

# Extreme Waves on Sheared Currents

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# Background – Introductory Definitions



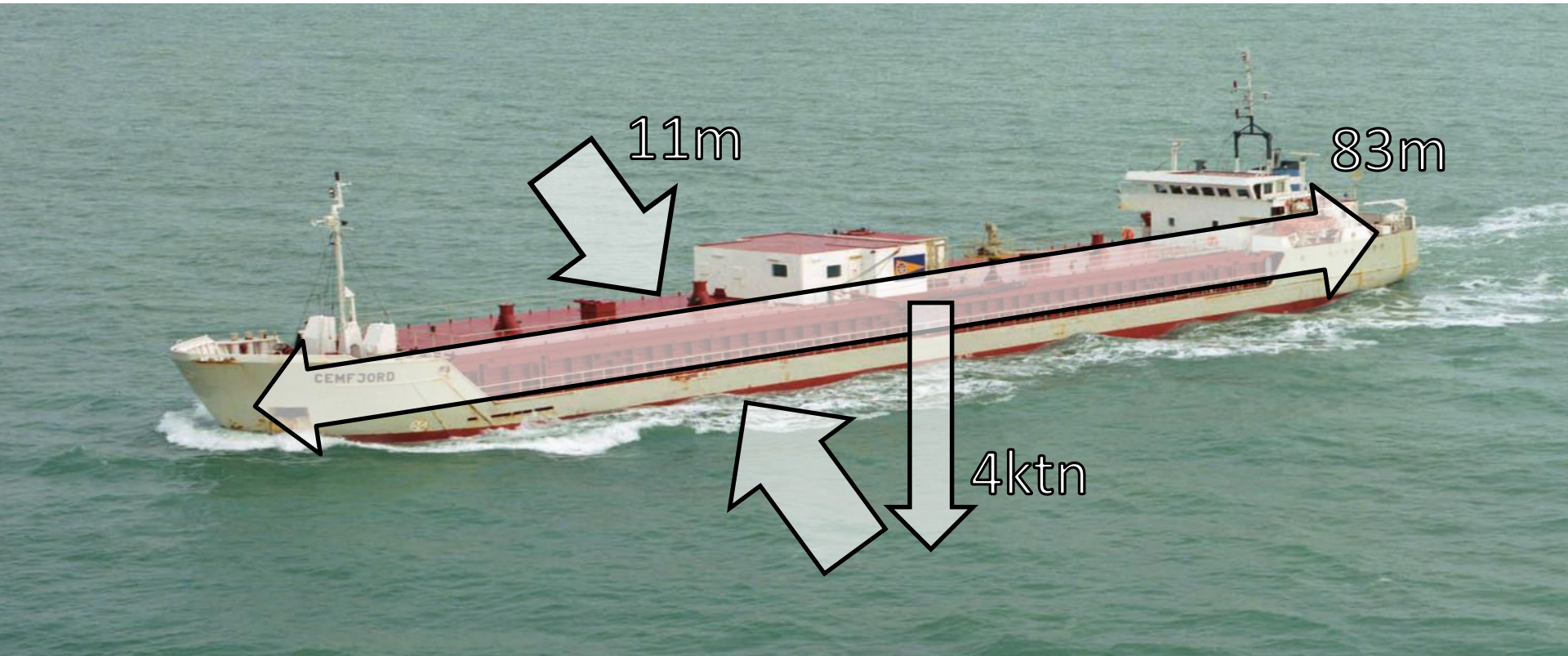
**Wave Stability:** Unstable regular wavetrains naturally evolve to become irregular

**Sheared currents:** Higher current velocities on the surface – almost zero velocity at the bed

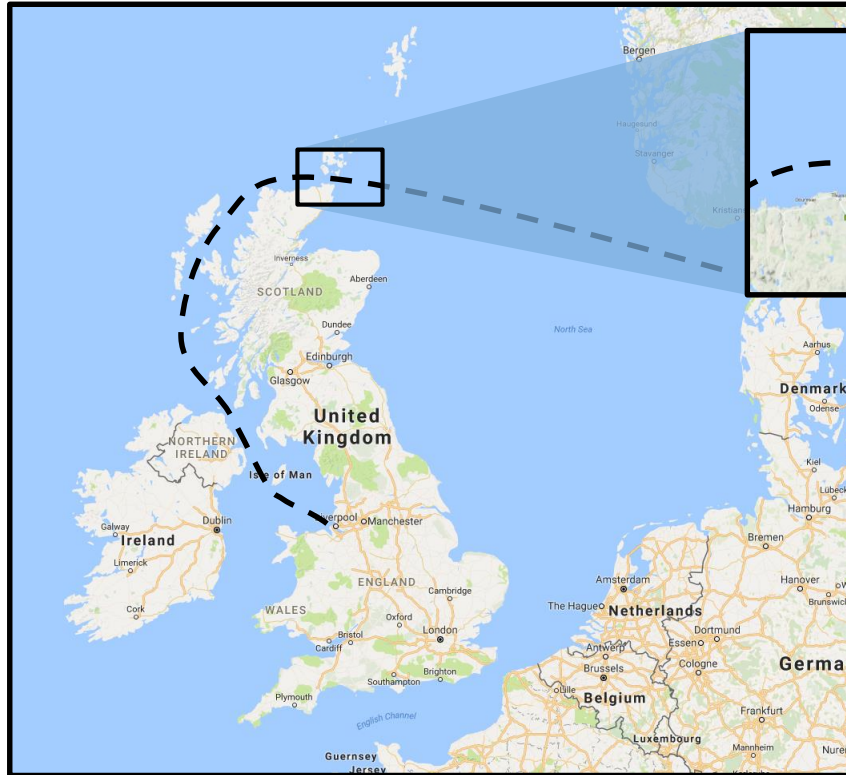
**Linear shear:** Constant change in velocity with depth,

$$\Omega = \frac{du}{dz}$$

# Cemfjord – A Medium Sized Cement Carrier



# Cemfjord – Journey through the Pentland Firth



**2<sup>nd</sup> January, 13:15** - Stops transmitting it's Automatic Identification System



**2014, 30<sup>th</sup> December** – Leaves port of Rørdal, Denmark

**2<sup>nd</sup> January, 12:36** - Enters the Pentland Firth

**3<sup>rd</sup> January, 14:16** – Hull of Cemfjord spotted

# Cemfjord – The Investigation (MAIB)



“Such extraordinary violent sea conditions were  
threatened by the Glenfance Wind supporting a strong  
attempted”

“*Cemfjord* capsized suddenly and rapidly when it  
encountered extraordinarily violent, breaking seas...”



