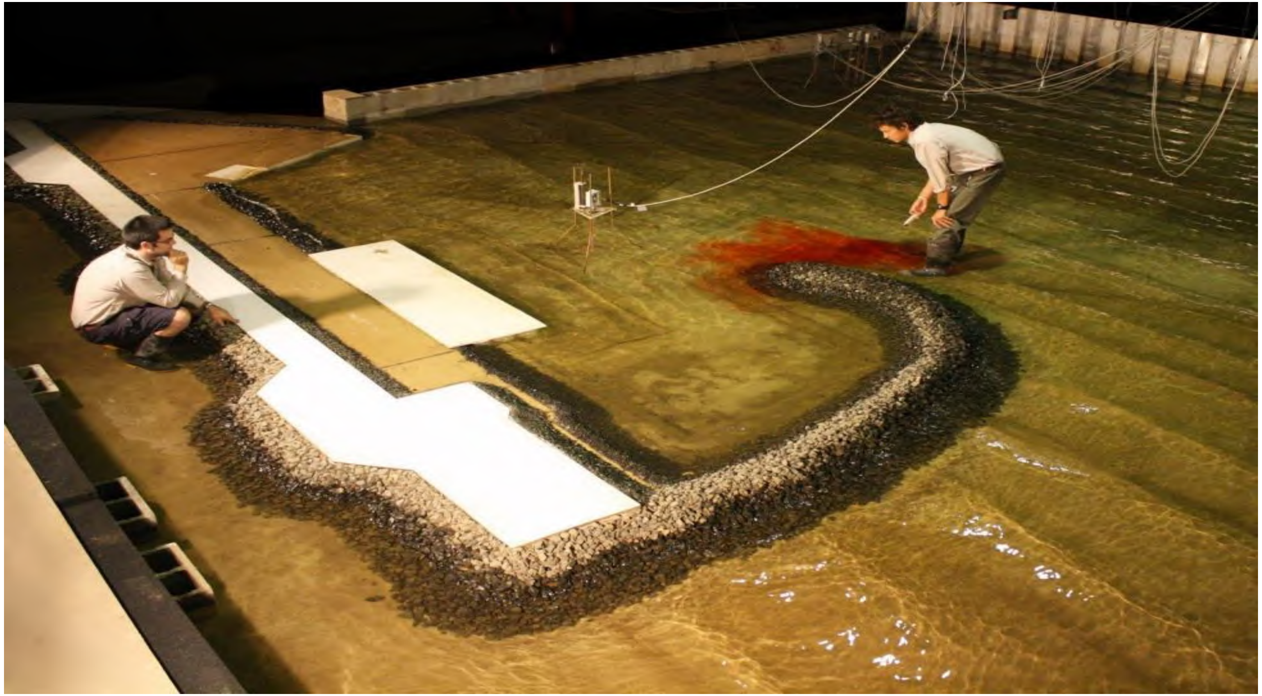
Water Research Laboratory | School of Civil & Environmental Engineering

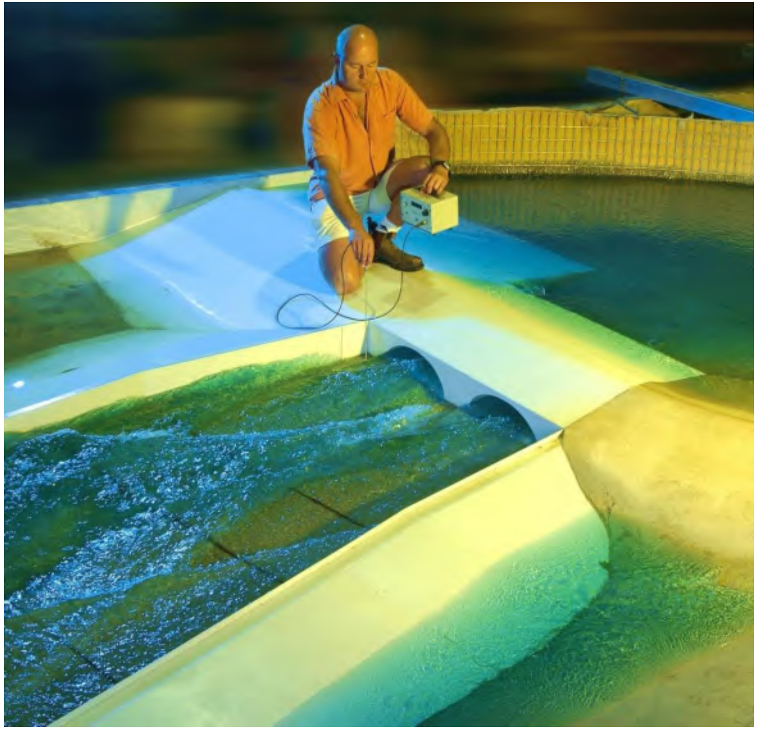
Bow Thruster Performance and Loading on Wharf Structures

