Rogue wave occurrence in mixed sea states: a laboratory experiment

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Project Aims

The main aim of the project is investigate the mechanisms that lead to rogue and extreme wave formation.

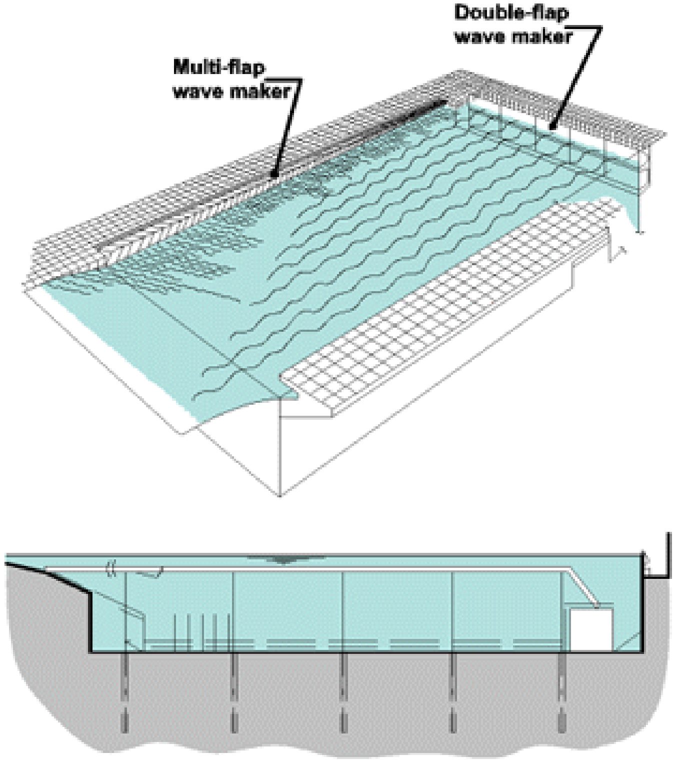
- The tests were designed to look for processes analogous to those found in super-fluid helium experiments in surface water waves.

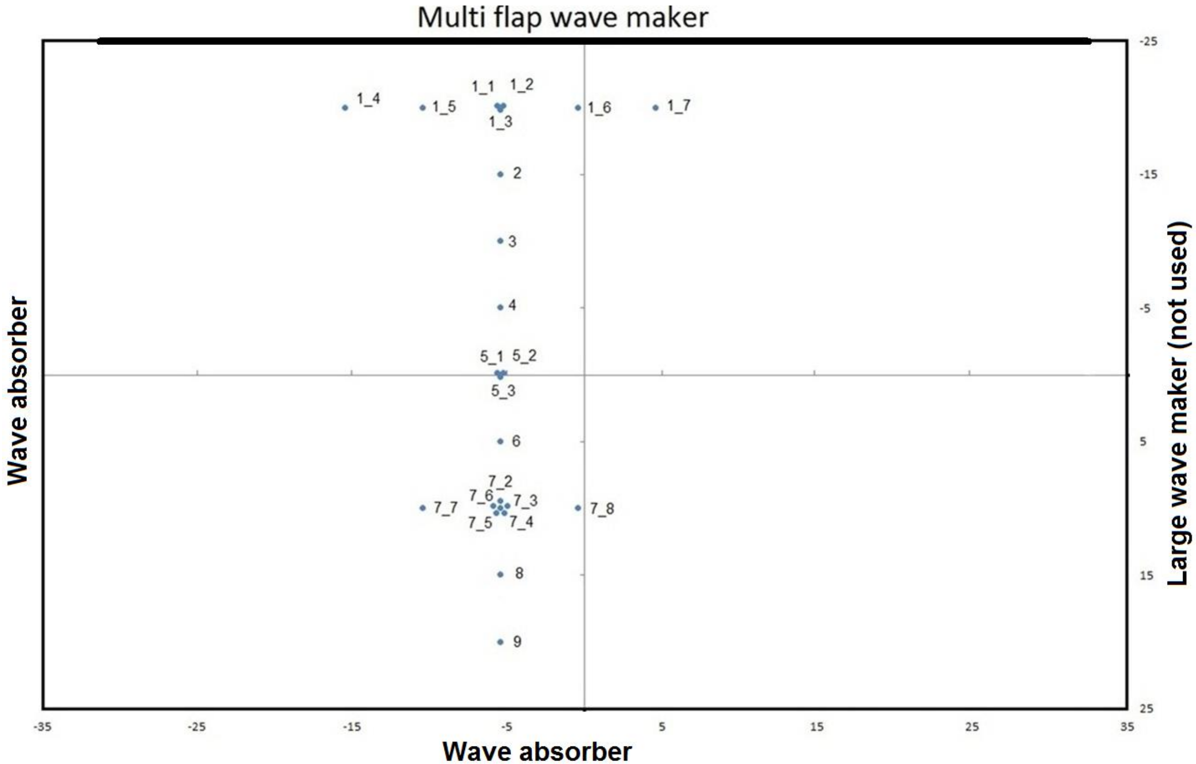
- The tests were also designed to investigate the wave dynamics and statistical properties of rogue waves under conditions close to those found at sea.