*Increase in wave steepness*

*Waves become unstable*

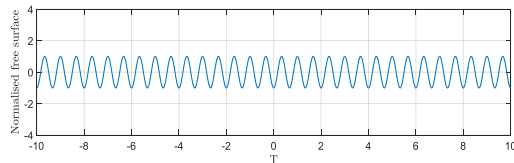
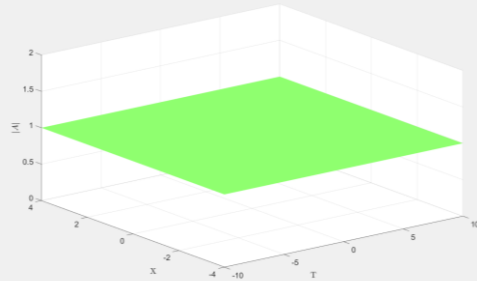
Increased amplitude

Increased frequency

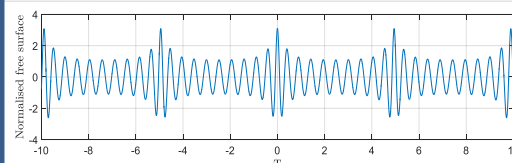
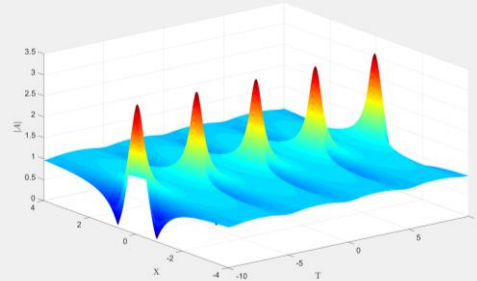
# Modelling Unstable Wavetrains



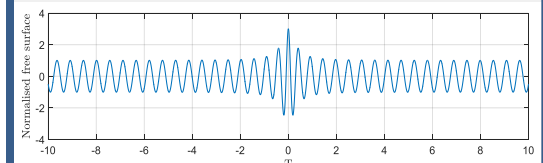
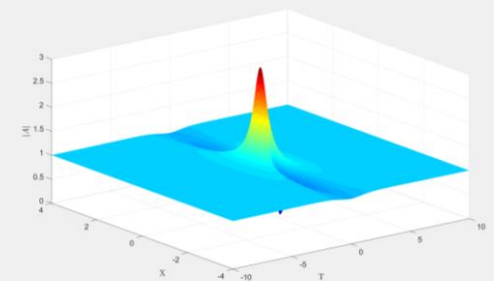
Stokes Solution  
– Regular wave –



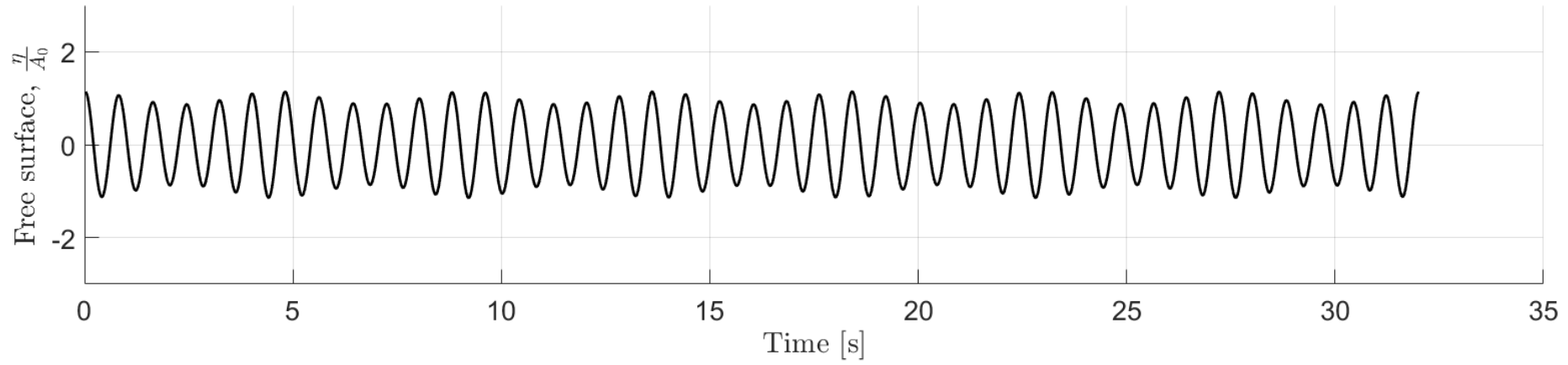
Akhmediev Breather  
– Periodic breather –



