

Centre for Ship Signature Management



CSSM



Understanding radiated noise measured at different sound ranges



WTD 71



Defence Research and
Development Canada

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pour la défense Canada

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Background

- The acoustic signature is an essential factor for the operational capabilities of naval platforms (submarines)
- Acoustic signature requirements have to be fulfilled and verified during the full life time
- Valid and reliable measurements are mandatory
- The acoustic signature of two naval research vessels was measured at different sound ranges and analyzed in order to identify range dependent differences

RIMPASSE

Radar Infra-red electro-Magnetic Pressure Acoustic
Ship Signature Experiments





Content

- Main influences
- Platforms
- Trials
- Sound ranges
- Comparison of static trials
- Comparison underway trials
- Summary



Main influences

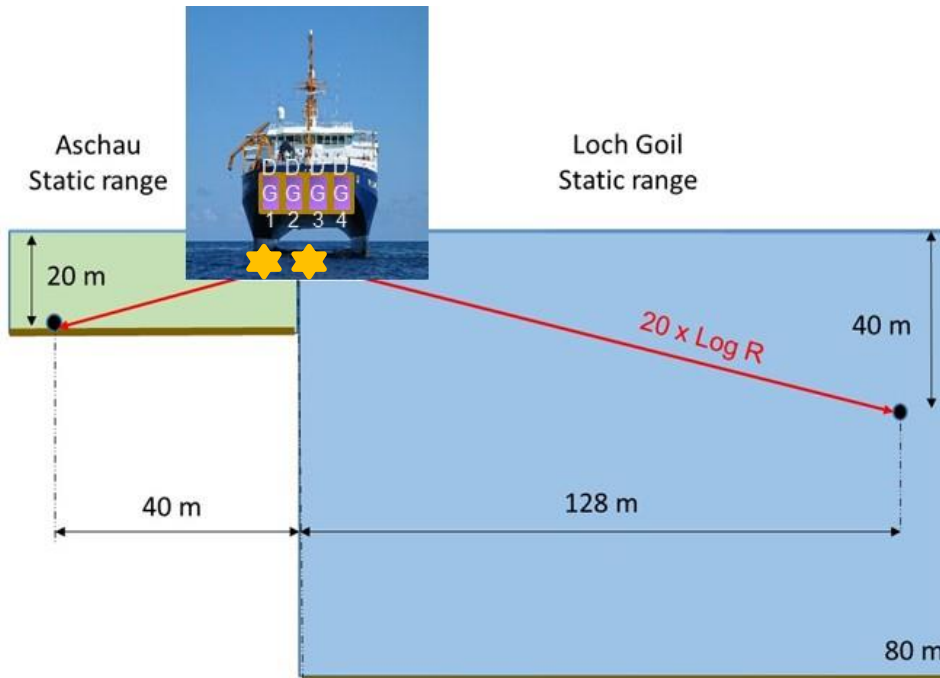
- Range geometry (underwater sensor layout)
- Passing distance (CPA)
- Propagation (bottom properties)
- Background noise
- Stability of the noise source (Platform)
- Used methodology for calculating average noise levels

Main influences

Range geometry & hydrophone layout

Possible differences due to:

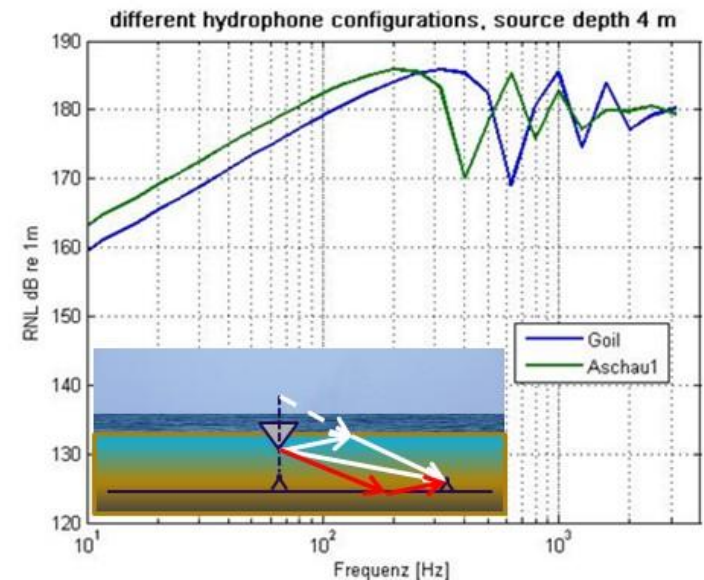
- Location acoustic centre
- Hydrophone layout



Acoustic centre

Sound Range	Planet (27 m)	Quest (12 m)
Aschau	3.1	1.0
Loch Goil	0.9	0.4
Possible error (dB)	2.2	0.7

Lloyd's Mirror

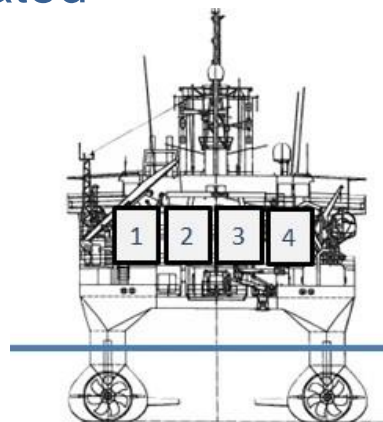


Platforms (sources)

Planet



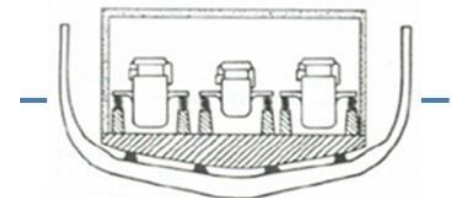
- Swath concept with PM propulsion
- 3850 ton/ 73 m / 27 m
- DG set double mounted and enclosed located above waterline