- Results presented here focus on spectral evolution of bi-modal short-crested sea:
  - Effect of varying separation in peak periods of two crossing sea states

Source: H. L. DeVore (2010)

Marintek Ocean Basin in Trondheim, Norway





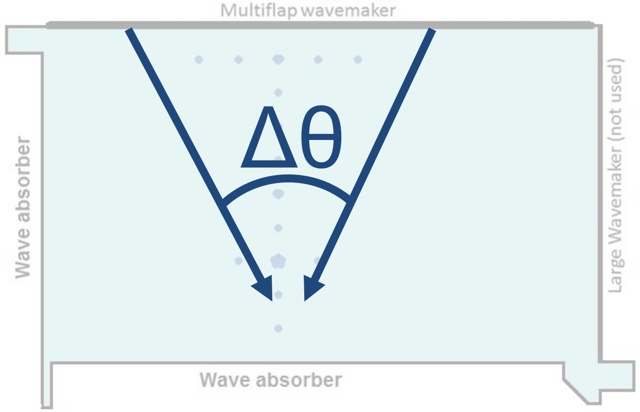
- 50 m long, 70 m wide, 3 m deep
- 144 flap type wave paddles
- 24 twin wire wave gauges

Test variables

- Tests were carried out in 20 minute runs, with four tests for each condition – roughly 4800 waves per condition.

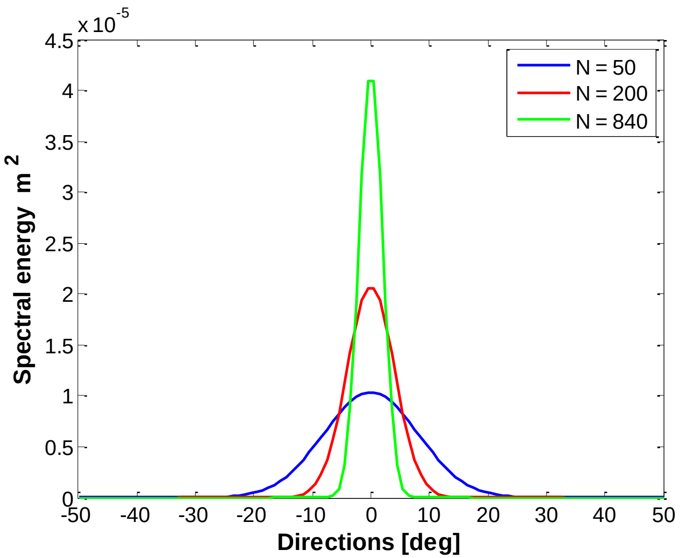
- The effect of changing crossing angle (Δθ), directional spread (N) and peak period (T_p) were investigated.

Crossing angle (Δθ)



Directional spreading (N)