Peregrine Breather  
– Localised breather –

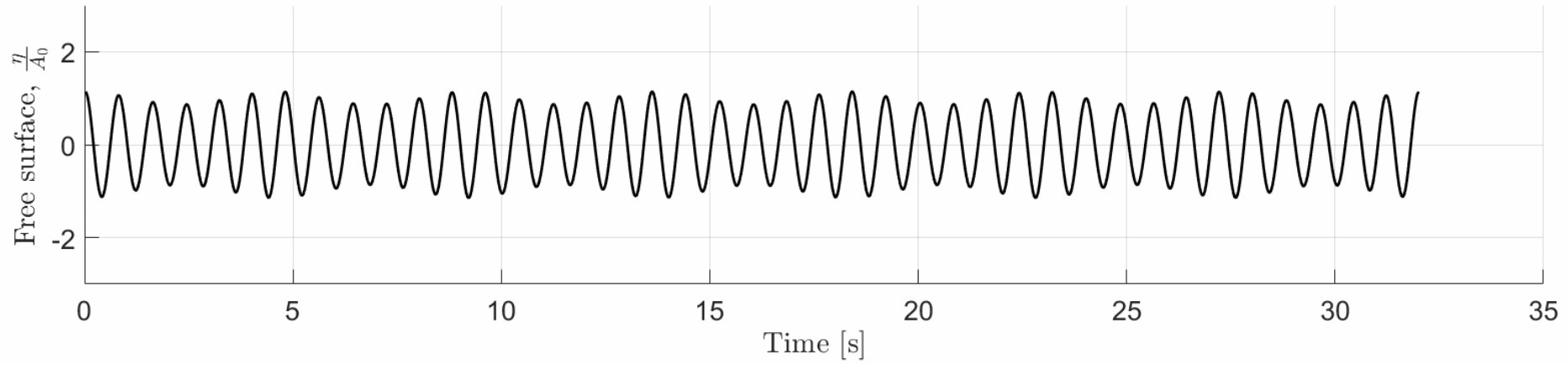


Stable wavetrain (on still water) at  $x = 0.00$  m

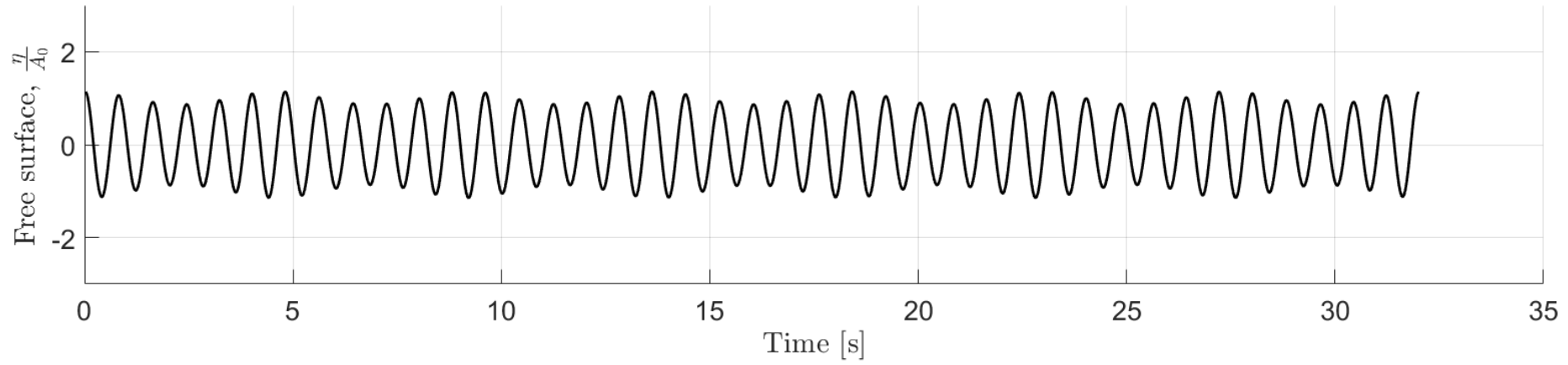




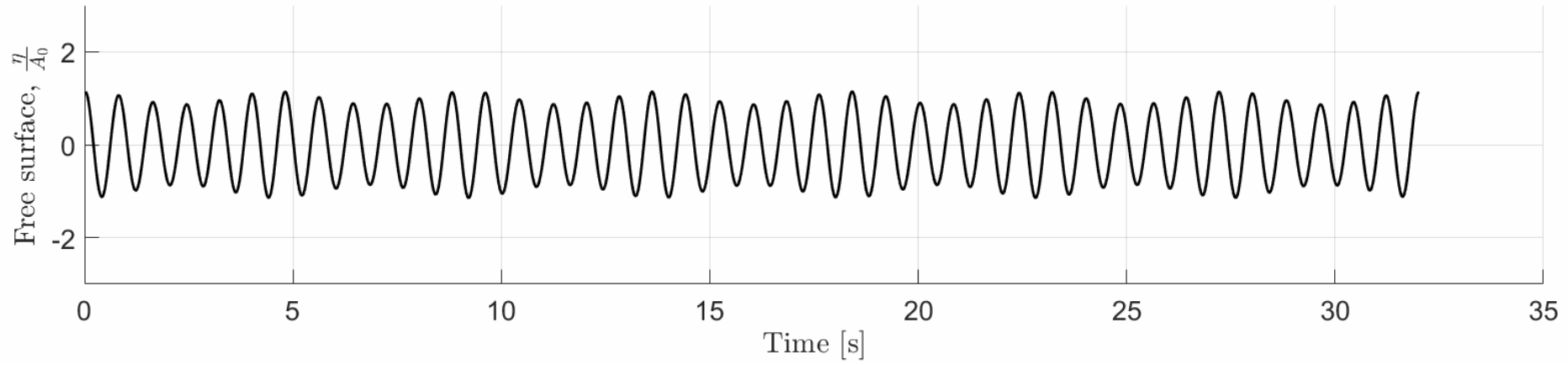
Stable wavetrain (on still water) at  $x = 0.00$  m



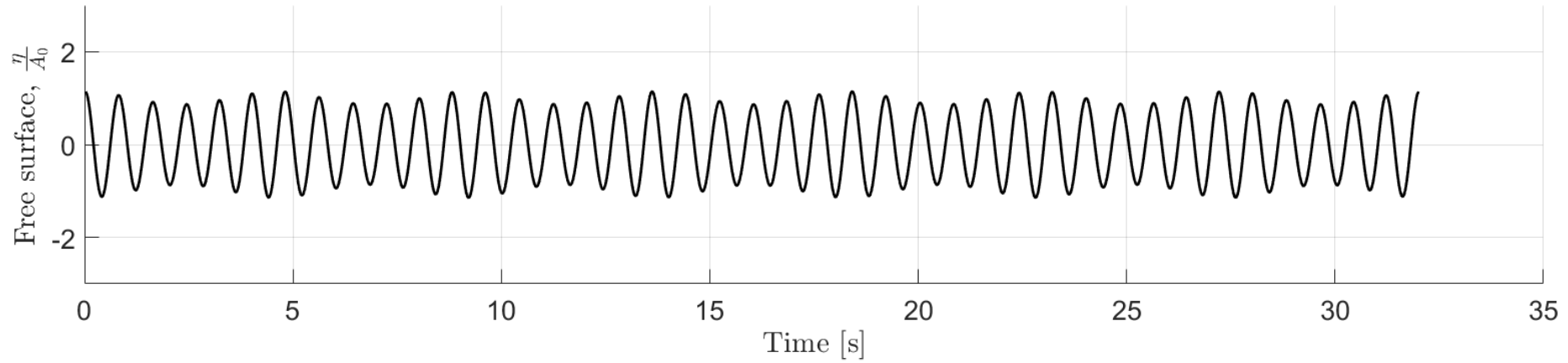
Unstable wavetrain on uniform current at  $x = 0.00$  m