Quest



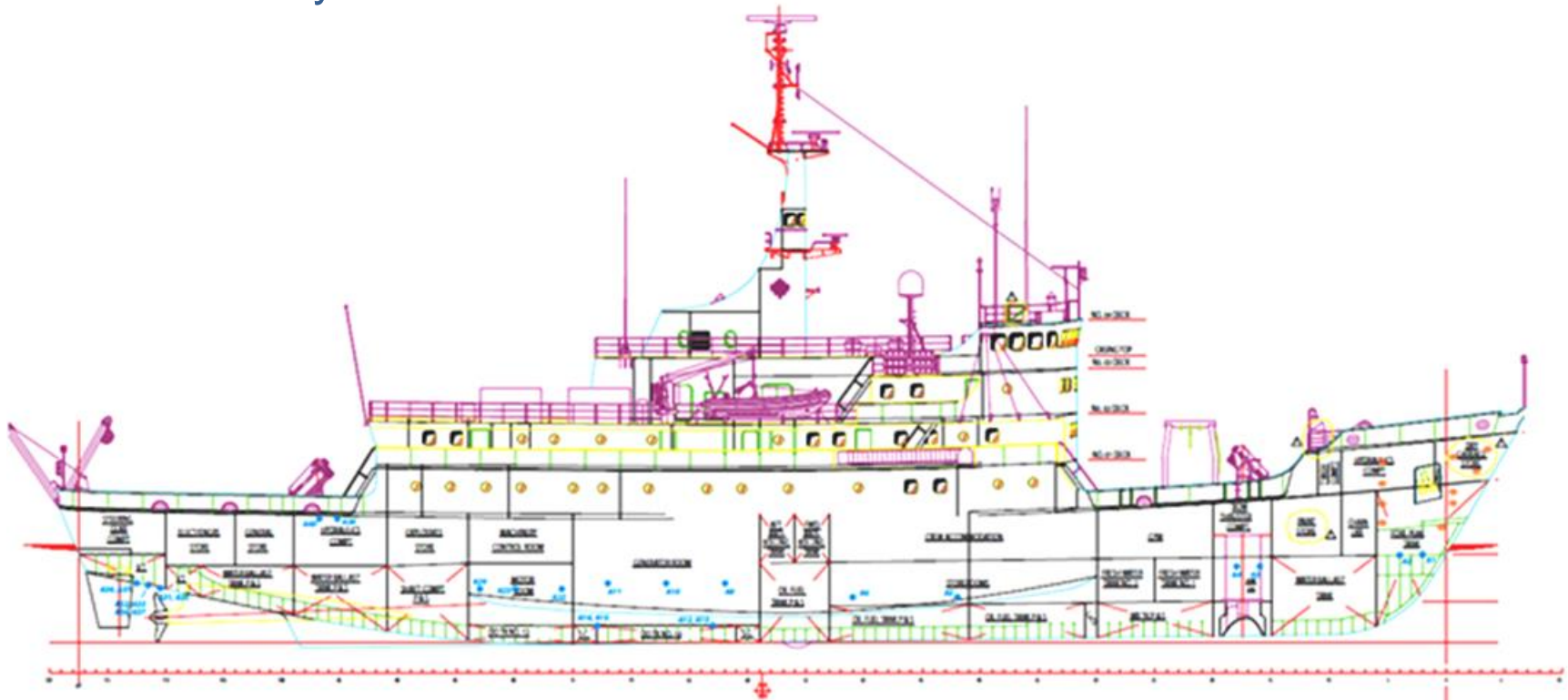
- Monohull concept with DC propulsion
- 2200 ton / 76 m / 12.5 m
- Damping tiles
- DG sets on common enclosed raft



Platforms (sources)

Onboard sensors:

- Structure borne noise was measured simultaneously during all trials
- Sensors mounted at hull frames, main machinery and machinery foundations



Trials

Static trials

- Platform moored between buoys
- Aschau 2 and Loch Goil
- Determine noise levels of individual (auxiliary) machinery and ship foundation transfer functions



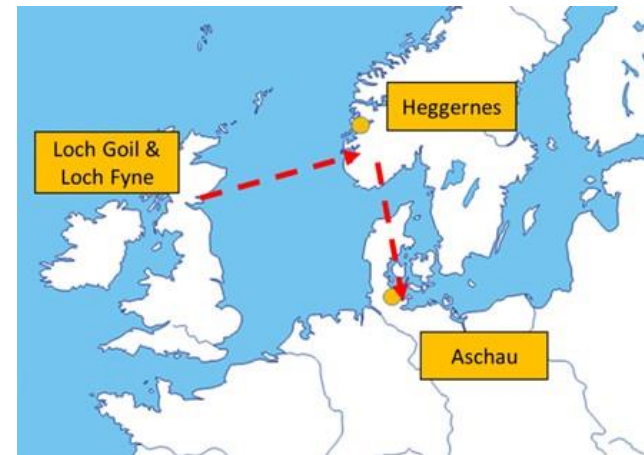
Underway (dynamic) trials

- Platform sails on dedicated track
- Loch Fyne, Heggernes, Aschau 1 and 2
- Determine the overall underwater noise levels as function of speed and platform configuration (6, 9 and 12 kts)



Sound ranges

- Loch Goil
- Loch Fyne
- Heggernes
- Aschau

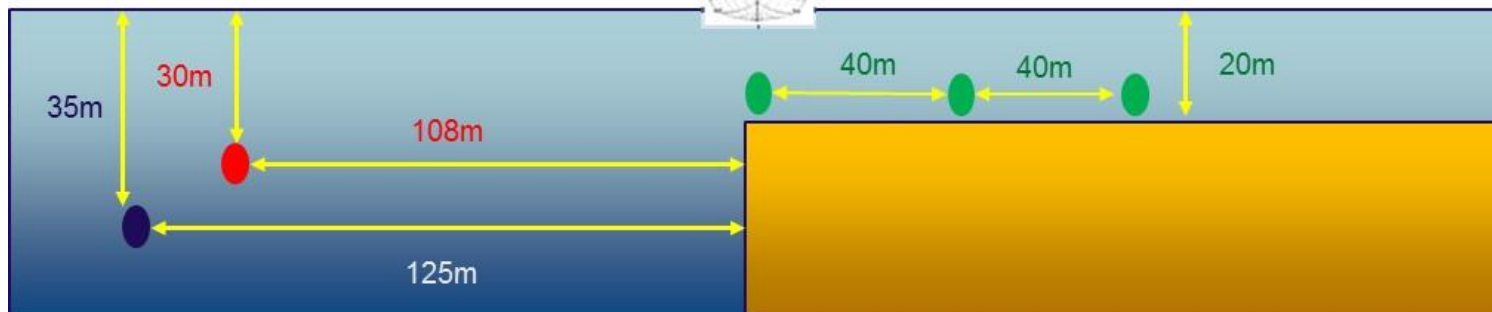


Aschau (DE)