$$D(\theta) = K_2 cos^N(\theta - \theta_0)$$



Summary of generated wave conditions

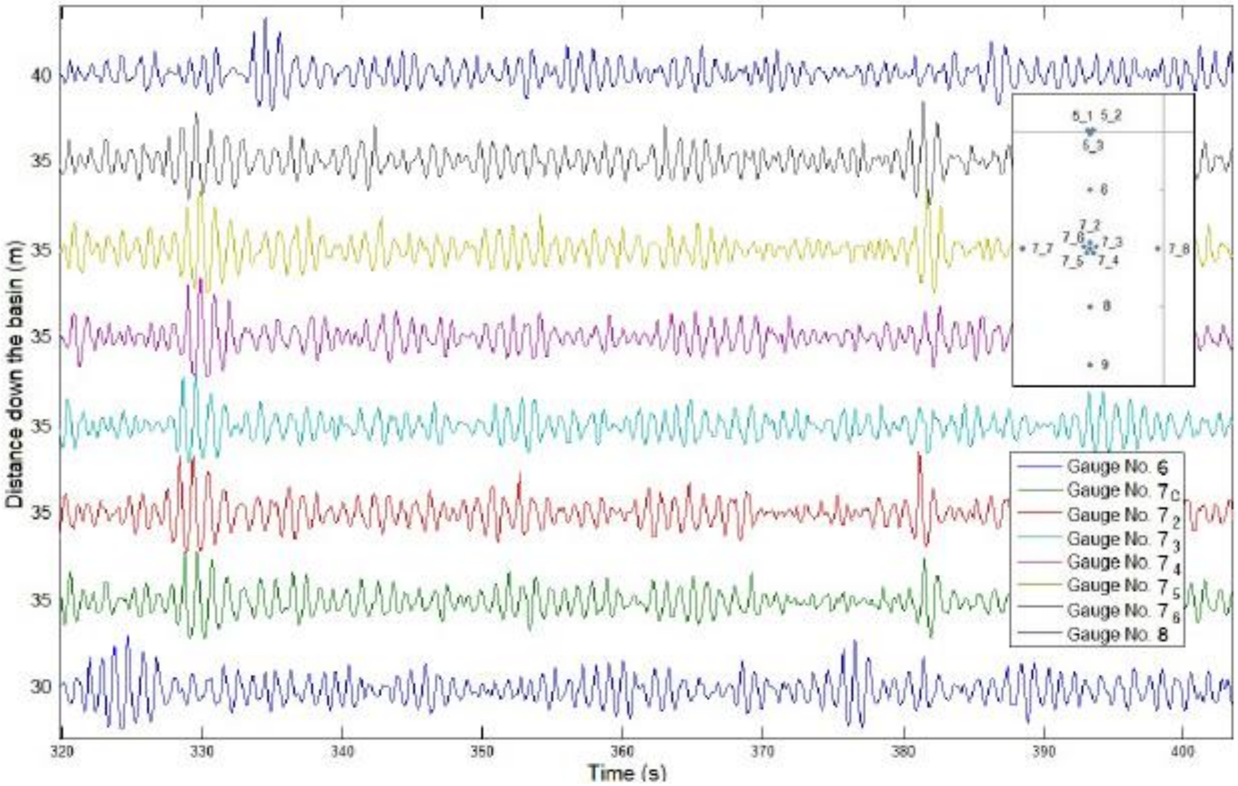
- Two JONSWAP spectra
- The combined mean measured Hs was 0.078 m
- The wave steepness varied from ~0.12 for a component to ~0.16 for the combined bi-modal sea state

Test no.	H_s (m)	Component 1 T_p (s)	Component 1 γ	Component 1 N	Component 2 T_p (s)	Component 2 γ	Component 2 N	Crossing angle (deg)
2500	0.058	1	Uni-directional		Uni-modal			-
2508	0.058	1	3	50	Uni-modal			-
2248	0.058	1	3	50	1	6	200	0
2308	0.058	1	3	50	1	6	200	10
2318	0.058	1	3	50	1	6	200	20
2328	0.058	1	3	50	1	6	200	30
2338	0.058	1	3	50	1	6	200	40
2408	0.058	1	3	50	1.11	6	200	40
2418	0.058	1	3	50	1.25	6	200	40
2428	0.058	1	3	50	1.67	6	200	40
2718	0.058	1	3	840	1	6	200	40
2728	0.058	1	3	200	1	6	200	40