Brett Miller

WRL : Coastal Physical Modelling



WRL – Hydraulic Modelling



UNSW SYDNEY

Water Research Laboratory

Prop Wash Modelling – A bit of both

Studies and Collaborators

Ausenco: Neville Berard, Sundar Prasad

Royal Haskoning: Dan Messiter

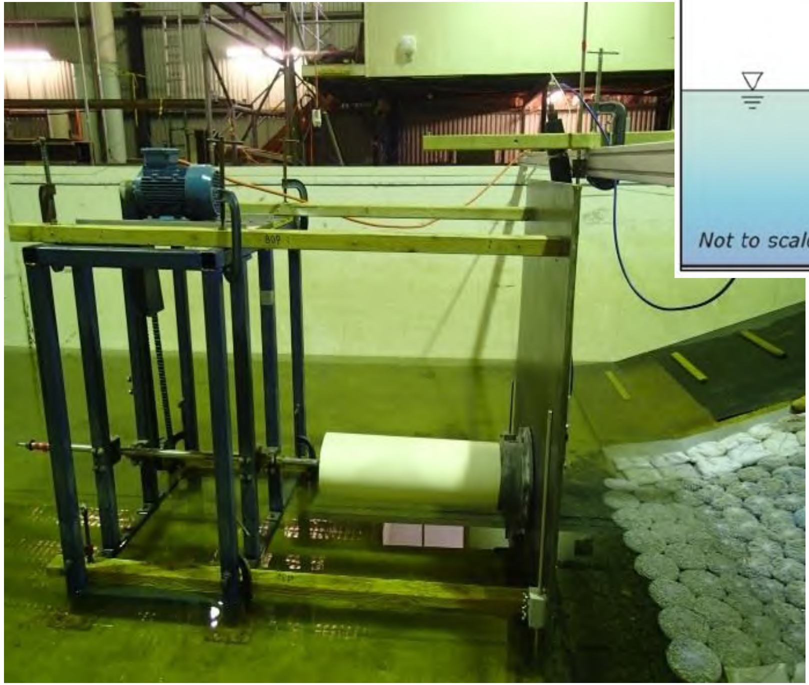
WRL: Mathieu Deiber, Gabriela Lumiati, James Simpson

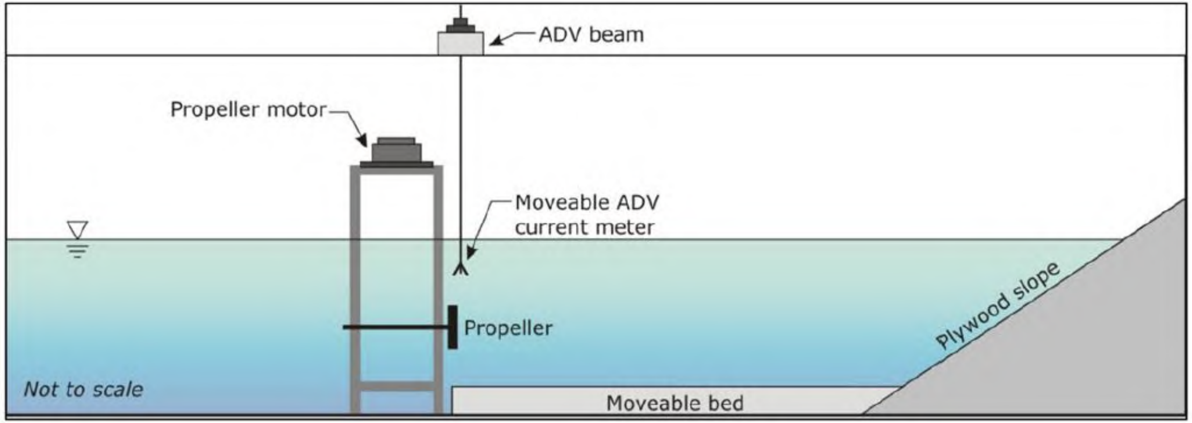
Berard et al : Physical Modelling Of Propeller Scour On An Armoured Slope,
PIANC World Congress Panama City, Panama 2018

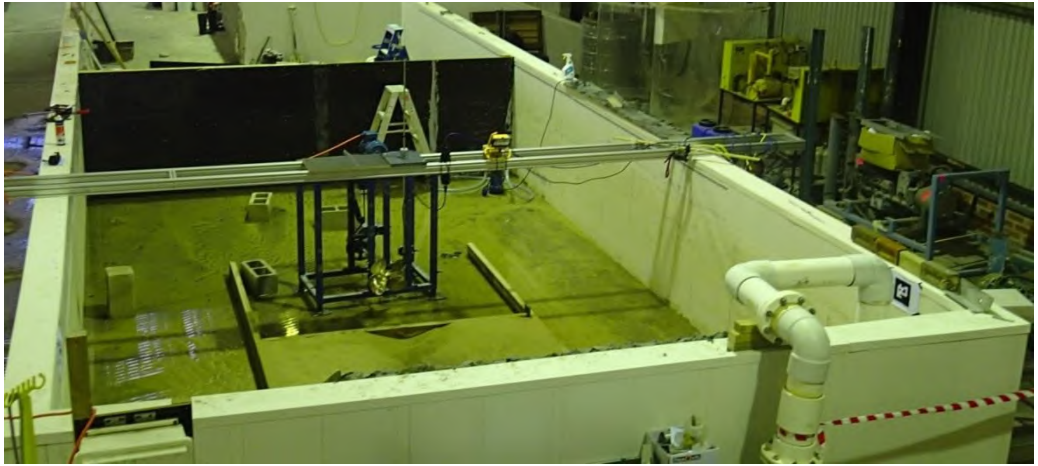
Messiter et al : Super Cruise Vessel vs Rock Bags,
Coast and Ports, 2019

