Monitoring and Analysis of Wake-Induced Vessel Motions: An Innovative Case-Study Williamstown, Melbourne

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Summary
The potential impact of wake generated by vessel traffic on assets and stakeholders is a common yet challenging issue around many ports. Managing this issue requires engagement with stakeholders, often with conflicting views. In this case study, for the Williamstown Maritime Precinct around the Port of Melbourne, we present innovative and affordable techniques for monitoring and analysing vessel generated wake, i.e., an evidence-based approach contributing to managing this issue.

Keywords: wake, waves, monitoring, stakeholders, management

Introduction
Marine traffic generates wake waves that propagate and can potentially impact on assets, environmental and social values around ports. This can be a challenging issue to manage for both port operators and affected stakeholders, who often have conflicting views on the causes and relevance of the issue. Collection of local data and analysis can assist in better understanding and documenting the actual occurrence of this issue; however, it is regularly regarded as an expensive exercise. In this case study, we present how innovative, simple, and affordable field monitoring of wake induced waves and moored boat motions, accompanied by analysis of marine traffic data can actually better inform and contribute to management of this issue.
This case study in the Williamstown Maritime Precinct, was motivated by local stakeholders who have repeatedly raised concerns and described *"wave, wash and surge events"* associated with marine traffic as inconvenient, damaging to infrastructure and moored boats, as well as threatening to people's safety.

Study Area Description
The Williamstown Maritime Precinct is an area of significance to the boating and maritime communities of Melbourne and broader Victoria, Australia. It is located within the north end of Port Phillip Bay, and in proximity of the Port of Melbourne. A series of piers and marinas exist within the Precinct, which extends approximately 1.5km from Point Gellibrand to the Yarra River mouth, where the Williamstown Channel (dredged channel of approximately 13m depth) provides access to shipping in the otherwise shallow waters of Hobsons Bay (of depths generally lower than 5m). The location and position of the Precinct provide partial natural sheltering to the prevailing seas, with protection enhanced by a few purposely built structures. At the same time the location makes the waterway one of the busiest in Victoria, with vessel wake waves propagating into the Precinct, effecting the infrastructure and boats at the local piers and marinas.

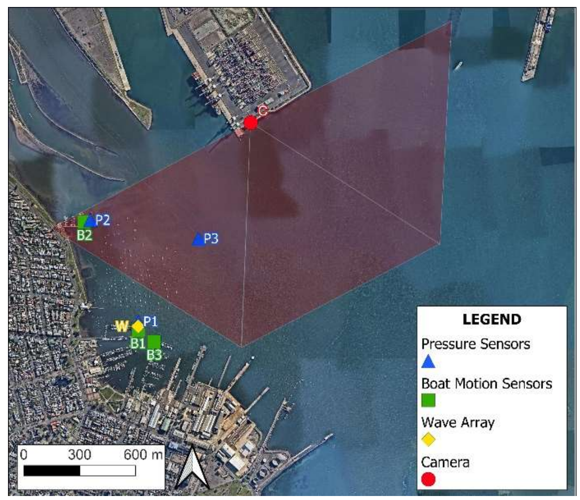

Figure 1 Study Area and Field Monitoring Plan, Williamstown Maritime Precinct, Melbourne, Australia

Methods
The study involved a field monitoring plan (Figure 1) using relatively simple and affordable instrumentation to collect measurements of sea state, response of moored vessels to sea state, and observation of vessel traffic passage around the study area, over a period of approximately 4 months (from 21 December 2020 to 14 April 2021). The sea state properties, specifically water level, wave height and wave period were collected from 3 pressure sensor units (RBR Solo; locations P1, P2 and P3) and one wave array instrument (location W) comprised of three time-synchronised ultrasonic distance sensors (Senix ToughSonic 30). The response of moored vessels was measured by 3 motion sensors (Marine Link Sense, MLS) deployed on three representative sailing yachts moored in three different locations within the Williamstown Maritime Precinct (locations B1, B2 and B3), identified collaboratively with local stakeholders.