Analysis and numerical modelling

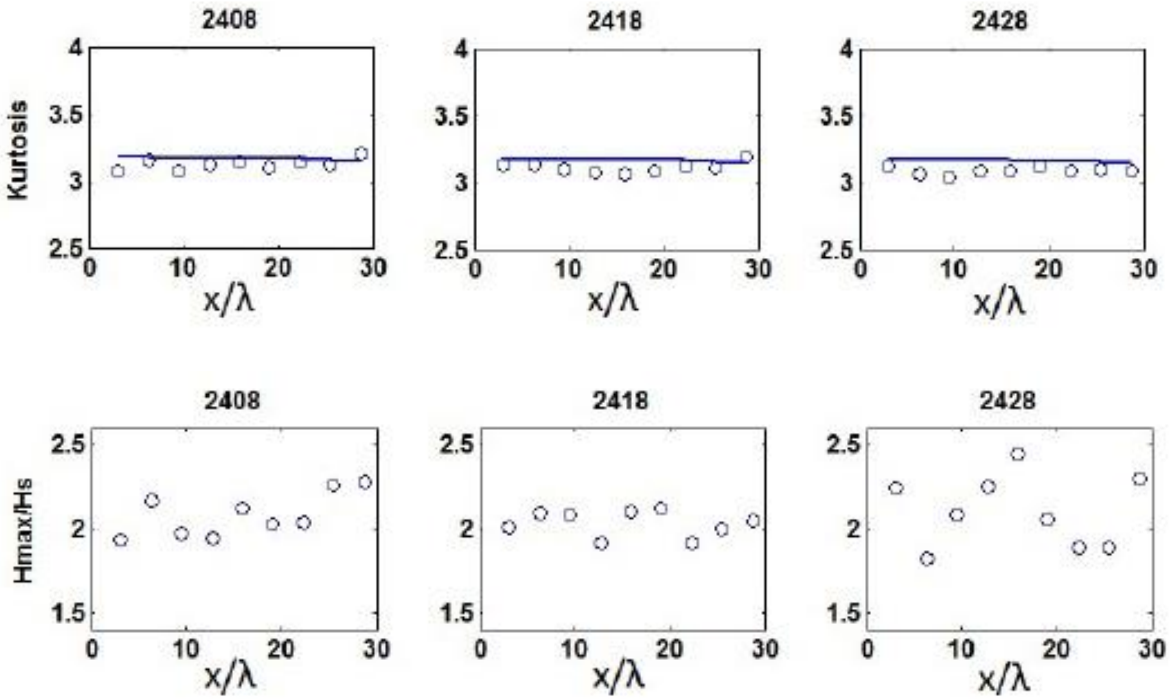
- Analysis
  - Frequency spectra using FFT and Wavelets
  - Directional spectra using IMLM
  - Spectral parameters such as:
    - The zero moment or the total energy (m_0)
    - The peak frequency (f_p) and the mean frequency (f_m)
    - The kurtosis (μ_4) and the peakedness parameter (Q_p)

Results



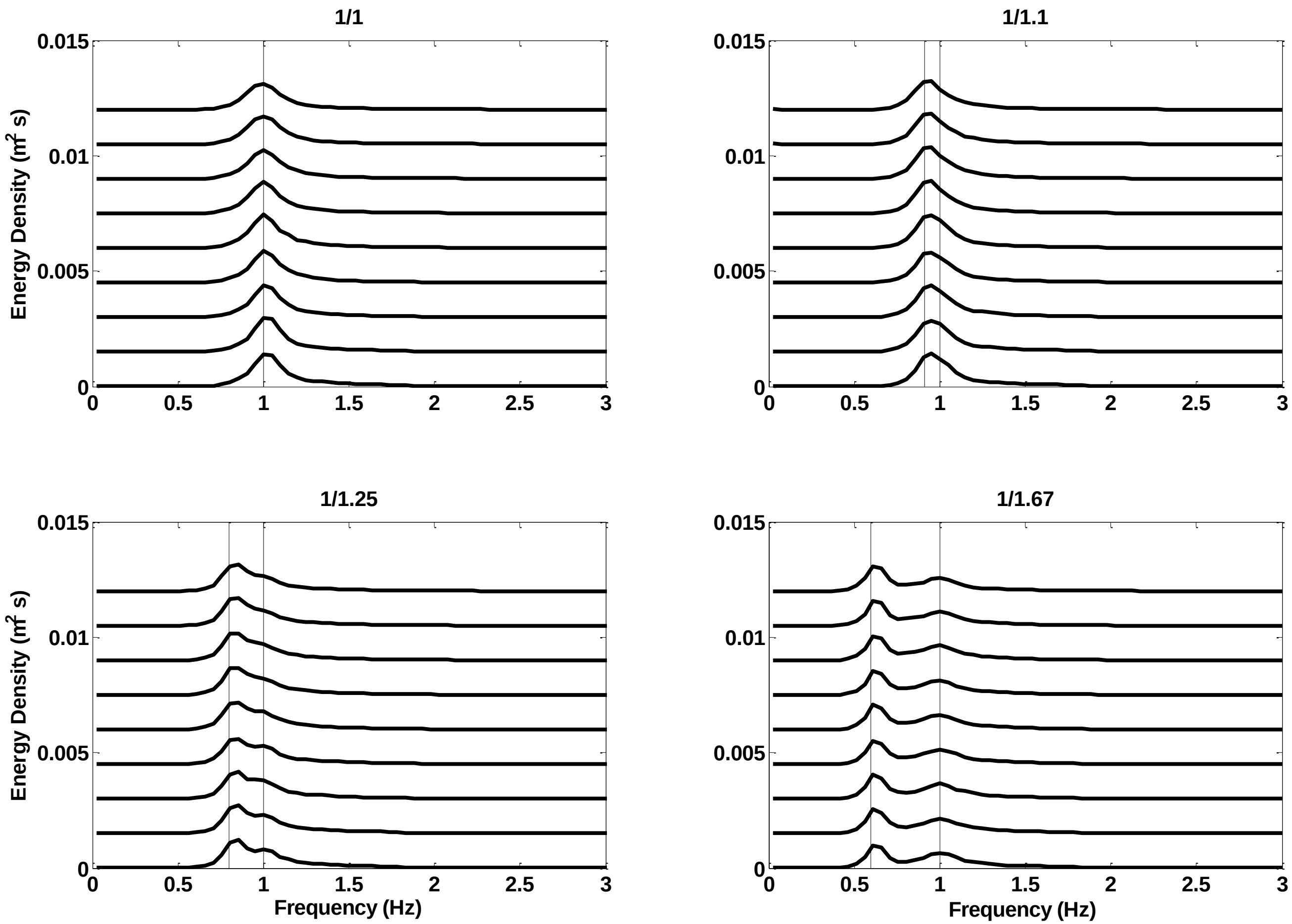
- Rogue waves for bi-modal case f_1/f_2=1/1Hz; Δθ=40º