Heggernes (NO)

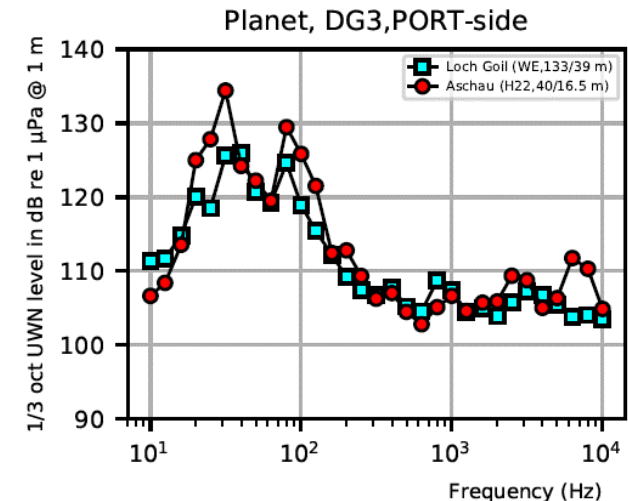
Loch Fyne (GB)

Deep water ranges

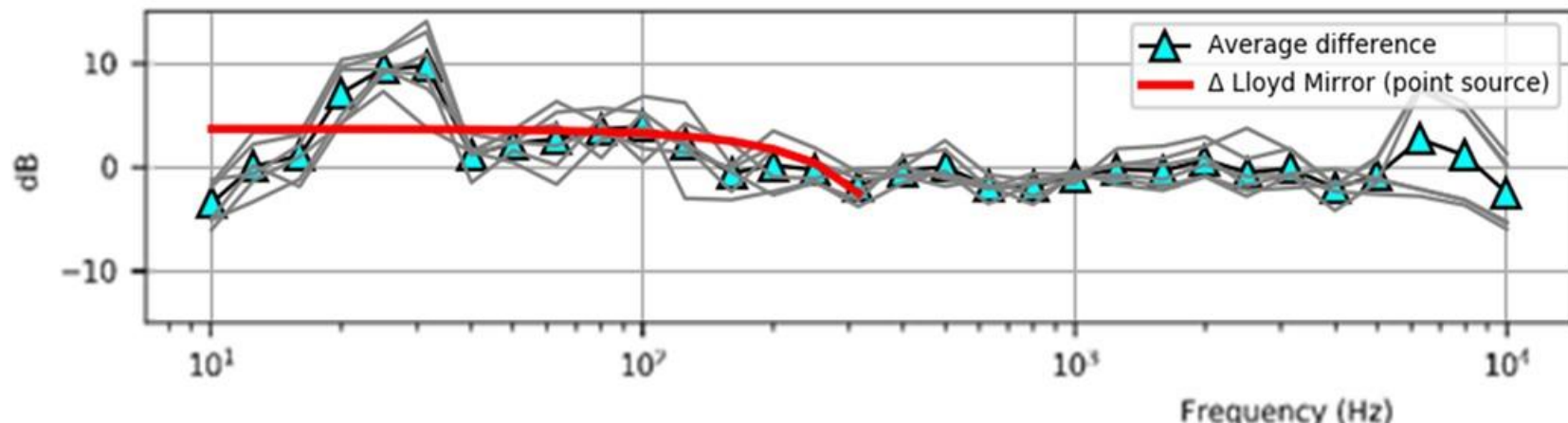


Comparison results static trials

- Individual DG-sets of Planet
- Higher levels at Aschau caused by range geometry and hydrophone layout
- Average delta is small taking in account Lloyd Mirror's



Underwater noise comparison Aschau 2 - Loch Goll
Average difference in beam aspect

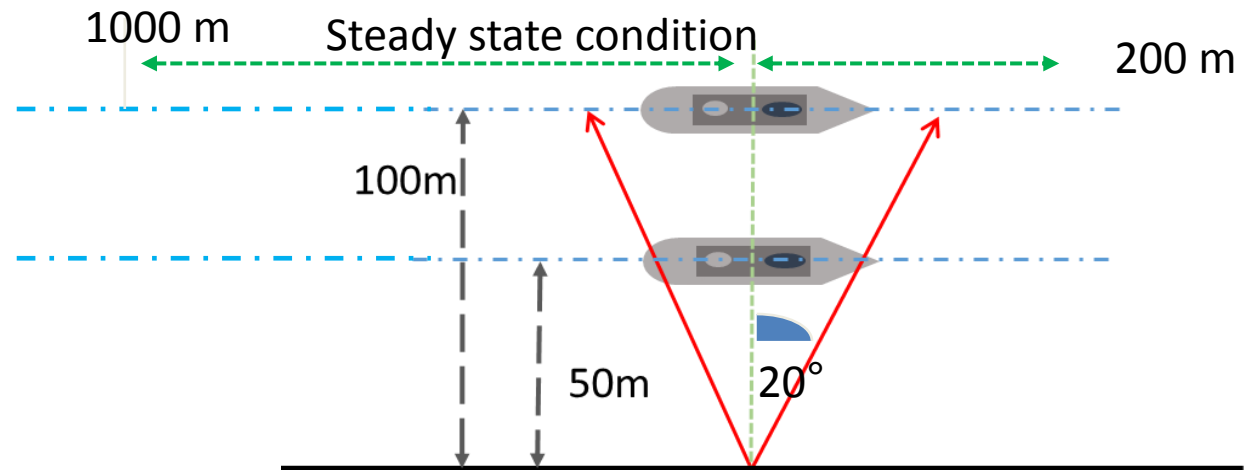


Comparison results underway trials

Methodology:

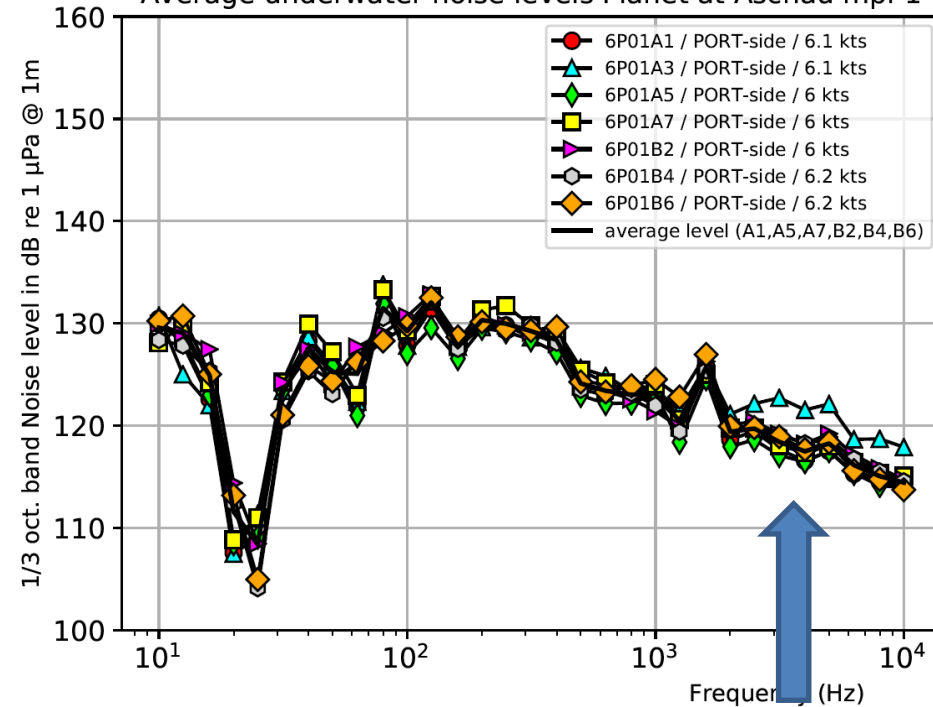
- Platform position was determined with DGPS
- Acoustic measurement were carried out in Port, Stbd and Keel aspect
- 1/3-octave band spectra were calculated for each second segment of the time series data
- Average Port and Stbd side noise levels were calculated when the platform was at CPA within $\pm 20^\circ$ arc
- Spherical propagation loss for distance corrections ($20 \log R$) was applied

Repetitions for each configuration were requested



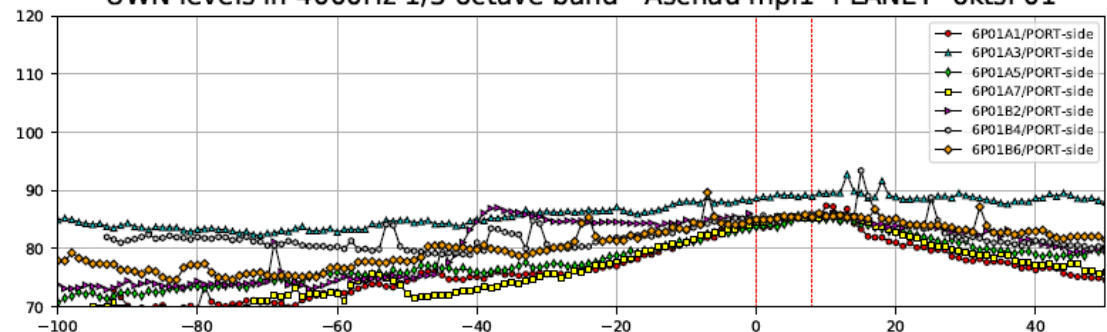
Planet 6 kts @ Aschau 1

Average underwater noise levels Planet at Aschau mpl-1

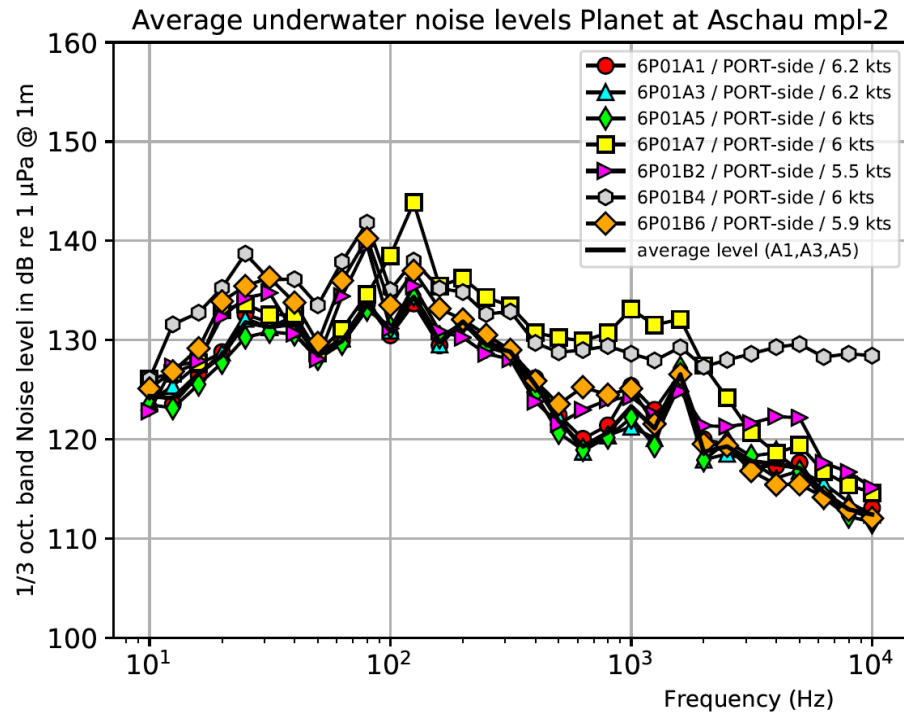


- Repetition is mandatory
- Each frequency band was inspected within a recorded time window
- Recordings with high deviation behavior were skipped