Three Water Research Laboratory Technical Reports

Laboratory

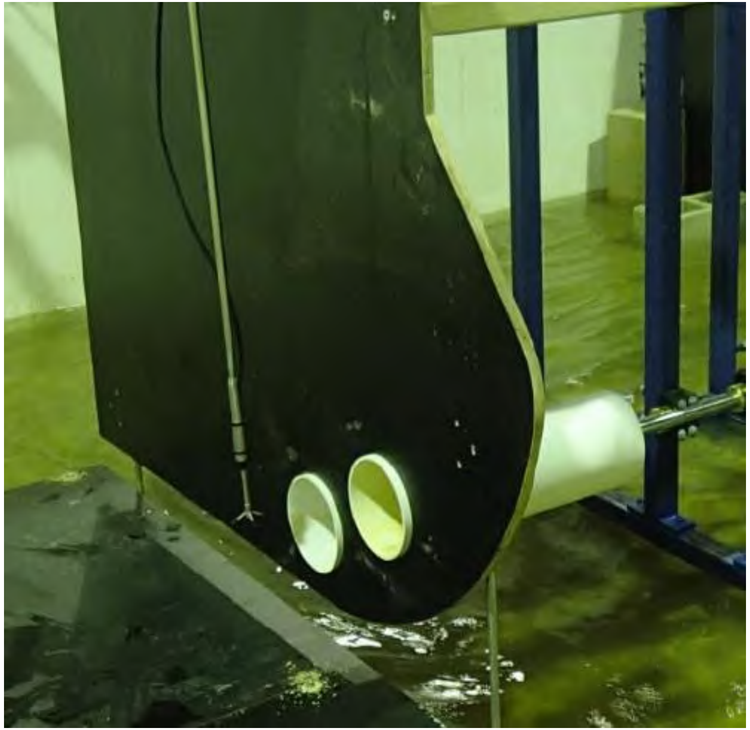



ADV beam
Propeller motor
Moveable ADV current meter
Propeller
Plywood slope
Not to scale
Moveable bed



Laboratory

4 m x 7 m x 1.4 m deep basin
A plywood slope upon which the revetment was built
A section of movable bed
A propeller drive and motor for the different configurations
A beam for supporting and moving the ADV current meter



Model Scale

The modelling was undertaken at a Froude scale of 1:13.5 for one study and 1:20 for another.

Scale was determined so as to:

- Maintain adequate turbulence for the rock stability testing;
- Follow coastal engineering scaling rules for armour mass.
- Provide adequate resolution and accuracy for model measurements
- Ensure the basin had enough space for water circulations and jet dispersion;

A 4.8m diameter main propeller

PIANC Report 180

Guidelines for Protecting Berthing Structures from Scour Caused by Ships

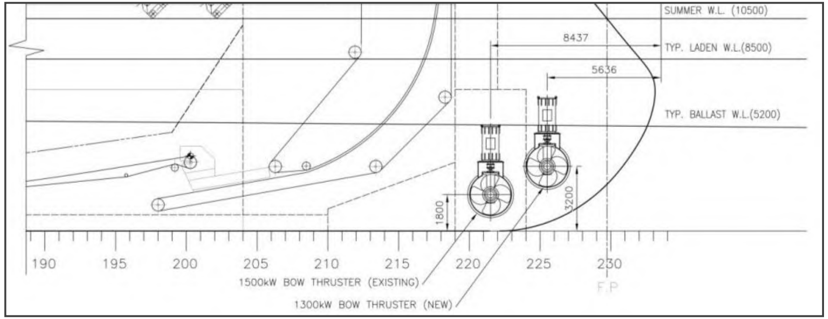
Provides methods for estimating propeller exit velocities

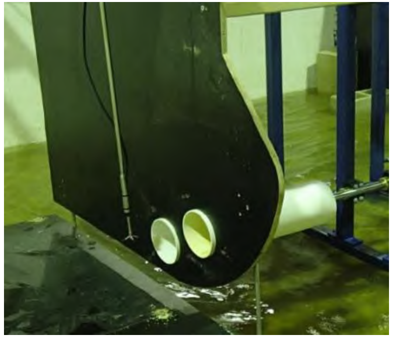
Methods for estimating jet dispersion

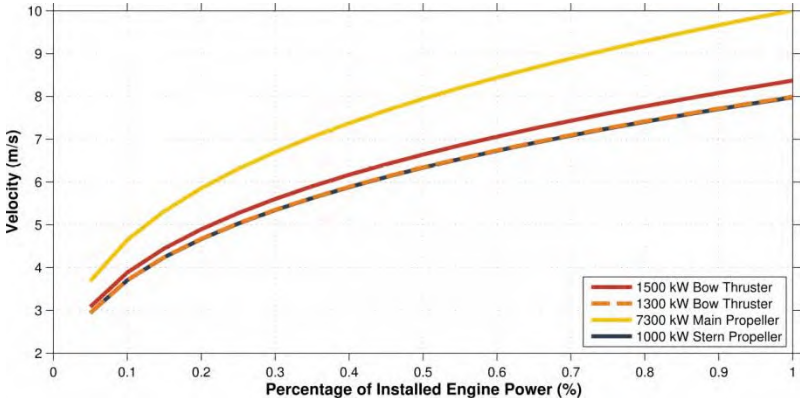
Methods for estimating stable rock sizes

However, complexities exist for slope, proximity of the jet to the bed, alternative protection and duration of impact. Physical model testing was needed.