These instruments measured the direction and amplitude of angular motions and accelerations (6 degrees of freedom) of the moored boats. A system of high-resolution cameras (location C) was also deployed to aid on the monitoring of marine traffic and identification of vessel types. The system consisted of 3 outdoor bullet network cameras (Vivotek IB9391-EHT) powered by a local 240V source with backup battery. The cameras, of approximately 60° viewing angle each, were arranged next to each other to cover over 180° field of view, approximately 70° to 250° N. The data from the boat motion sensors and wave array were transmitted and streamed in near real time to a cloud platform (BMT Deep) for storage and visualisation using a purpose-designed online viewing portal. Camera imagery was available in real-time, through internet connection to a single network video recorded (NVR, Vivotek ND9541P). Additionally, metocean and marine traffic data from Automated Identification System (AIS), provided by the Victorian Ports Corporation Melbourne (VPCM), were analysed (as further described below).

Results

A dynamic threshold algorithm was developed to analyse the MLS data to identify significant moored boat motion "events" and filter out boat response to background sea state. Applying this algorithm to analyse the measured data, an extensive catalogue of detected events was collated. The catalogue comprised over eight thousand event detections (8,378 in total) from the 3 boat motion sensors. Events were detected on every day of the data collection period, with an average of approximately 70 event detections per day. Event amplitude (measured as degrees of roll motion), ranged from close to 0° to more than 25° roll, although approximately 90% of the event detections had amplitude 10° or less. Event duration ranged between less than 30 seconds and up to more than 6 minutes, with more than half of the detections lasting for less than 1 minute. Analysis indicated that roll motion events were also associated with peak accelerations in moored vessel surge and sway motions.

The catalogue of event detections was analysed against the marine traffic AIS data to identify vessel type, size, speed and direction of travel for vessels passing through the area of interest with the potential to generate wake waves propagating into the Precinct and could be associated with recorded "events". The camera system recording allowed further identification and verification of passing vessel types and features. The time-synchronisation of the various datasets allowed validation and collation of a series of distinctive visual observations provided by local stakeholders. From the analysis conducted, 14 categories of vessel types were identified, these were further summarised into five groups: Non-AIS vessels, Port Support Vessels, Large Commercial Vessels, and Other. The associated percentage distributions of the detected events by passing vessel type and amplitude are summarised in Table 1.

Table 1 Distribution of "wave, wash and surge events" detected (percentage of the 8,378 detections catalogue), by passing vessel type and measured boat roll amplitude°

Vessel Type	0-5°	5-10°	>10°	**Total**
Non-AIS Vessel	30.5	12.8	2.1	**45.3**
Fast Ferries	9.4	8.3	3.4	**21.1**
Port Support Vessels	5.3	1.7	0.4	**7.4**
Large Commercial Vessels	12.9	7.2	2.0	**22.1**
Other	2.6	1.2	0.4	**4.2**
Total	**60.7**	**31.1**	**8.2**	**100.0**

Discussion and Conclusion

The monitoring plan, with a relatively simple set of instruments and methodology, was successful in allowing detection of a large number of *"wave, wash and surge events"* and facilitated the association of events with wake generated by various passing vessel types. The data collected and subsequent analysis provides a clear, evidence-based, and robust statistical characterisation of the complex vessel traffic and associated wake issue in the Precinct. The improved understanding and objective results have facilitated effective engagement with stakeholders. Furthermore, the findings inform the identification and assessment of management and mitigation options, which could potentially include: operational controls, such as managing vessel transit and speed limits; structural options for attenuating incident waves (including wake waves) that otherwise propagate into the Precinct; and/or option to reducing the effect of the incident waves (including wake waves) on the boats and infrastructure within the Precinct.

This case study demonstrates the feasibility and benefits of this monitoring and analysis approach that can be customised for implementation at other ports and waterways to address a range of issues arising from vessel transit and the associated wake impacts.

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