Results



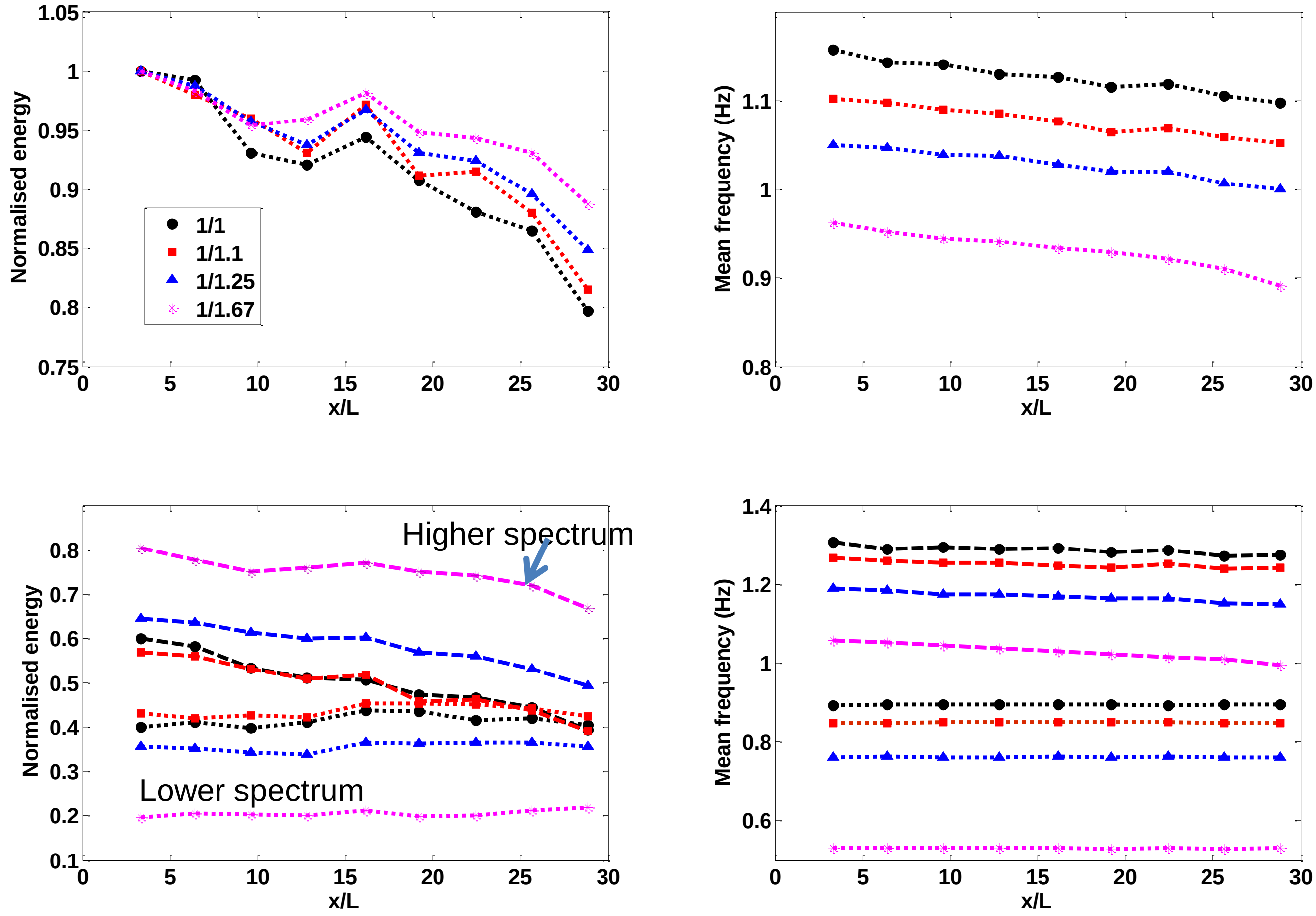
- Kurtosis and H_{max}/H_s

Results