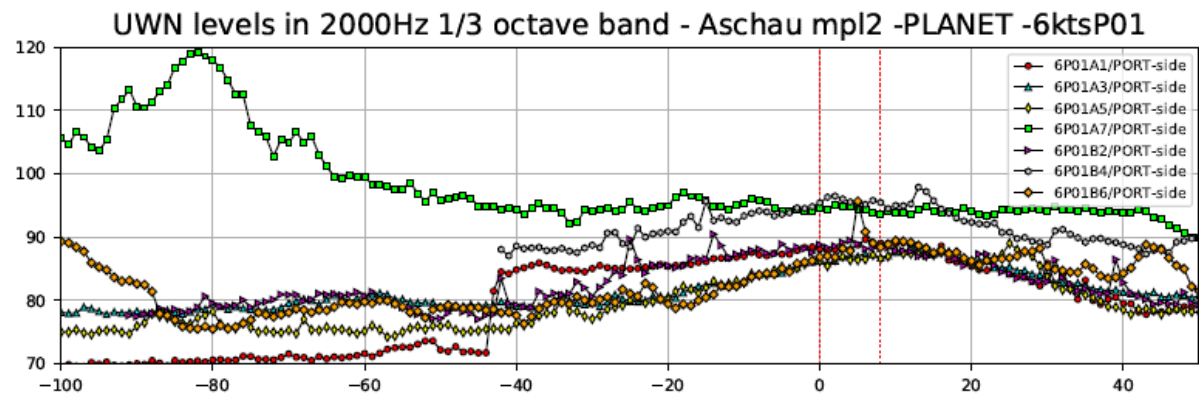
UWN levels in 4000Hz 1/3 octave band - Aschau mpl1 -PLANET -6ktsP01



Planet 6 kts @ Aschau 2

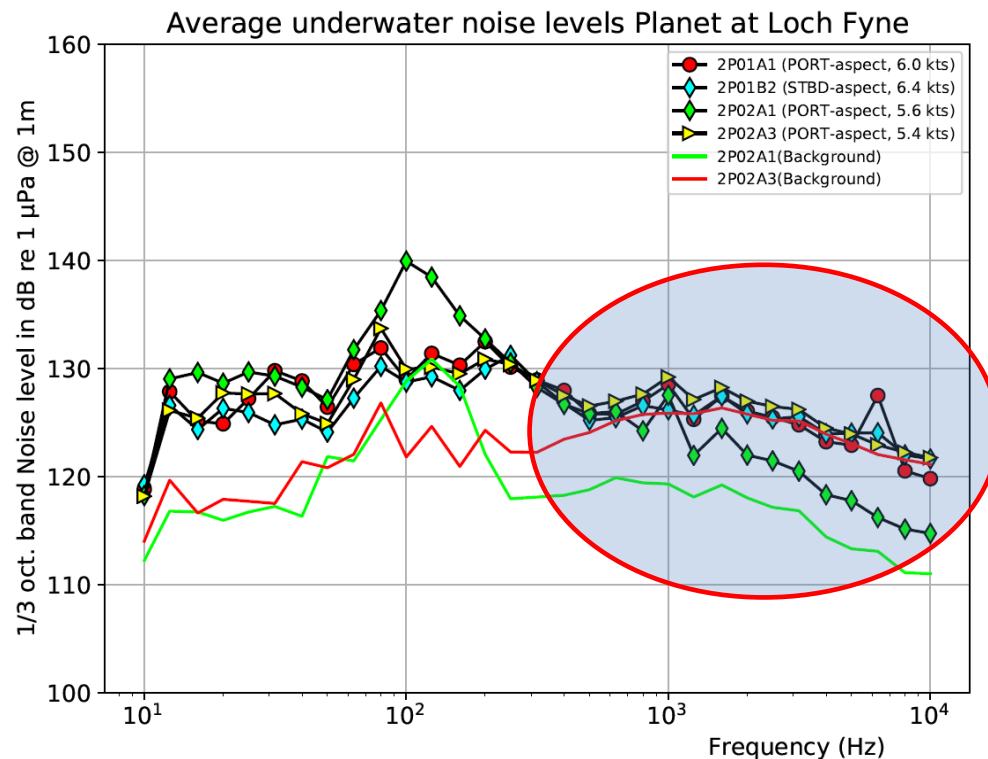


- Larger deviation than MP 1
- Only 3 of 7 runs were valid
- More helm activity during the recording due to the physical range limits



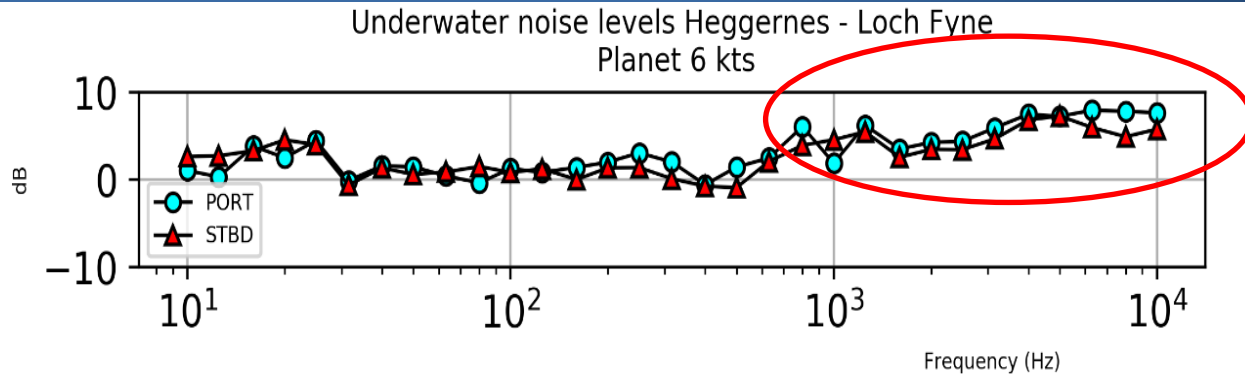
Planet 6 kts @ LF

- CPA at Loch Fyne and Heggernes > 100 m
- Impact of background noise
- Low background noise levels are required in order to have sufficient signal to noise

