Apollo Bay, Victoria, Wave Climate Study

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Summary
The marina berths within Apollo Bay Harbour have suffered damage from wave activity and require rehabilitation. Cardno undertook a detailed wave climate study covering the whole harbour area to define wave heights, periods and directions. Colac Otway Shire Council provided some in-harbour wave data, recorded by RBR instruments, and was used for model calibration. Offshore global wave data was used to define the long-term offshore wave climate that was transferred inshore to the harbour entrance using SWAN, and then from the harbour entrance to berth areas using SWASH.

Keywords: Marina development, Apollo Bay, SWAN and SWASH, numerical wave modelling

Introduction
International Marina Consultants (IMC) engaged Cardno to undertake a wave climate study to prepare design wave parameters for the design of marina extension facilities within the Apollo Bay Harbour in south-western Victoria.

The marina design task required design wave and water level data and this paper describes the investigations undertaken to prepare that data; noting that the investigation was to provide design wave data on a wider basis than the footprint of the existing marina area.

Cardno was required to define the following design criteria:

1. Extreme event wave parameters, including 1, 50, 100 and 200-years ARI, and corresponding wave periods and directions at selected locations throughout the interior of the harbour;
2. Tabulated joint occurrence data for Hs and Tp; and
3. Noting that wave direction is important because of AS3962 requirements in terms of wave heights and directions relative to at-berth vessel alignments; provide realistic wave direction data.
4. Design water level data

This site is exposed to wave energy caused by frequent Southern Ocean storms; albeit the marina is protected by the main and lee breakwaters of the harbour. It is sheltered from westerly sector waves, but easterly to south-easterly winds in western Bass Strait will cause high waves near the entrance to the Apollo Bay Harbour.

Recent wave recordings using RBR pressure transducers had been made at four sites within the harbour and access to that data as time-series of significant wave height (Hs) and significant wave period (Ts) for each location, was provided. That data provided one basis for wave model verification.

Following these initial investigations, Cardno were requested to undertake similar investigations that included a panel breakwater arm extending into the harbour from the seaward end of the existing northern panel breakwater and deck.

This paper describes the data, methods and outcomes of this wave climate investigation, including the panel breakwater extension outcomes.

Data
Apart from tidal and bathymetric data, a range of wave data items were available and were applied to this investigation.

These datasets comprised wind and wave time-series of long-term global hindcast model data (CSIRO CAWCR Reanalysis) of 42 years in length, and local wave buoy measurements, height, period and direction, within the Apollo Bay area. This wave buoy was deployed east of Apollo Bay Harbour and spanned approximately 1.2 years between October 2019 and January 2021. It was operated by Deakin University.

Wave Models
The propagation of Southern Ocean/Bass Strait swell waves into Apollo Bay was investigated by applying the SWAN wave model to prepare wave transfer coefficients for a full suite of offshore wave heights, periods and directions

The SWAN wave modelling set-up consisted of a series of rectilinear grids of varying resolution. The developed model domain is sufficiently large to simulate the full range of wave processes, particularly offshore wave direction, across the study area and into Apollo Bay.

Figure 1 presents the SWAN wave model grids and bathymetry.

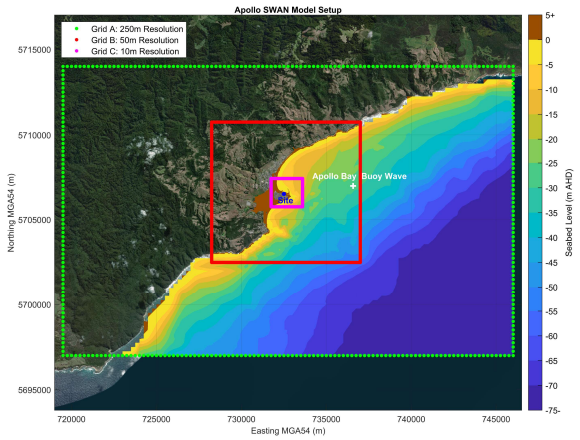

Figure 1 SWAN model grids and bathymetry applied to wave transformation modelling

To estimate wave conditions in and around the harbour, the detailed phase resolving SWASH model was applied. Figure 2 describes the SWASH wave model grid and bathymetry developed for this investigation. The bathymetry of the Apollo Bay Harbour entrance is complex, with shoaling common on the eastern side and scouring on the western side near the vertical screen wall. Tidal currents will be small – so, these features are likely caused by wave processes, including some wave reflection from the panel structure. The SWASH model set up consisted of a 2m resolution rectilinear grid extending 850m offshore (in the E-W direction) and alongshore (in the N-S direction).