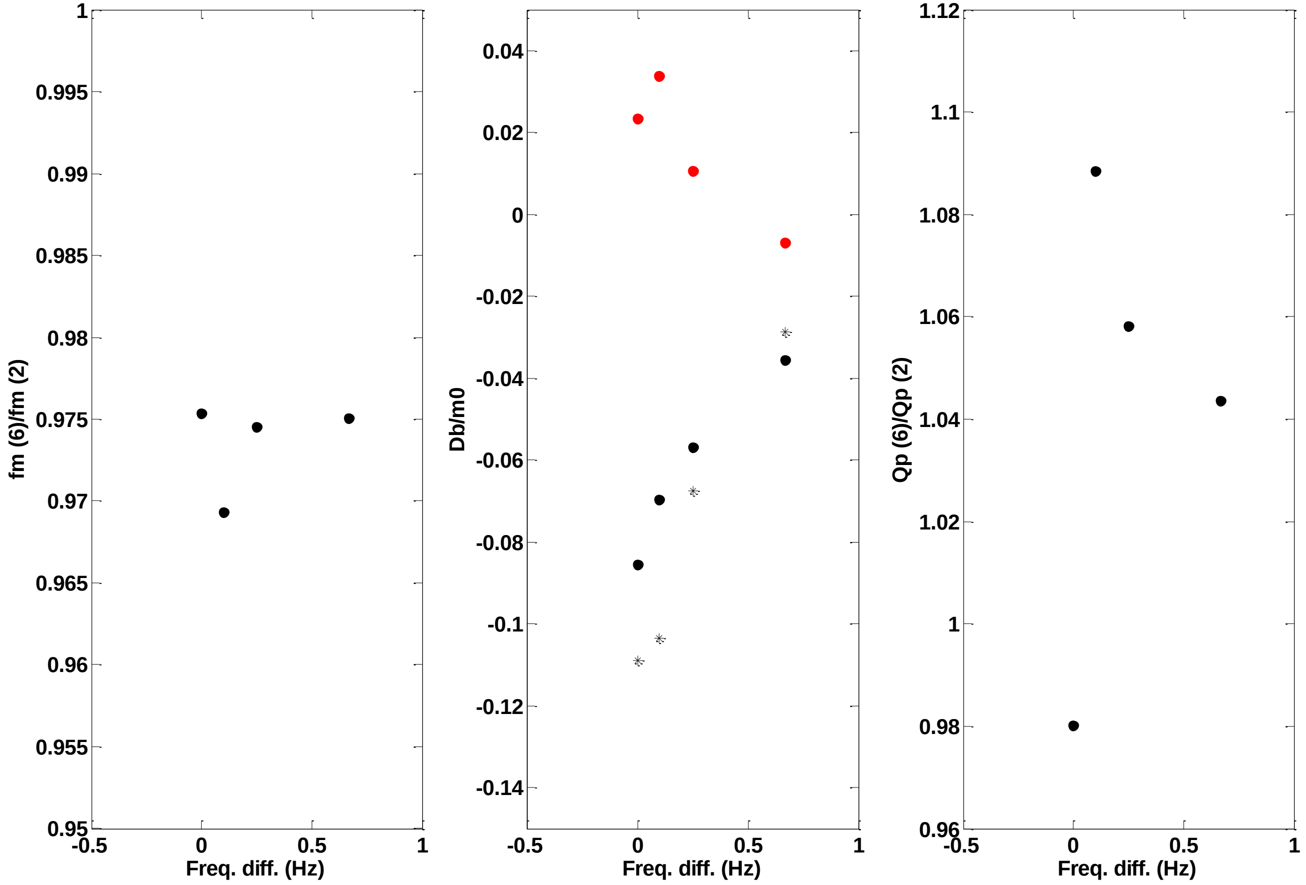
- Change in spectral shape down the tank