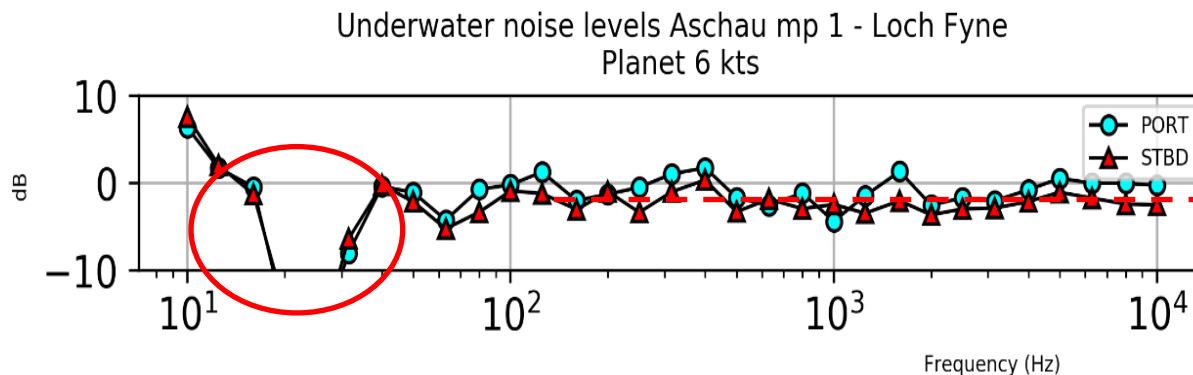


Different results
due to ambient
conditions

Comparison results underway trials Planet 6 kts

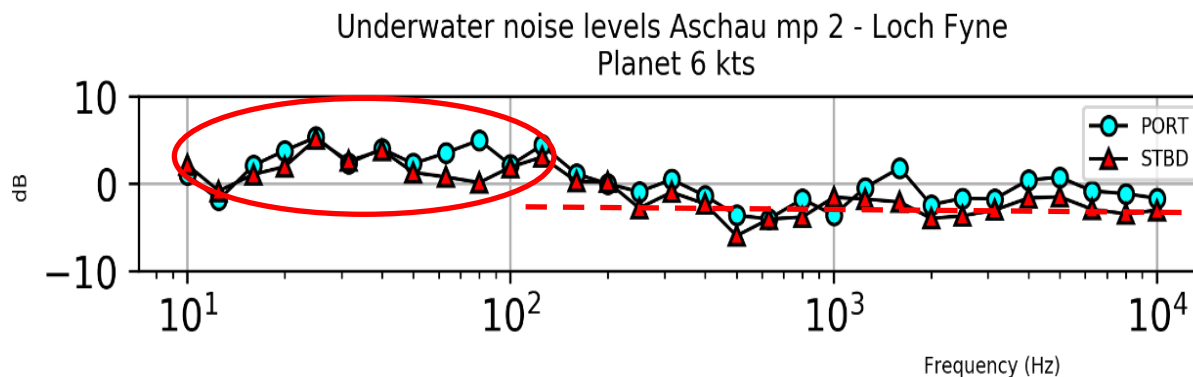


Ambient
noise



Bottom
effect

Distance
Correction
 $\Delta \sim 2$ dB

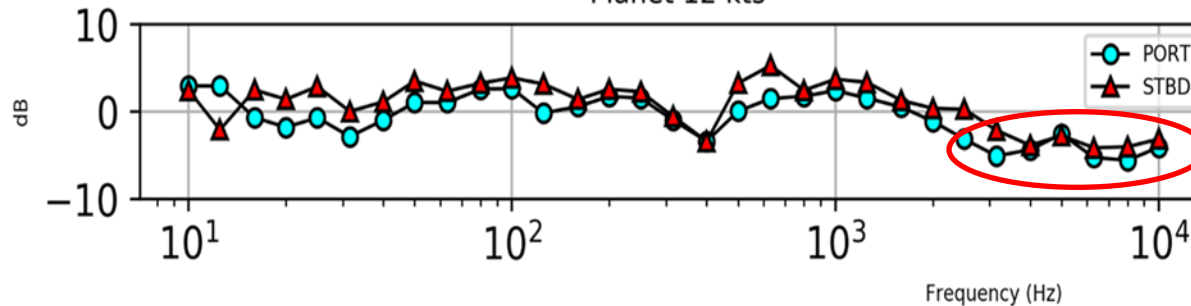


Lloyd's
Mirror

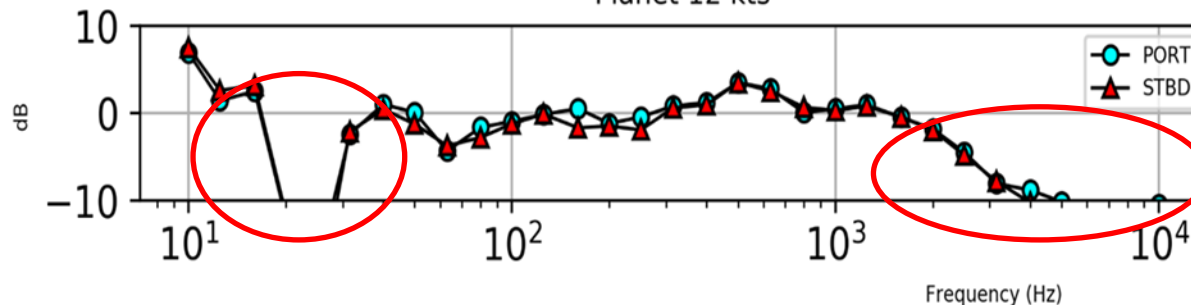
Comparison results underway trail Planet 12 kts



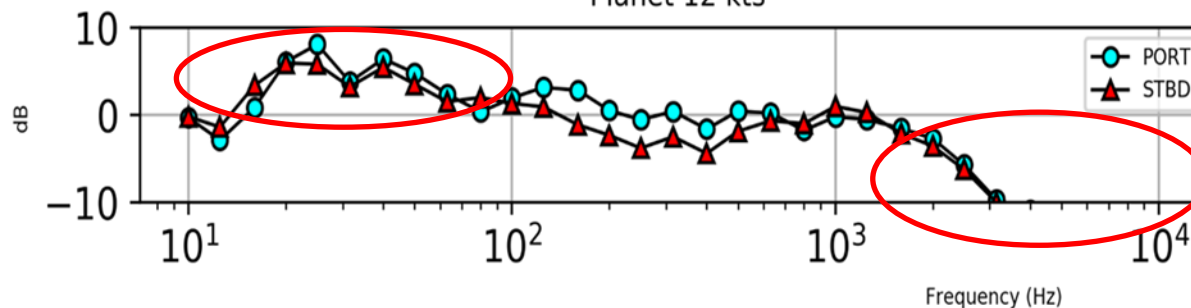
Underwater noise levels Heggernes - Loch Fyne
Planet 12 kts