Fully absorbing sponge layers were applied on the western and northern boundaries of the model. The harbour breakwaters have been included in the model's bathymetry and a porosity value of 0.6 has been mostly used to represent the armour layer. However, along the lee breakwater and within the harbour area a fully reflective structure or a porosity value of 0.45 has also been used to define the vertical screen wall or rock protection in front of the walls. A porosity value of 0.45 has also been used to include the revetments near the boat ramp area.

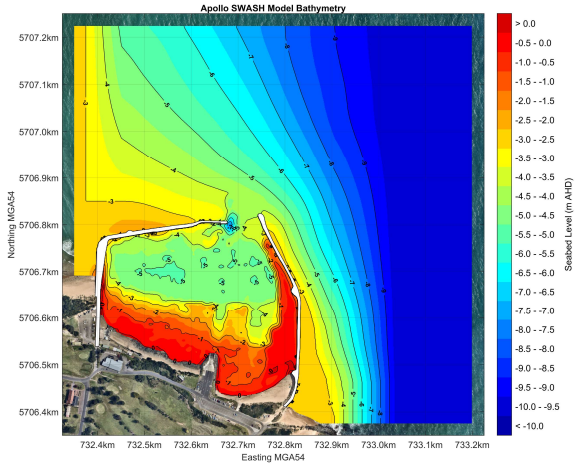

Figure 2 SWASH model extent and bathymetry

Outcomes

An example of SWASH modelling results in terms of mean wave direction vectors is presented in Figure 3. Figure 4 describes the results of the wave climate investigations in terms of 1-year ARI wave heights and periods.

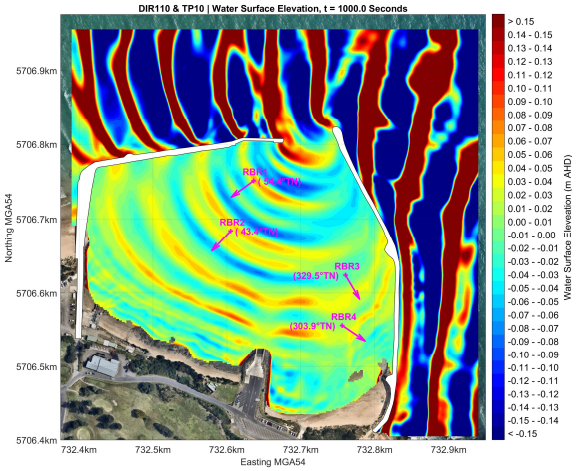

Figure 3 An example of mean wave direction vectors from SWASH modelling results

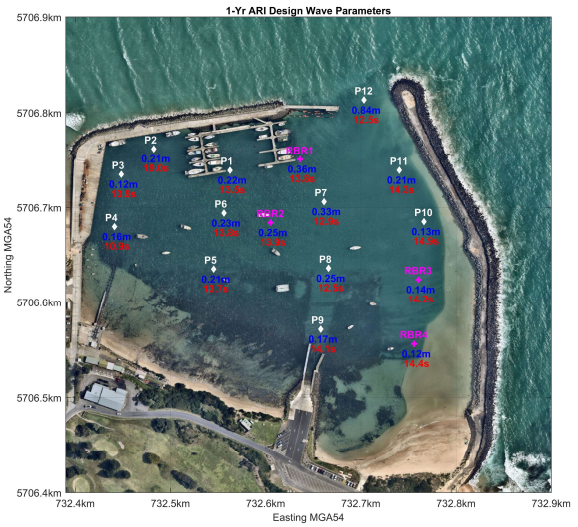

Figure 4 1-Year ARI design wave parameters