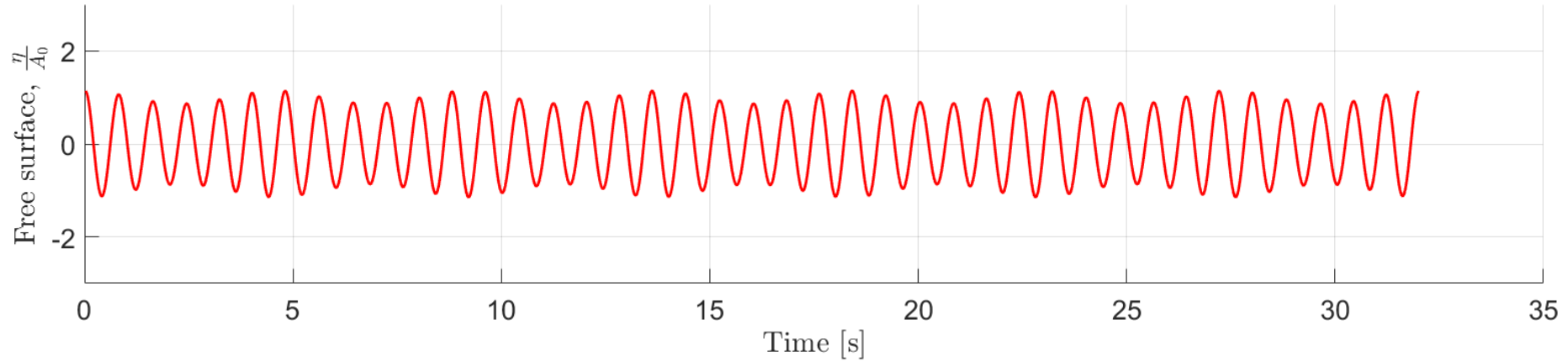
Unstable wavetrain on uniform current at  $x = 0.00$  m



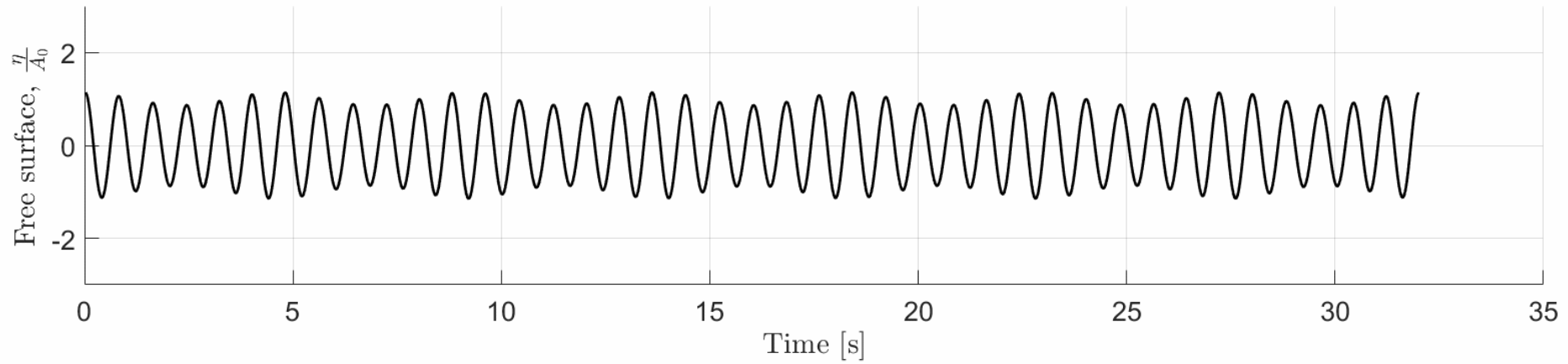
Unstable wavetrain on uniform current at  $x = 0.00$  m



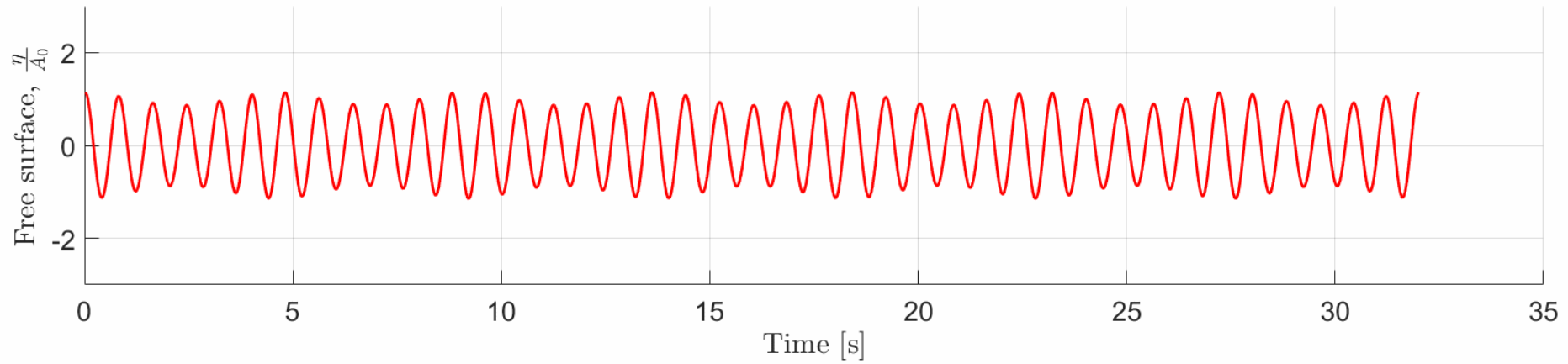
Unstable wavetrain on sheared current at  $x = 0.00$  m