Underwater noise levels Aschau mp 1 - Loch Fyne
Planet 12 kts



Underwater noise levels Aschau mp 2 - Loch Fyne
Planet 12 kts



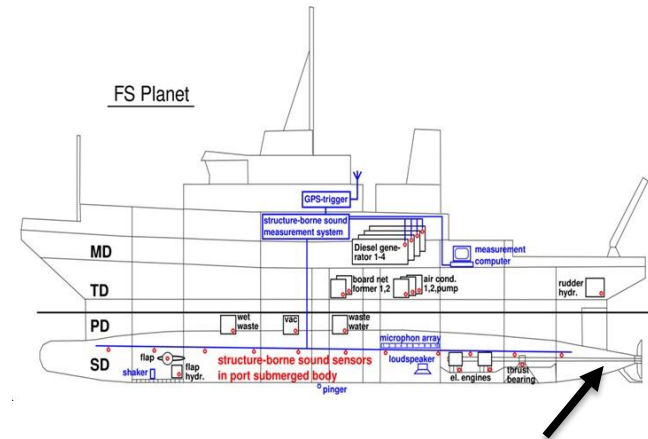
Bottom
effect

Propeller
cavitation

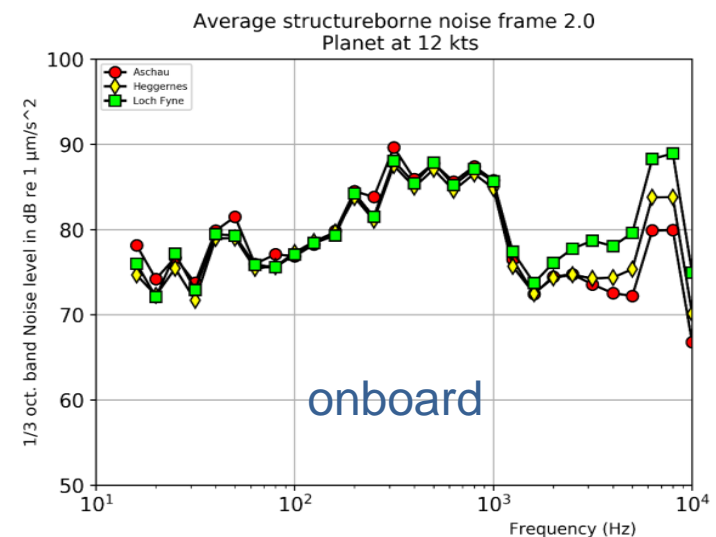
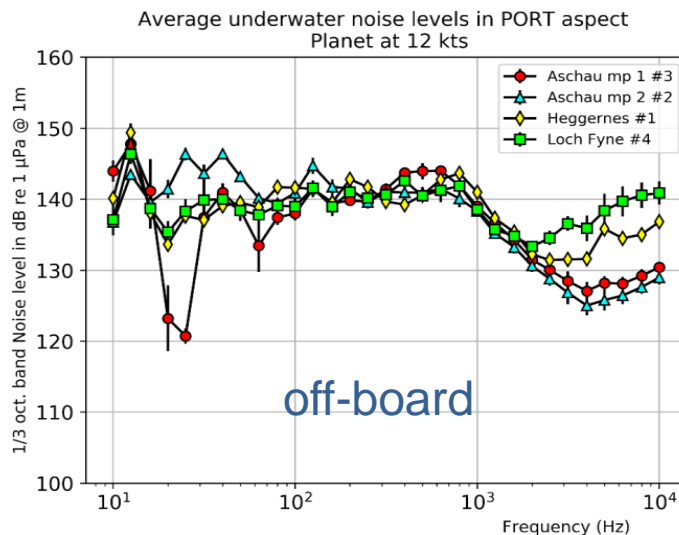
Lloyd's
Mirror

Correlation onboard & off-board measurements

- Significant higher underwater noise levels at Loch Fyne and Heggernes
- Identified underwater differences correlation with structure borne noise near the propellers
- Acoustic monitoring yields UW acoustic estimation