Study 1 – Cape Preston, Donnaconna Vessel



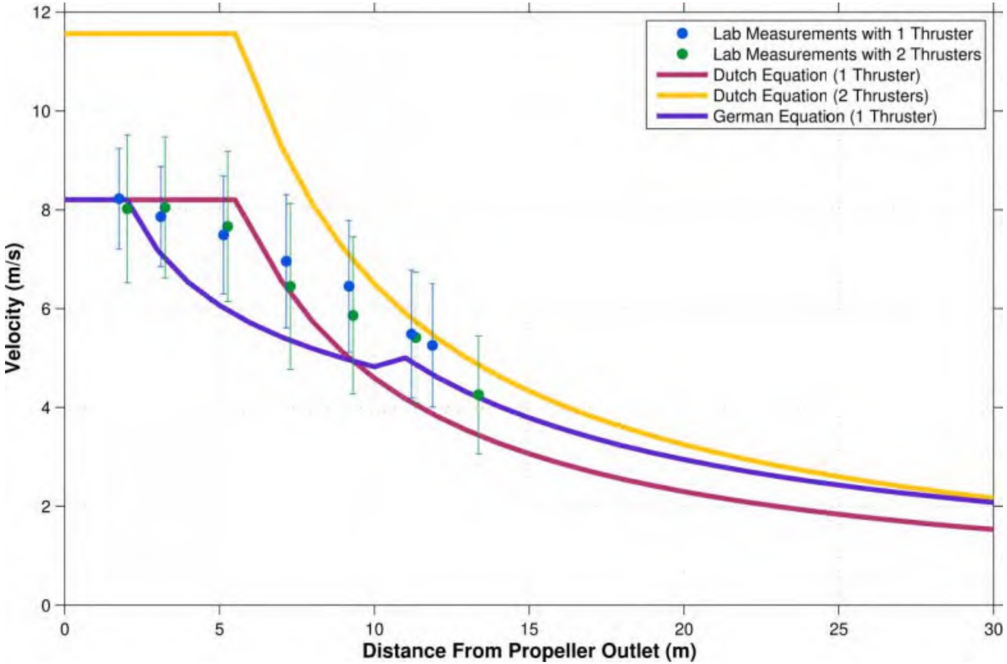




Tested for armour movement with the vessel at maximum displacement on LAT. The bow thrusters were as close to the bed as possible.

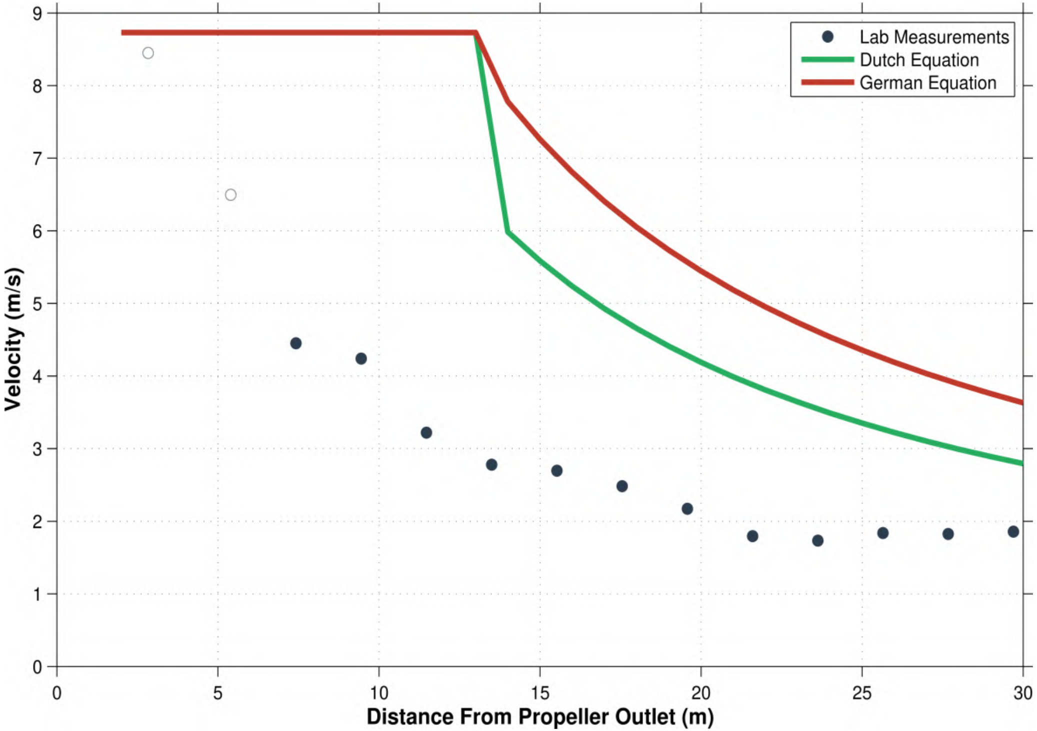
Tested for various operational engine powers and ship offsets from the berth.

