Measurement and Modelling of Seiche Phenomena in NSW Harbours

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Summary
Coastal harbours are often subject to periodic surface water level and current speed oscillations ('seiche') on the order of 1 minute and longer, which can impede harbour operations by causing vessels to surge and sway at their berth; strain or break mooring lines; or otherwise cause structural damage through overtopping or scour. Harbours known to seiche typically require investigations utilising both physical and numerical models to minimise or mitigate adverse impacts by any proposed development that may alter the resonant characteristics of the harbour or its response to incident forcing functions. This paper outlines some of the successes and difficulties encountered by the authors in measuring seiching in NSW harbours (Coffs, Crowdy Head, Ulladulla and Port Kembla) prone to resonate from infragravity wave forcing during swell wave storm events and matching the model results to the measured seiche.

Keywords :Seiche, Infragravity Wave, Harbour Resonance, Numerical Modelling, Physical Modelling.

Introduction
Coastal harbours are often subject to periodic surface water level and current speed oscillations ('seiche') on the order of 1 minute and longer due resonant amplification of incident long waves within the harbour's resonance frequency band [1, 2]. Seiches can impede harbor operations by causing vessels to surge and sway at their berth, which can strain mooring lines and can make loading and unloading difficult; or otherwise cause damage to structures through either overtopping or current induced scour (Figure 1).

Figure 1 Damage at Crowdy Head harbour jetties due to seiche activity during the June 2016 storm [1]

Harbours known to seiche typically require investigations utilising both physical and numerical models, to minimise or mitigate adverse impacts by any proposed development that may alter the resonant characteristics of the harbour or its response to incident forcing functions.

Seiche in NSW Harbours
This paper presents and summarises some of the successes and difficulties encountered by the authors [3, 4, 5, 6] in measuring harbour seiching in NSW harbours prone to resonate from infragravity wave forcing during storm events (e.g. Figure 2 and Figure 3); and reproducing the observed seiching through a combination of physical and numerical modelling (e.g. Figure 4 and Figure5).

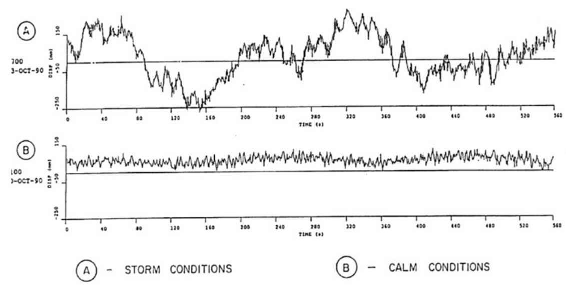
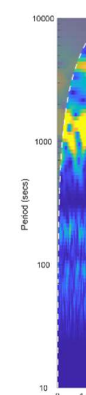


Figure 2 Historic water level times-series data collected at Crowdy harbour showing seiche at 200s–230s

Discussion
This paper will elaborate on the following.

- Measurements and analysis of harbour seiche forcing by long waves and surf beat.
- The simulation of recorded seiche periods both numerically and physically.
- Analytical methods of identifying modes and seiche frequencies both in rectangular (Coffs) and circular (Crowdy) harbours.
- Eigenfunction analysis of 'white noise' numerical simulations to identify potential harbour resonance modes, and comparison with observations.
- Methodologies using impulse functions and long wave modelling to simulate seiche physically in a 3D physical model.
- Some (almost) discarded physical modelling methodologies and proposed new methods in modelling seiche in small harbours.



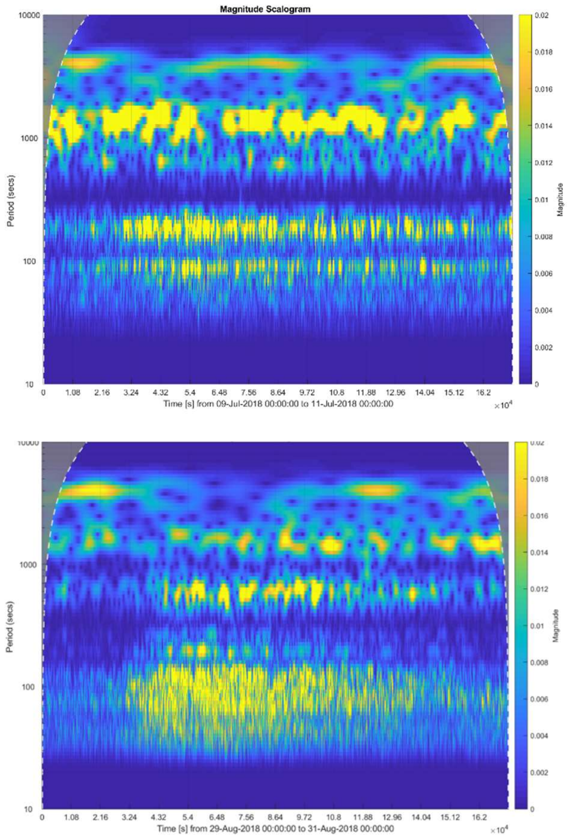


Figure 3 Magnitude-scalograms from Continuous Wavelet Transform (CWT) of 2Hz surface elevation data in Port Kembla Inner Harbour (top panel) and Outer Harbour (bottom panel) during a 24-hour swell wave storm event, showing development and attenuation of transient resonance at 1-, 1.5-, 3-, 5-, 10-, 30- and 60-minute periodicities

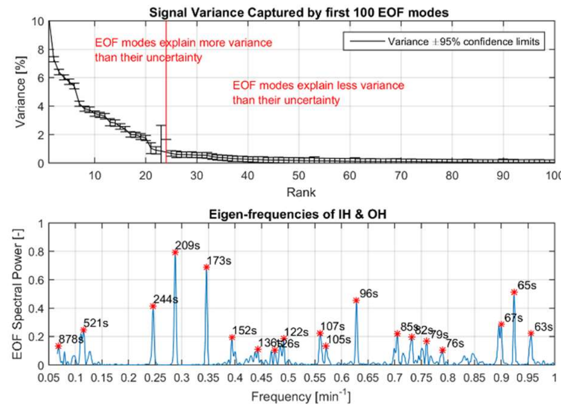


Figure 4 Spectral analysis of the first 20 Empirical Orthogonal Function (EOF) modes derived from the spatial water level field from a simulation of Port Kembla forced by a broad-band (1–10 minutes) 'white noise' spectrum at the ocean boundary, identifying spectral peaks at eigenfrequencies corresponding to 1-, 1.5-, 2-, 3-, 5- and 10-minute periodicities

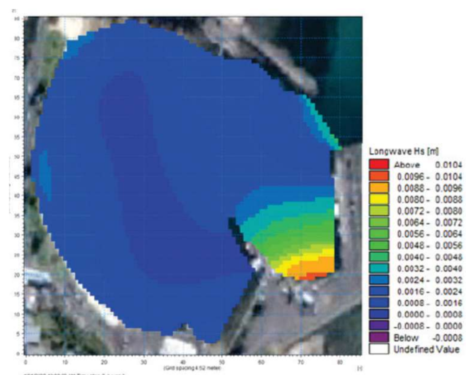


Figure 5 -White noise model of Ulladulla harbour indicating 105s-130s seiche with antinode at the boat ramp.

References

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