Results



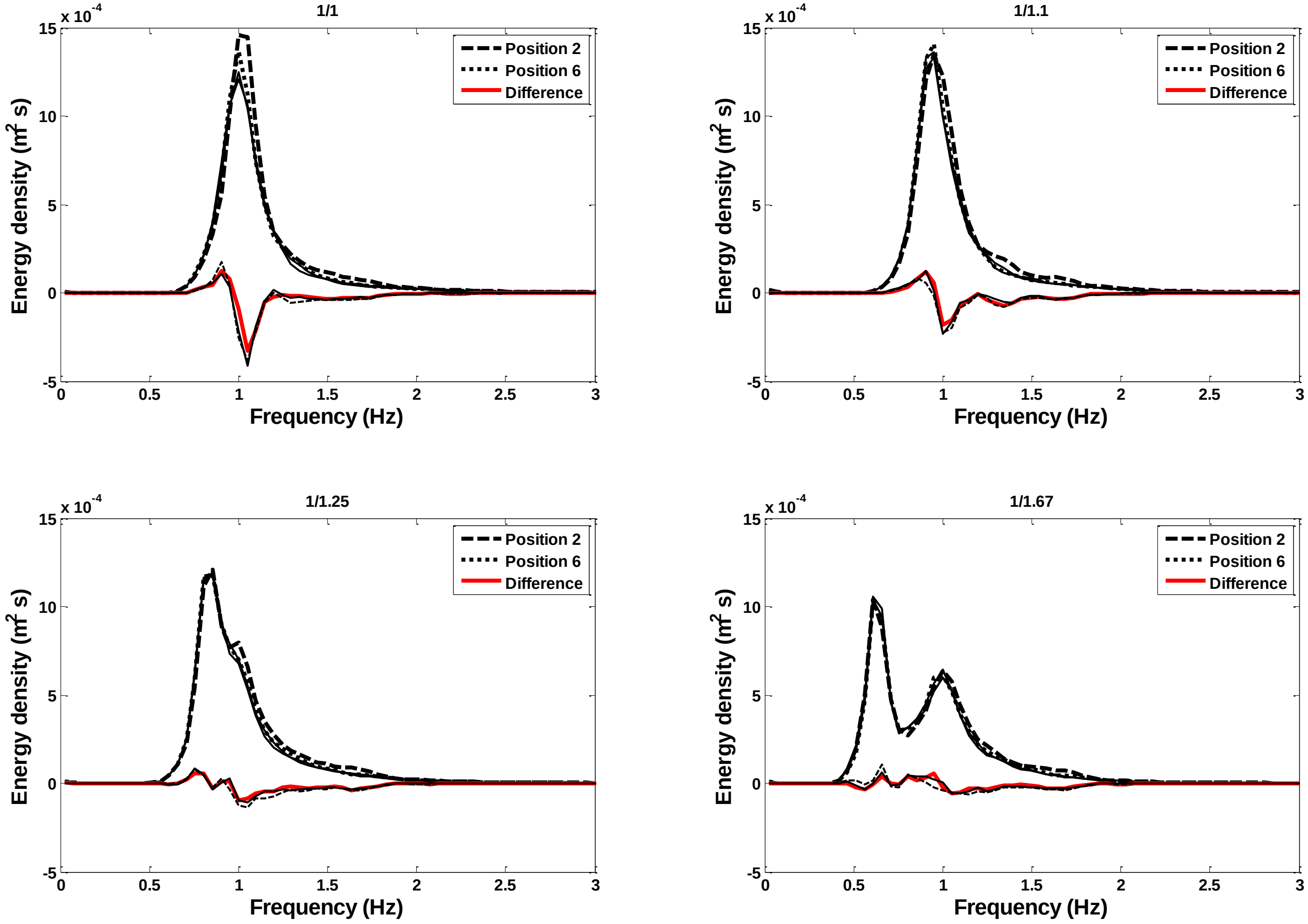
➢ Change in the total energy and the mean frequency down the tank