Jet Dispersion – Bow Thrusters



When measuring along the centerline of a one bow thruster jet there was no increase in velocity along the propeller axis when the second jet was operational. The modification of equation (2) for two jets is likely conservative, especially in the zone closest to the propeller outlet. This supports the findings of Dykstra et al. (2010) who came to similar conclusions;

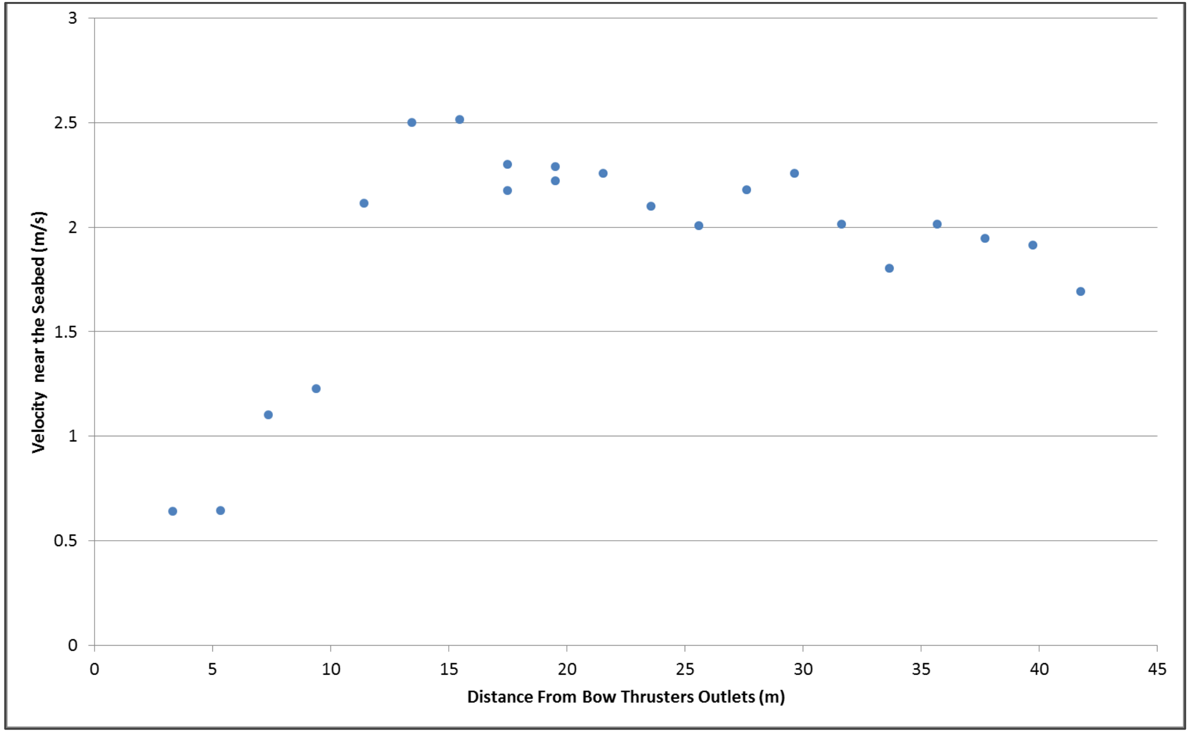
Jet Dispersion – Stern Propeller



Velocities were seen to drop sharply with distance from the propeller. The zone of flow establishment which is typically valid for 2.6*Dp may not be representative for large propellers.

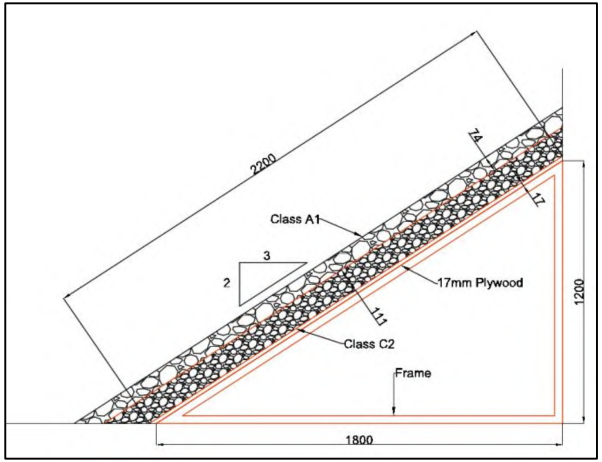
This modelling was done at a much larger scale than previous literature. Scale effects?