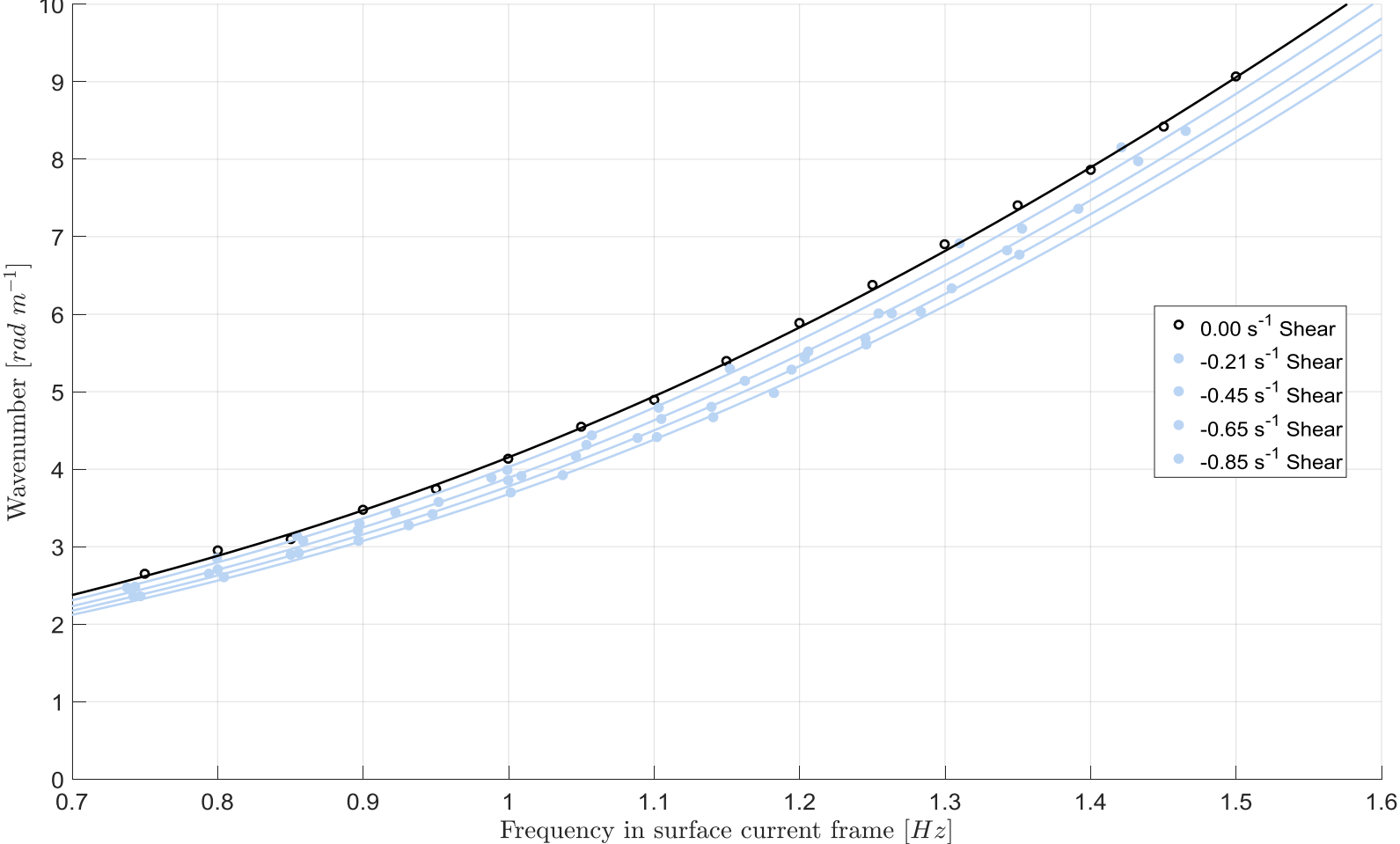
Unstable wavetrain on uniform current at  $x = 0.00$  m