Results



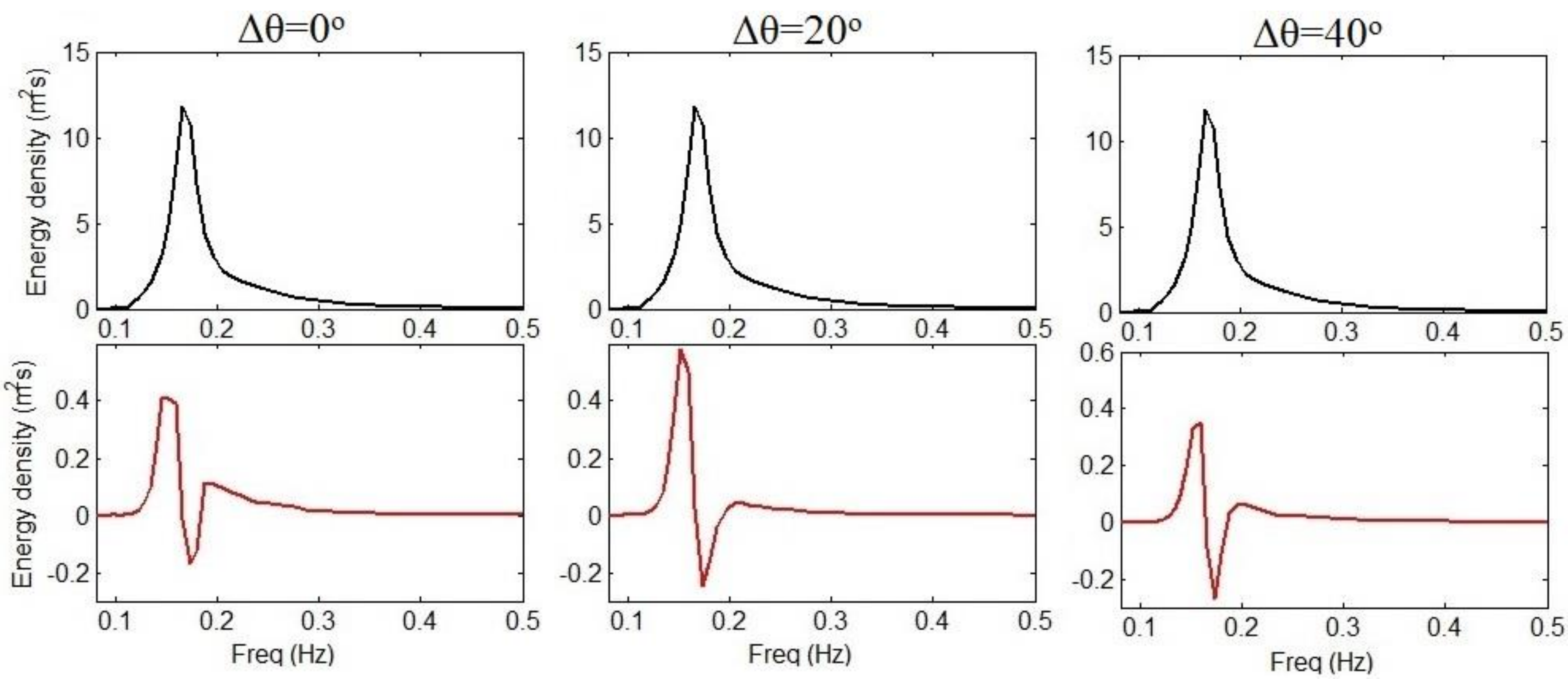
- The rate of frequency downshift, dissipation and change in spectral peakedness

Results



➢ Energy density spectra at positions 2&6 and their difference

Results



- SWAN simulations using XNL – Difference in energy density spectra at positions 1&3

Conclusion

- A large facility based experimental study has been carried out investigating deep sea wave development.
- A spectral downshift in energy and main frequency was observed down the tank.
- The energy lost from the higher frequency peak to the lower frequency peak seem to stabilise the lower frequency peak.
- The results are in agreement with the work of Masson (1993), who found that if the frequencies of two wave fields are well separated, the spectral energy can be transferred from the high into the low frequency, increasing chance of the occurrence of rogue waves.

Acknowledgement

- The funding was obtained by EU-HYDRALAB IV.
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