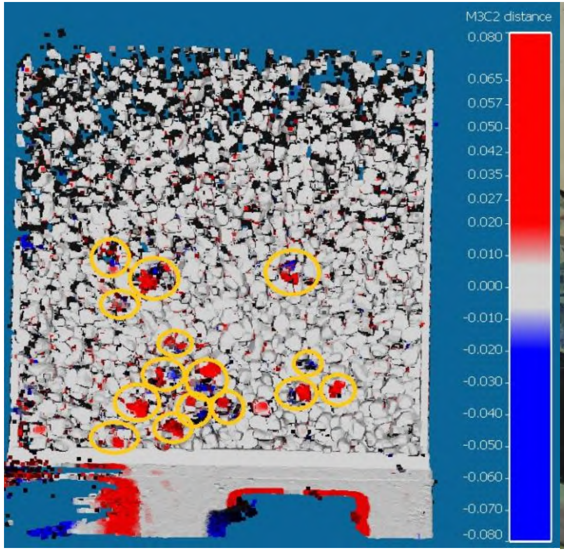
Velocity on the Seabed

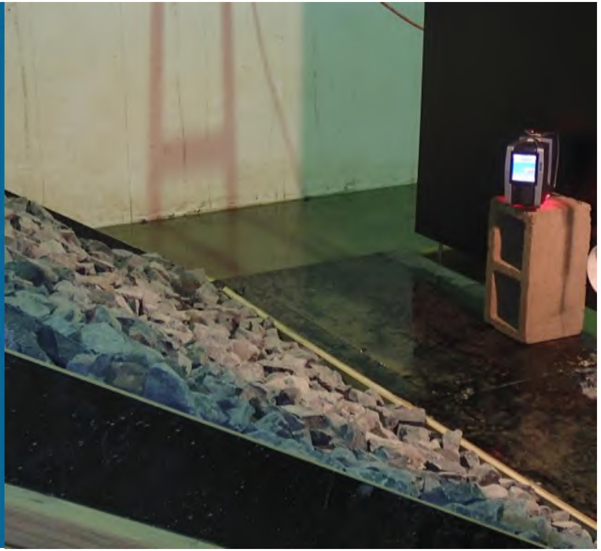


Rock Armour

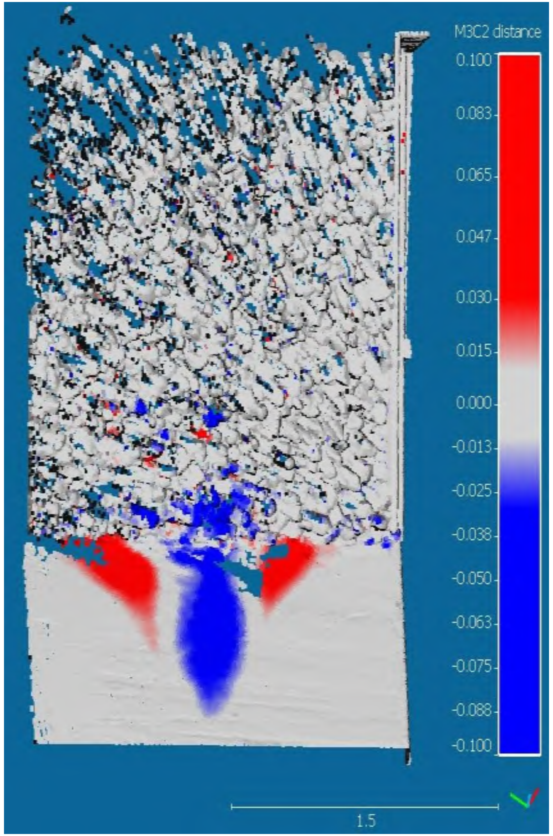
In general the armour was more “stable” than predicted by the empirical methods. This is due to a combination of: armour slope (the jet is pushing into the slope rather than across bed protection); jet dispersion and energy dissipation though the armour layers.







Bed Scour

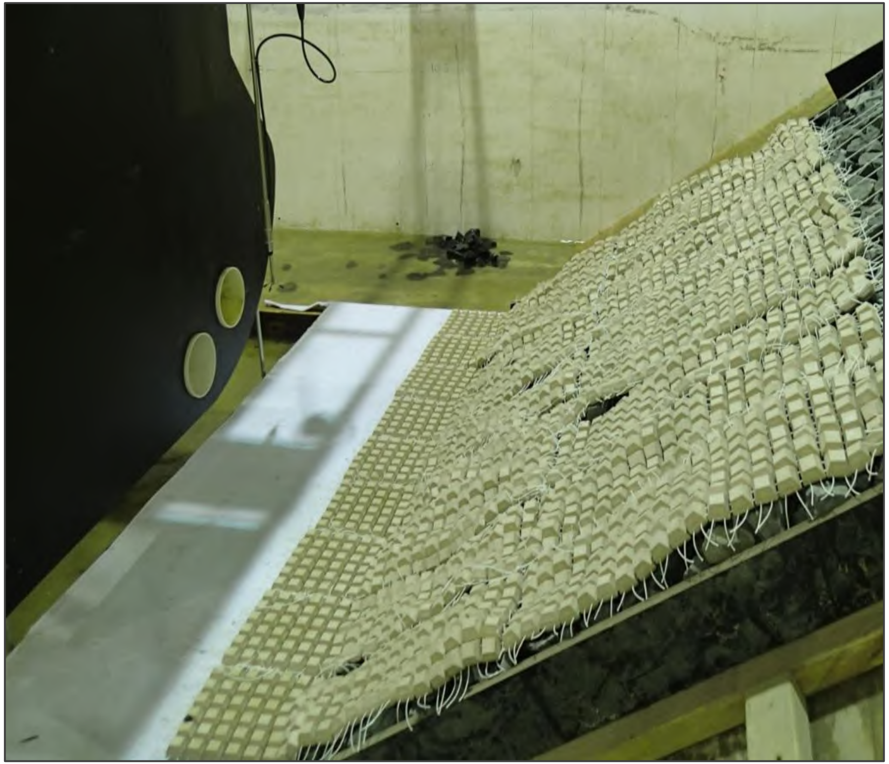

M3C2 distance
0.100
0.083
0.065
0.047
0.030
0.015
0.000
-0.013
-0.025
-0.038
-0.050
-0.063
-0.075
-0.088
-0.100
1.5

“Stability”

Only minor rock movements were observed. However, if 0.5m diameter rocks are being moved each ship transit, and the underkeel clearance on LAT is <0.5m, you will eventually end up with a rock blocking the berth.

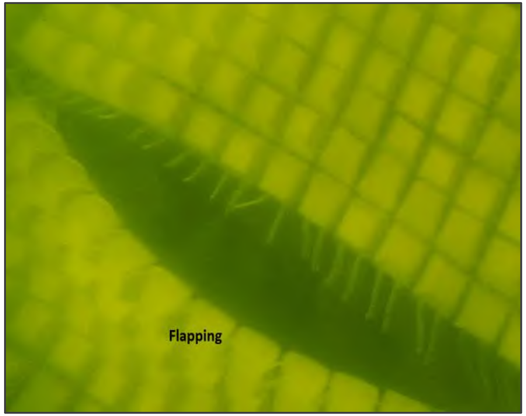
However empirical methods had estimated stable rock sizes many times larger than the 0.5 tonne (50^{th} percentile) to 1.0 tonne (90^{th} percentile) tested in the laboratory.