Unstable wavetrain on sheared current at  $x = 0.00$  m

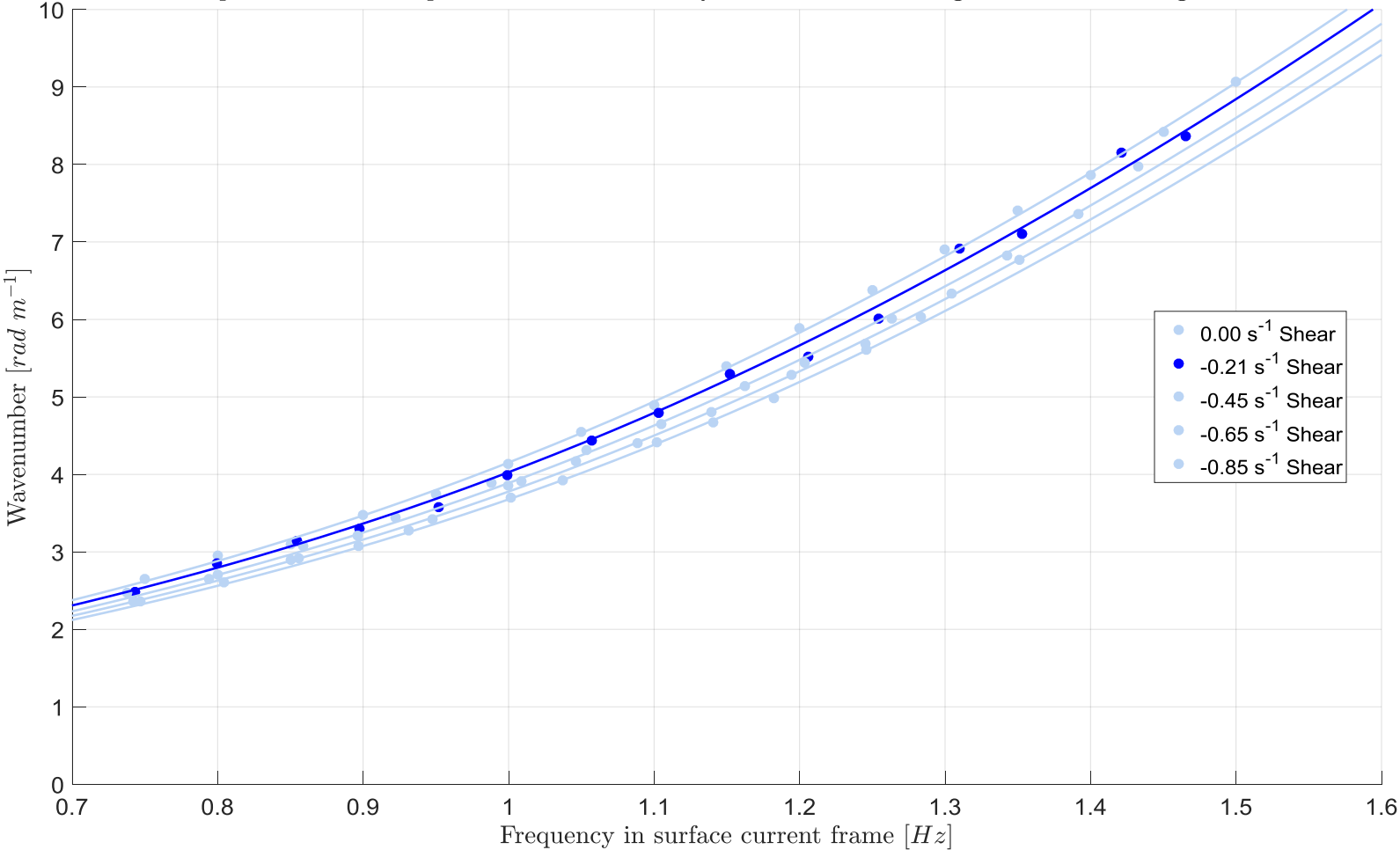


Dispersion relationship of waves on a vertically sheared current using measured wavelength data

