Angle:

Standard	DWL (m)
STANAG 1136	209
ISO	121
Heggernes	56



Comparison of range standards

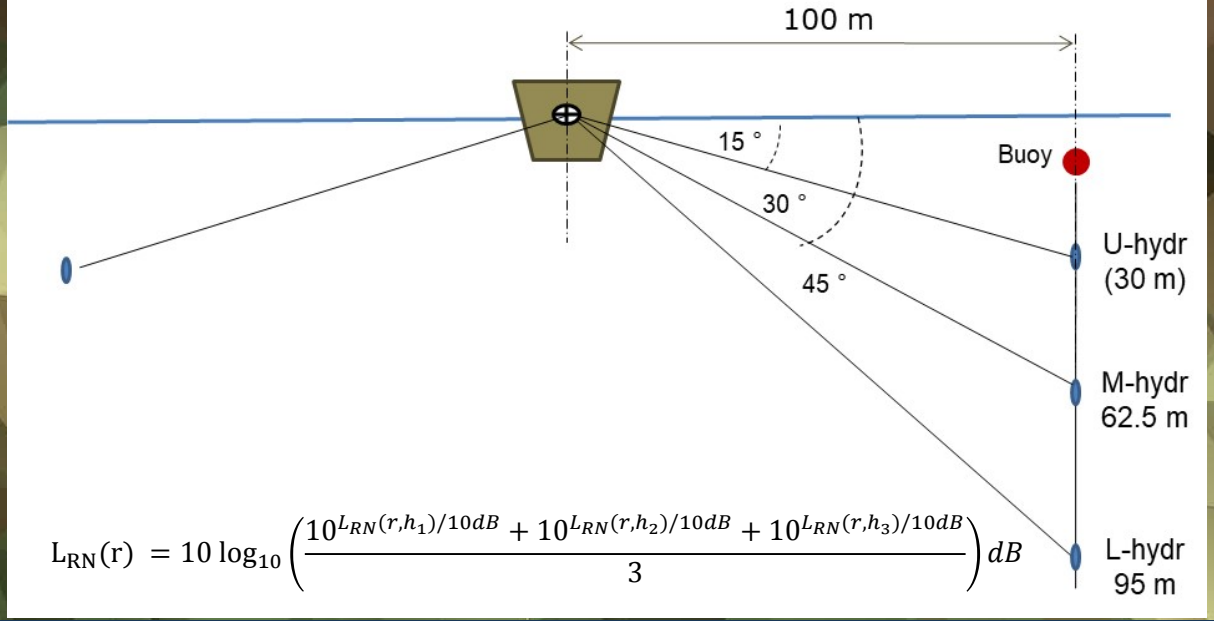
Effect of Data Window Angle (DWA):



Comparison of range standards

Effect of Hydrophone layout:

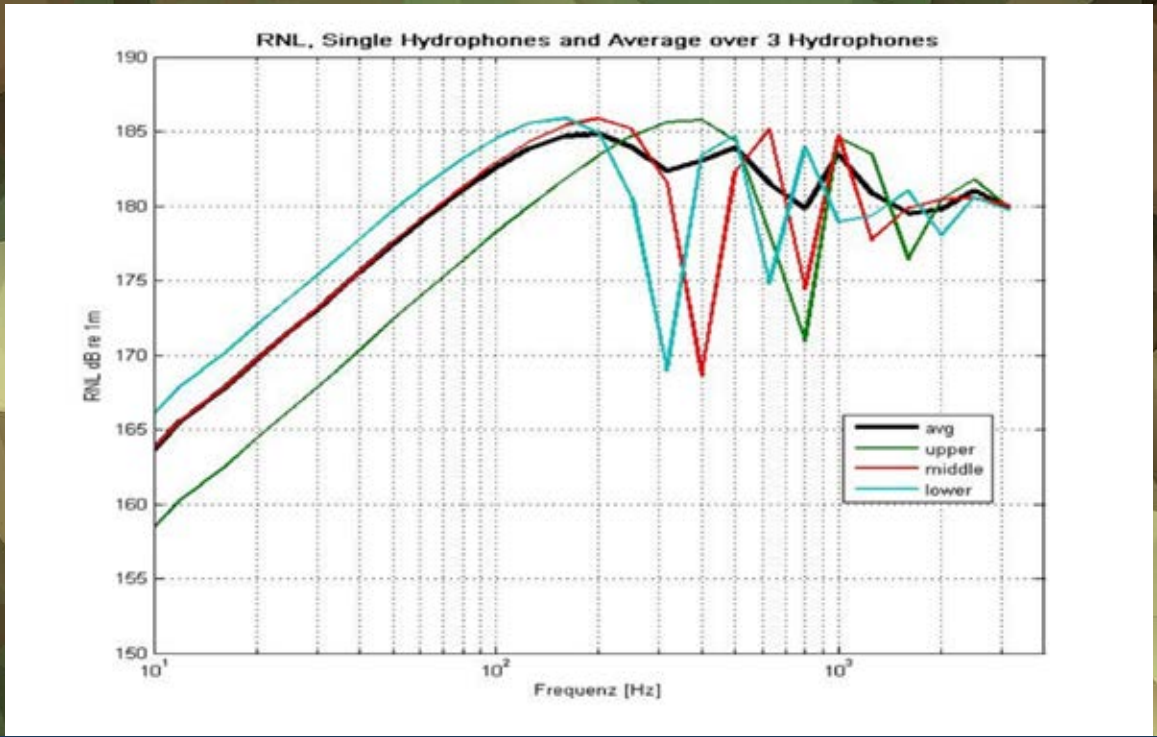
STANAG 1136 ISO 17208



$$L_{RN}(r) = 10\log_{10}\left(\frac{10^{L_{RN}(r,h_1)/10dB} + 10^{L_{RN}(r,h_2)/10dB} + 10^{L_{RN}(r,h_3)/10dB}}{3}\right) dB$$

Comparison of range standards

Effect of Hydrophone layout:



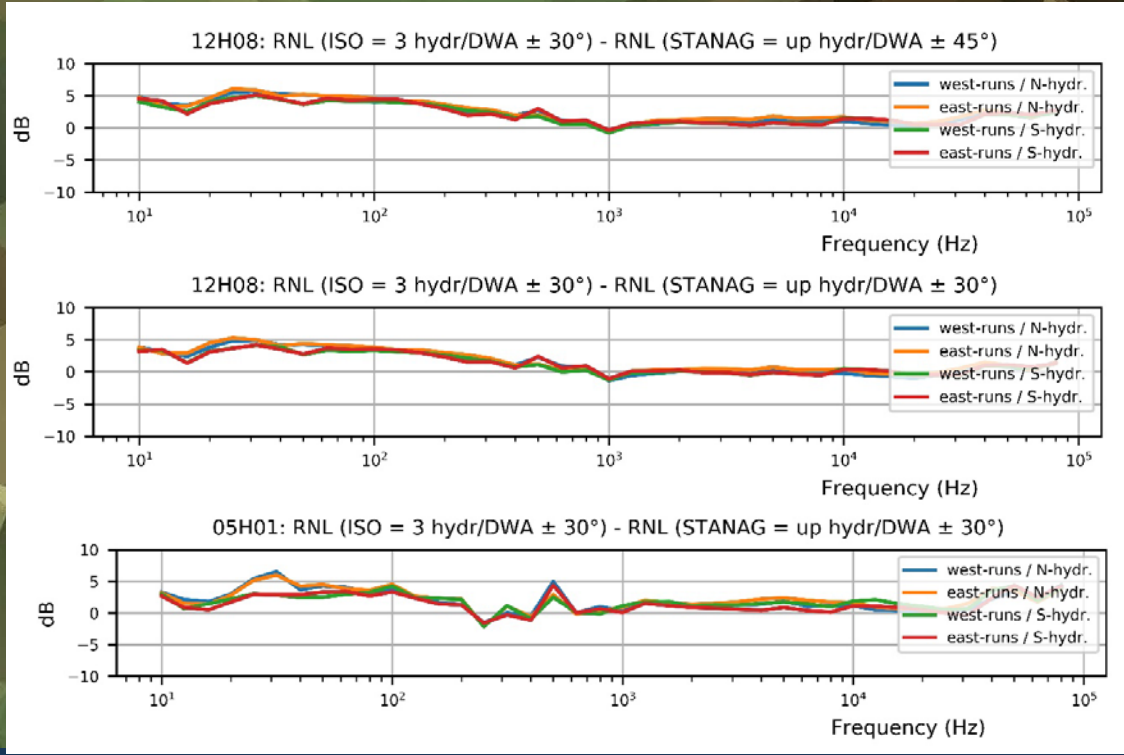
Comparison of range standards

Effect of Hydrophone layout:

ISO – STANAG for 12 kts

ISO – STANAG for **12** kts
Similar DWA

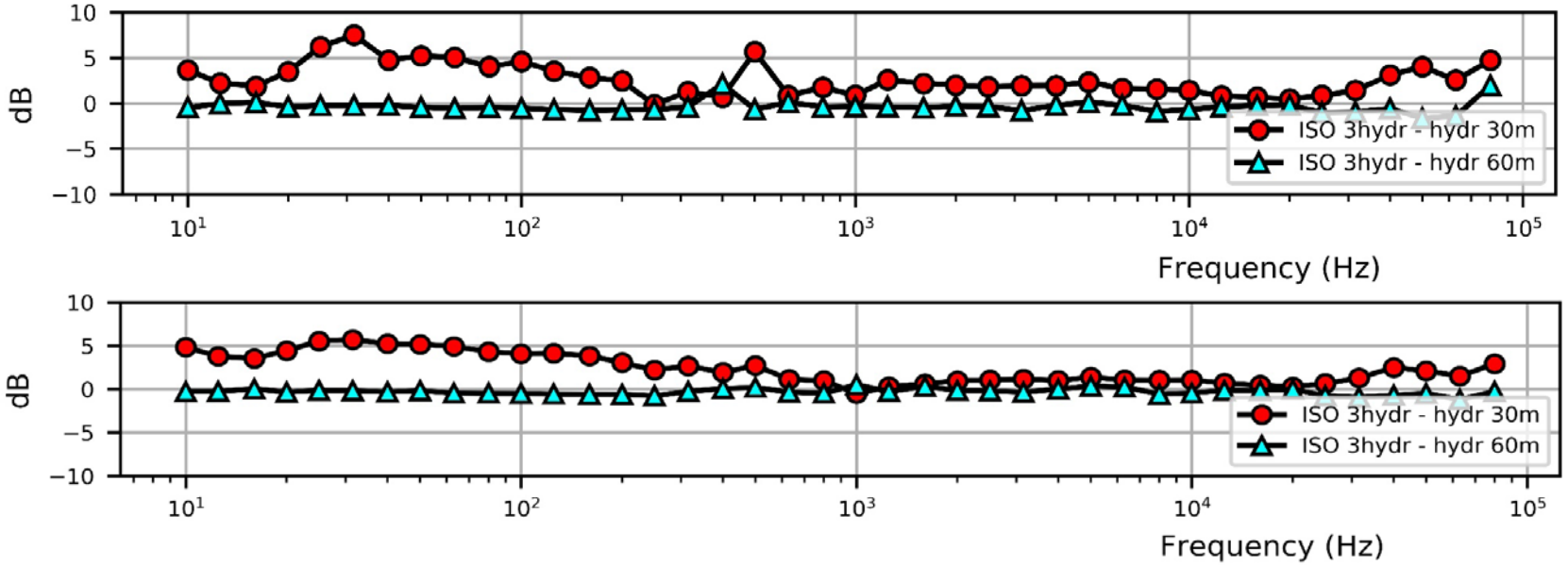
ISO – STANAG for **5** kts
Similar DWA



Comparison of range standards

Effect of Hydrophone layout:

Average over 3 hydrophones – Single hydrophone



5 kts

12 kts

Conclusions

- The Heggernes sound range has a hydrophone layout which complies with the specification of ISO 17208-1.
- A large DWL in relation to the length of the ship as specified by STANAG can lead to an underestimation of Radiated Noise Levels.
- DWL should be related to the ship length, especially for small ships.
- The hydrophone layout specified by ISO is smoothing the Lloyd's mirror effect in a broad frequency range.
- Radiated noise levels measured with a single hydrophone at 30° are comparable with results of ISO using 3 hydrophones at different depths.