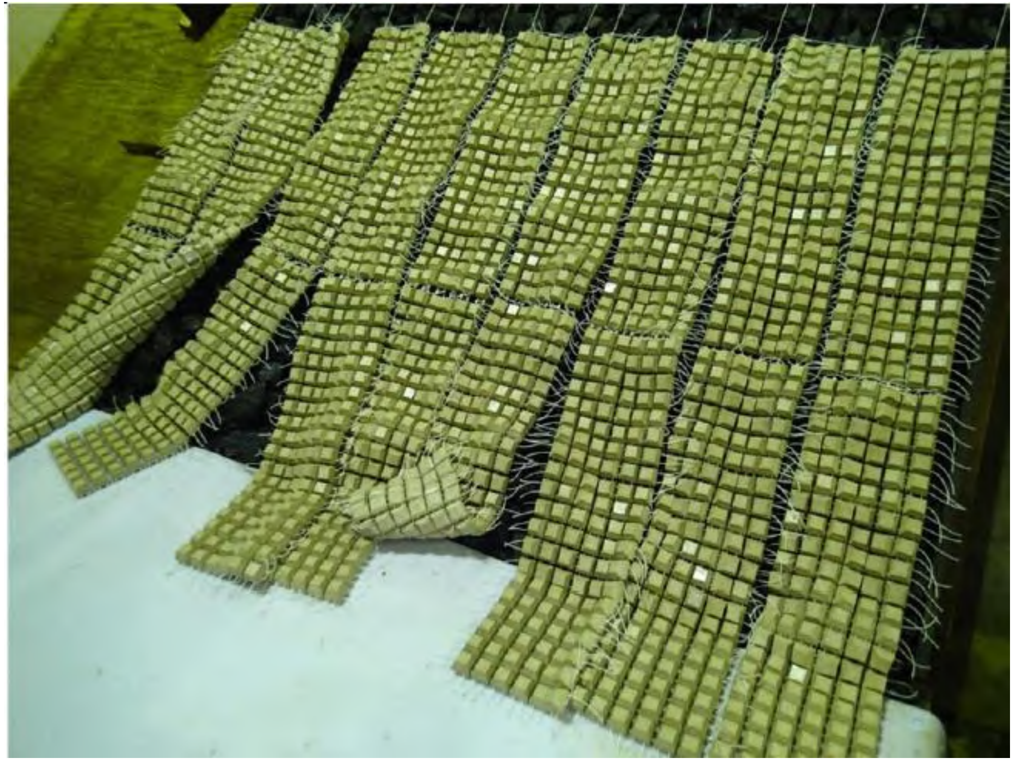
An Articulated Concrete Mattress (ACM) was tested to see if this would stabilise the rock revetment.



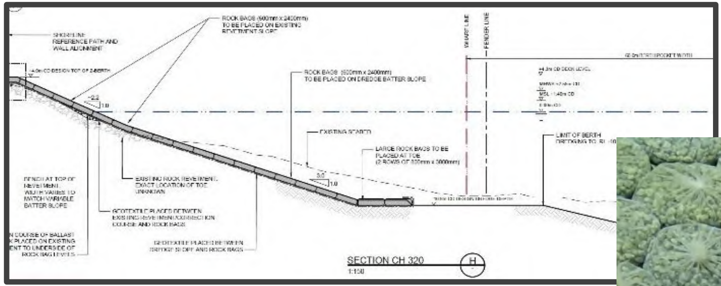
Stable when tied together

Articulated Concrete Mattresses were found to be effective at stabilizing the velocities produced by the propulsion system only if tied together at the toe and top of the slope. For real world applications it is recommended that the ACMs should be connected along their full length to neighbouring mats