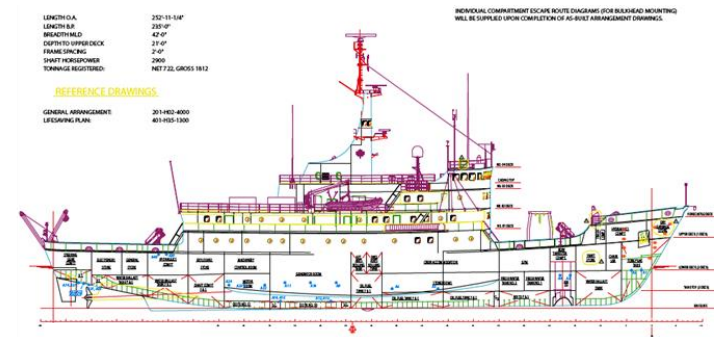


Accelerometers at thrust bearing

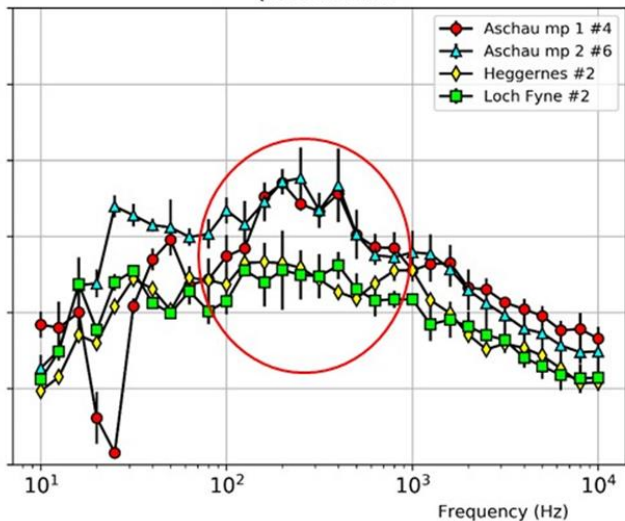


Quest 6 kn range comparison

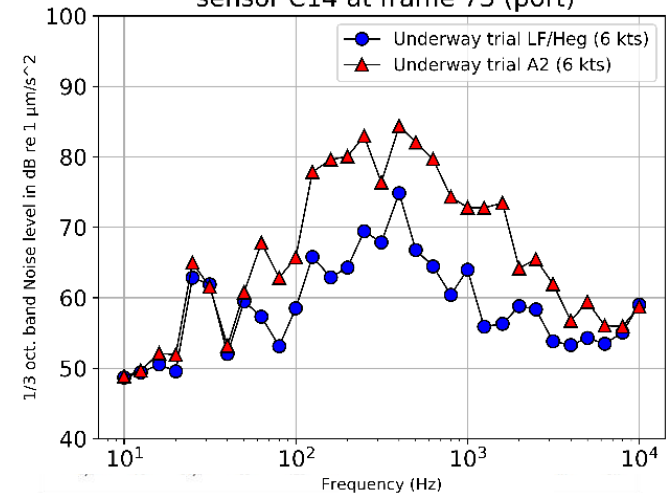
- Comparable results at Loch Fyne and Heggernes
- At Aschau substantial higher results due to contribution of diesel noise
- Good correlation found between off-board and onboard measurements



Average underwater noise levels in PORT aspect
Quest at 6 kts

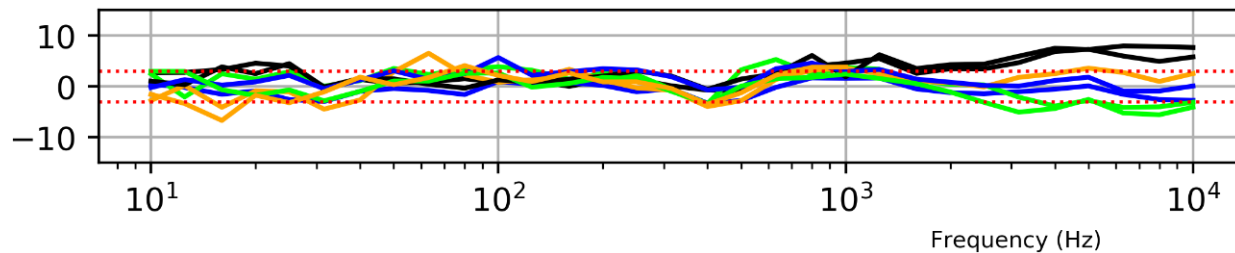


Quest, Structureborne noise levels
sensor C14 at frame 73 (port)

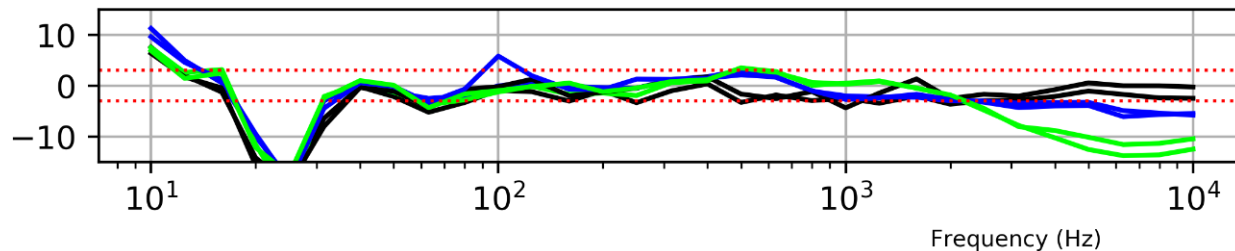


Overall results

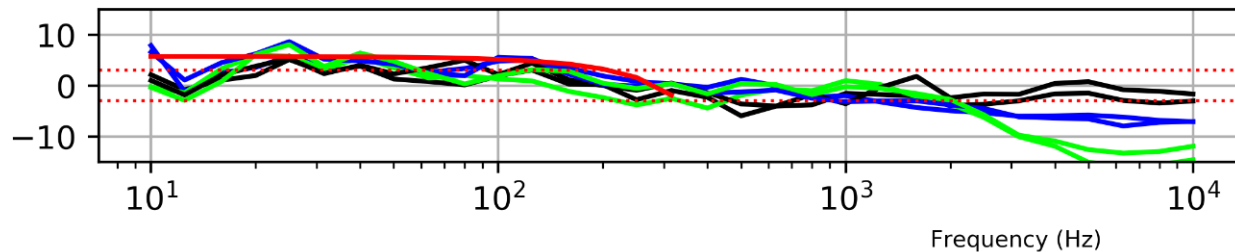
Underwater noise levels Heggernes - Loch Fyne



Underwater noise levels Aschau 1 - Loch Fyne



Underwater noise levels Aschau 2 - Loch Fyne



- Planet 6 kts
- Planet 9 kts
- Planet 12 kts
- Quest 6 kts

Taking in account all
range and platform
effects
 $\Delta < 3$ dB

Summary

- The difference in the radiated underwater sound can be explained by the different hydrophone configurations
- Deviations within an acceptable margin ($\Delta < 3$ dB)
- Background noise and partial inconsistencies of both vessels as noise sources limit the range comparison
- Signature components changed across sound ranges (Machinery sound short and Cavitation behavior)
- Very good correlation can be observed between the underwater noise results and the on-board structure borne sound measurements (acoustic monitoring is feasible)



Acknowledgements

- RIMPASSE was an excellent international cooperative measurement trial resulting in a unique signature dataset
- Germany (WTD71) and Canada (DRDC) made available two naval research vessels, Planet and Quest, respectively
- In a time frame of 6 weeks, acoustic measurements were carried out at different locations by QinetiQ, WTD71, DST Group, TNO, DMO, DGA and FFI.
- Results are used for feasibility studies on the development of a signature management system (COSIMAR) and several range comparison studies

QUEST-IONS