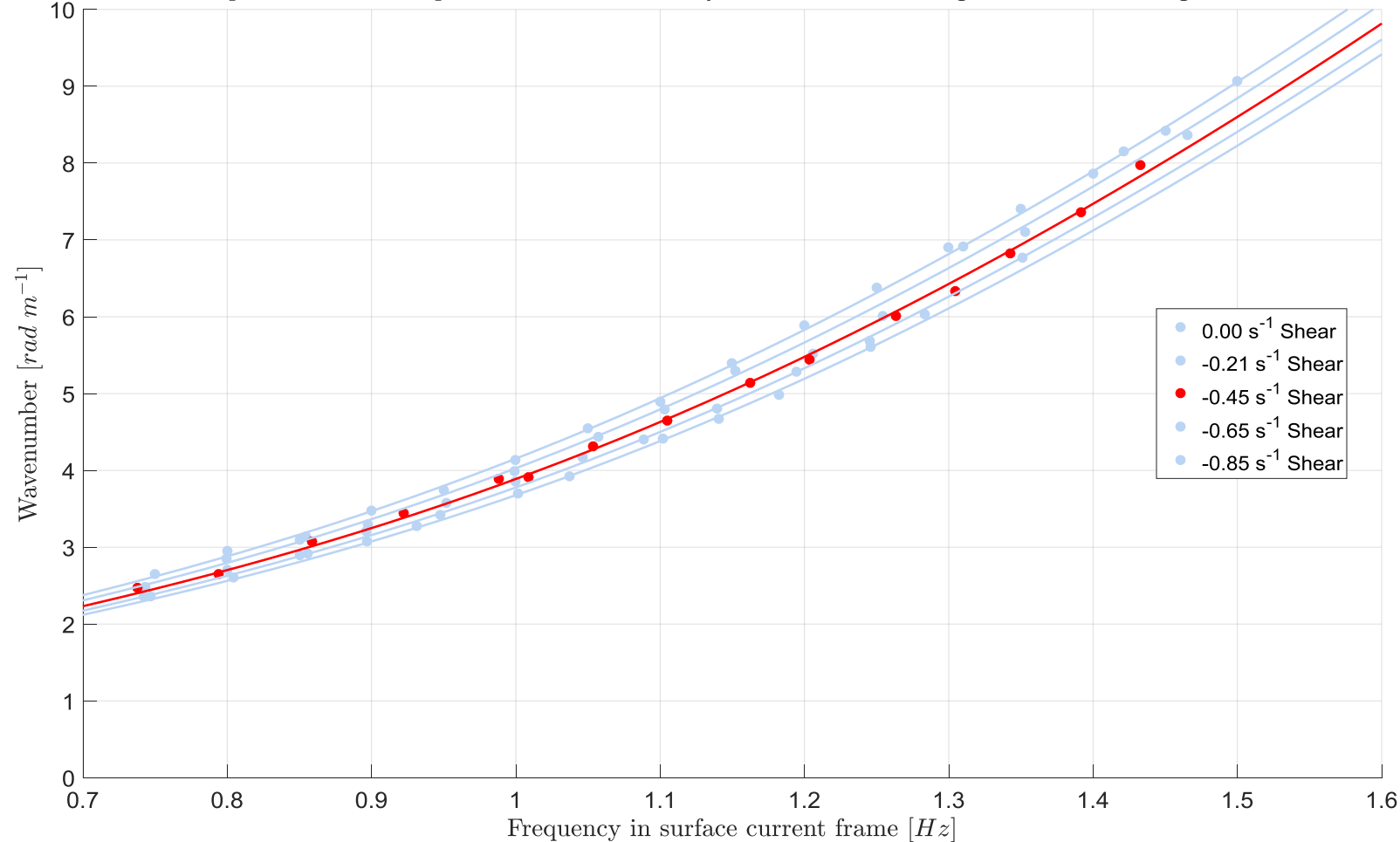




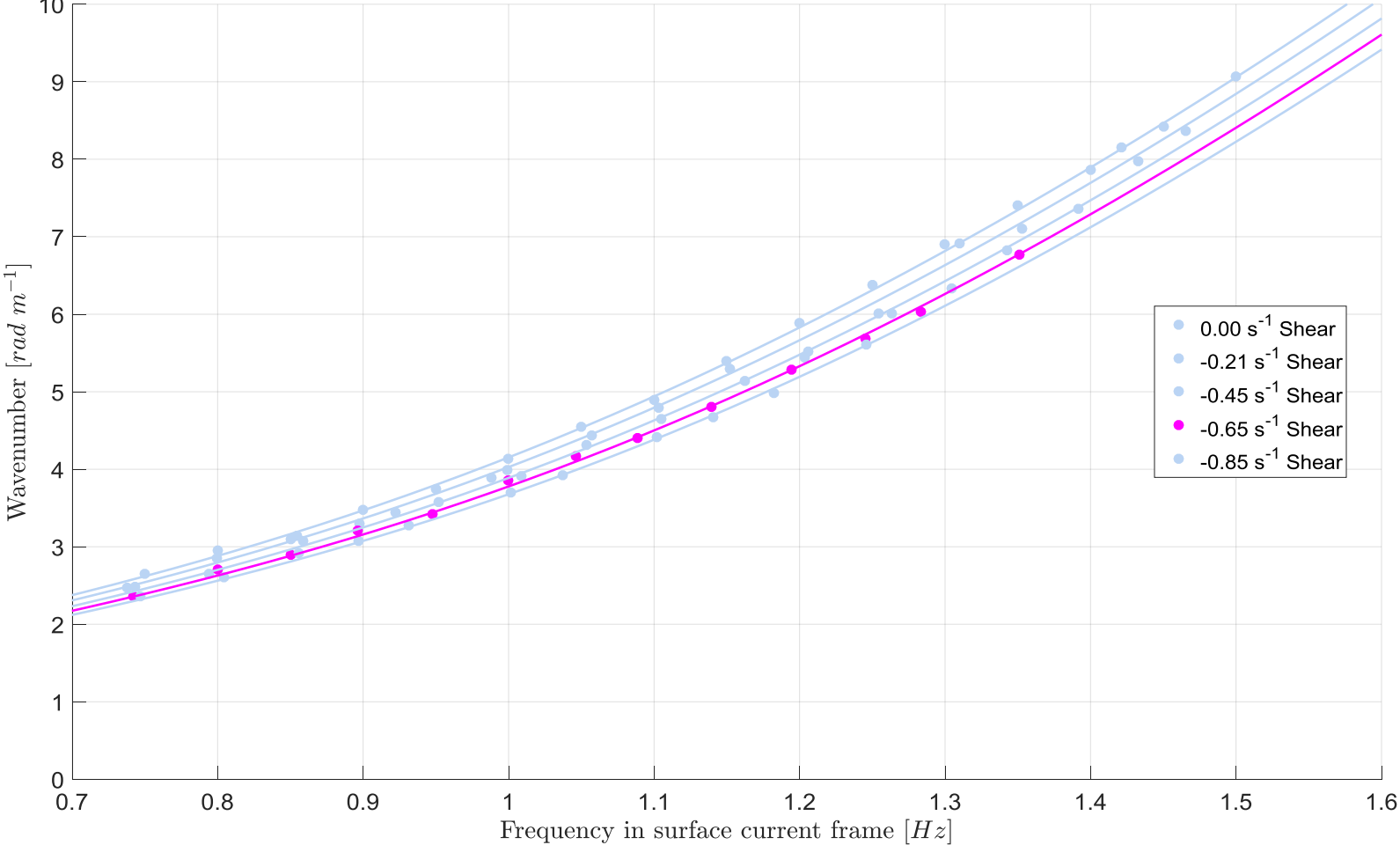
Dispersion relationship of waves on a vertically sheared current using measured wavelength data



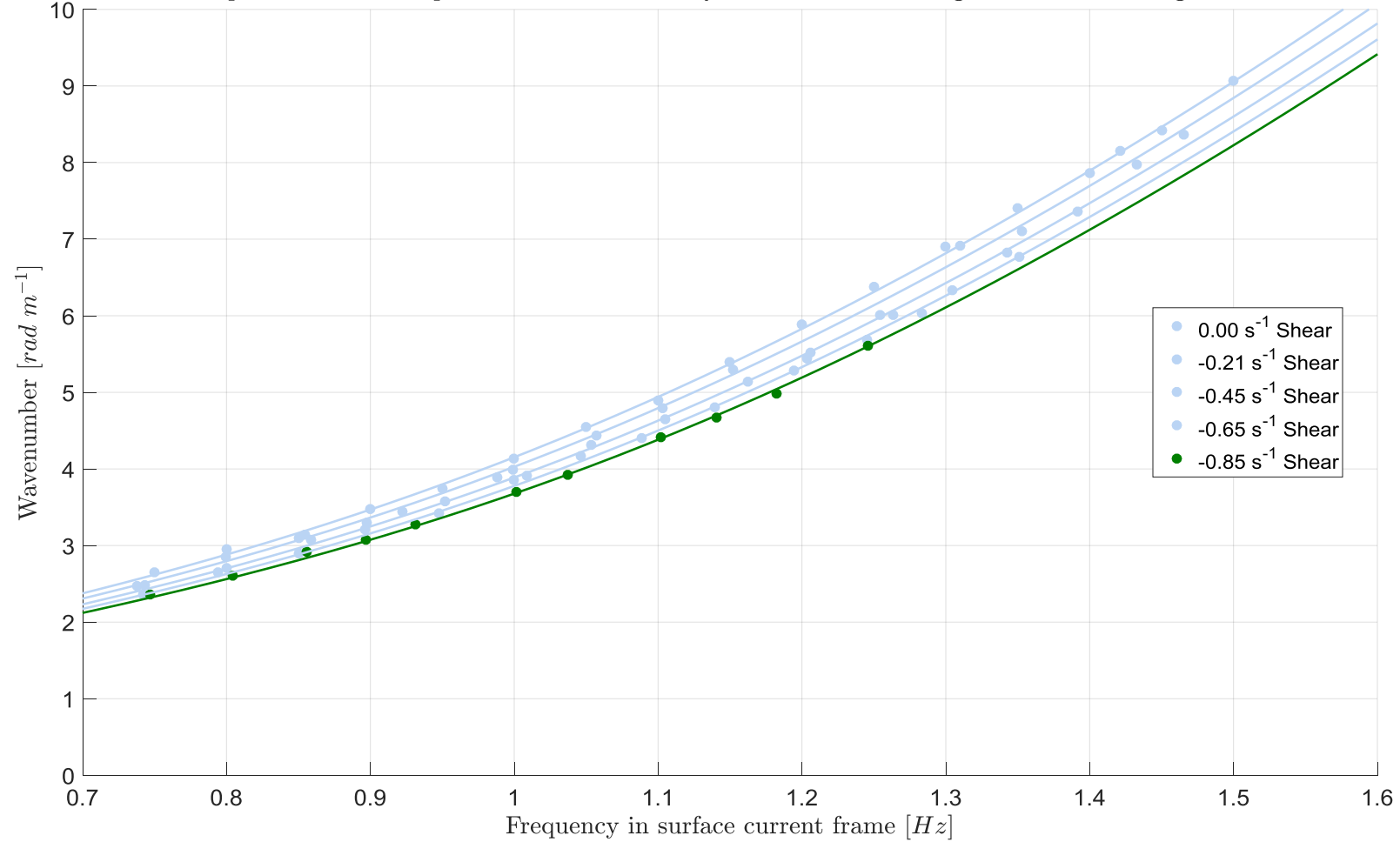
Dispersion relationship of waves on a vertically sheared current using measured wavelength data