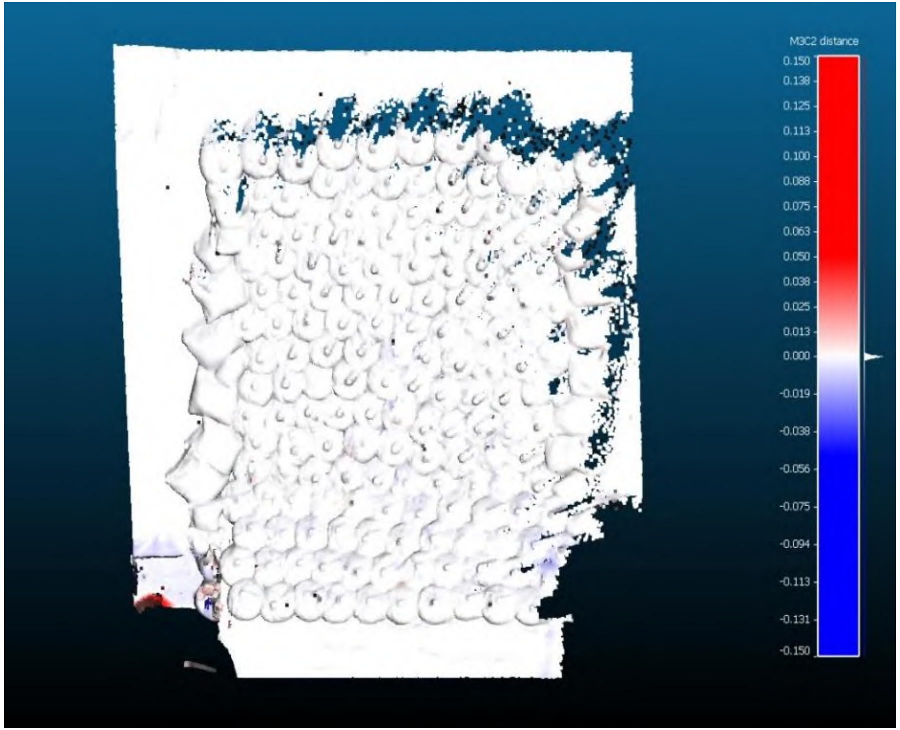




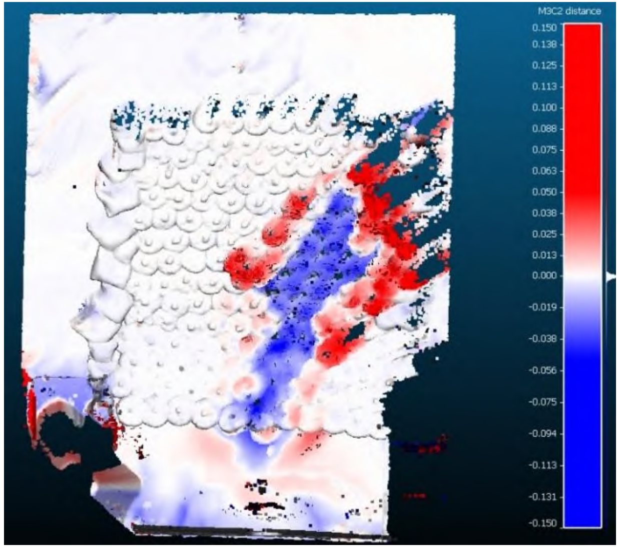
Study 2


ROCK BAGS (600mm x 2400mm)
TO BE PLACED ON EXISTING
WHARF LINE
FENDER LINE
REFERENCE PATH AND
WALL ALIGNMENT
ROCK BAGS (600mm x 2400mm)
TO BE PLACED ON DREDGE BATTER SLOPE
MSL
EXISTING
LARGE ROCK BAGS TO BE
PLACED AT TOE
LIMIT OF BERTH
EXISTING ROCK REVETMENT.
EXACT LOCATION OF TOE
UNKNOWN
BATTER SLOPE
GEOTEXTILE PLACED BETWEEN
COURSE AND ROCK BAGS
GEOTEXTILE PLACED BETWEEN
DREDGE SLOPE AND ROCK BAGS
SECTION CH 320
1:150
H

Generally Stable for the Design Velocity



Physical Modelling Allows for Testing to Destruction



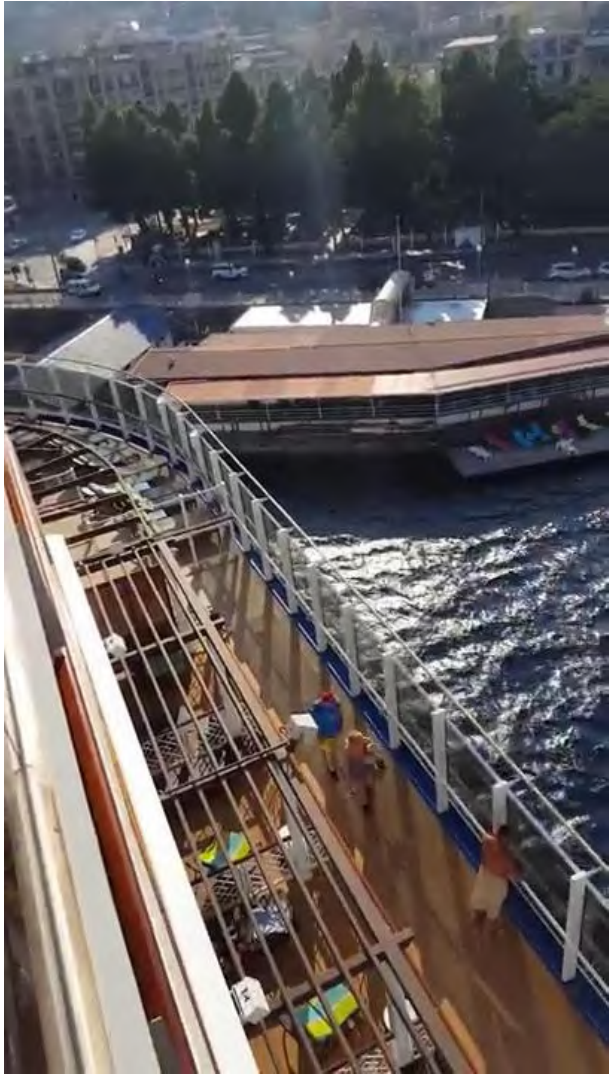
Occurring after 2 minutes of impact from bow thrusters at 100% power, which is above the design condition.

Take Away Messages

- Velocities decay faster than empirical methods predicted
- For ships near the berthline, each bow thruster impacts independently
- Rock armour was generally more stable than empirical methods however individual rocks were moving
- ACM’s should be tied at the top and toe and to each other
- The rock bags tested were stable for the criteria but for higher flows, failure was sudden and substantial.

- Don’t compromise on model scale.

Messina - Italy



Thank you

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