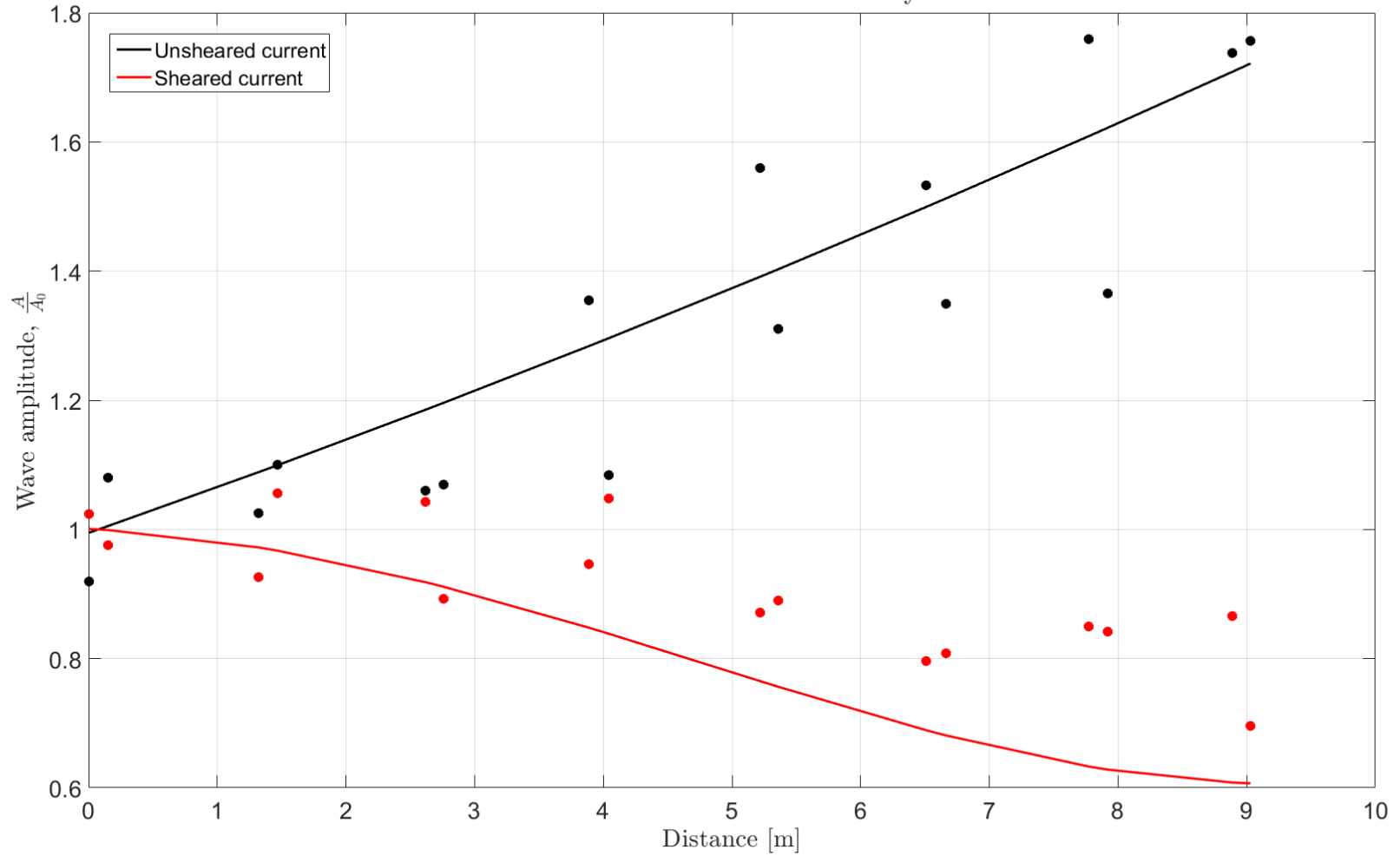
Dispersion relationship of waves on a vertically sheared current using measured wavelength data



Dispersion relationship of waves on a vertically sheared current using measured wavelength data



Effect of a sheared current on the stability of waves



# Conclusions

- Numerical analysis shows that shear within current drastically alters the behaviour of waves
- Experiments have been completed to test this theory
- Results will be used to aid in the placement of marine energy devices





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