CHALLENGES OF BOUNDARY CONDITIONS IN OPEN OCEAN MODELS

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INTRODUCTION

The development and calibration of coastal numerical models to support engineering design and environmental impact studies is a challenging process and one that requires professional judgement and continual assessment of all aspects of the model makeup. Fundamental to the integrity of the model are appropriate boundary conditions and quality observational data for calibration. Open ocean boundary conditions are typically the most complex and important aspect of a model build. They represent the influence of dynamics occurring beyond the model extent, bridging large-scale dynamics to the small-scale processes in the model. This study discusses the challenges of open ocean boundaries and how we utilised data to achieve an effective model.

The project examined Merimbula Bay, on the southern coast of NSW, Australia (Figure 1). A model was developed using the Delft3D suite to support the proposed Merimbula treated wastewater ocean outfall concept design and environmental assessment. The model allows investigation of hydrodynamic processes in the bay and the dispersion of wastewater plumes.

Figure 1 – Merimbula Bay and Lake, NSW, Australia

THE CHALLENGE

Central to the verification effort was the challenge of finding boundary conditions to account for the variable offshore currents and meso-scale eddies, dominated by the East Australian Current (EAC) and overlain by passing local weather systems. Figure 2 shows the model extent and boundary locations.

Fixed point and spatial ocean current data gathered in the area provided useful calibration events. The initial approach, using Regional Ocean Modeling System (ROMS) boundary conditions, did not prove adequate for calibration. Two main shortcomings were identified:

- The time step was too coarse (daily).
- The ROMS simulation is free running (not data assimilating) and hence does not represent the location and timing of EAC meso-scale eddies.

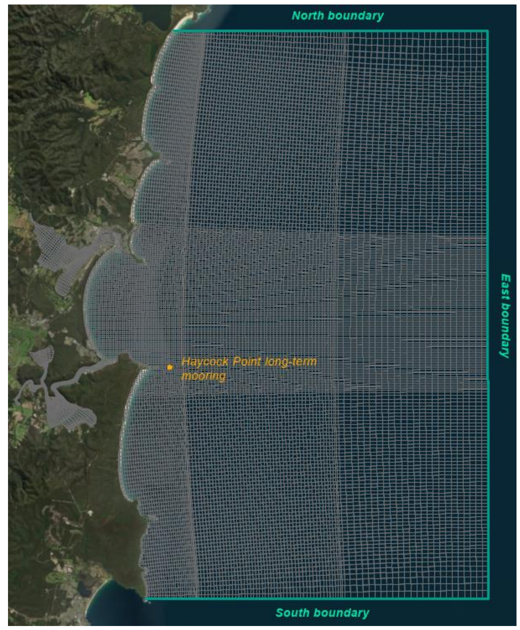

Figure 2 – Numerical model setup

APPROACH AND OUTCOME

In the absence of a deep ocean mooring, an approach to develop prescriptive 2-dimensional design boundary conditions using long-term acoustic doppler current profiler (ADCP) mooring data was devised. Data collected by Manly Hydraulics Laboratory (MHL) at the Haycock Point mooring over 19 months proved invaluable for design boundary conditions and model verification. Fortunately, the mooring was located at a site characterised by near free stream currents despite its near-shore location. Model verification focused on events corresponding to available field ADCP data events. Generally, good agreement was achieved between model and observed water levels and currents.

For one such event on the 11 June 2015, there was good agreement between modelled and observed water levels at Merimbula and Pambula Lake and near-shore Haycock Point. Good agreement was also shown between modelled and observed time series of current speed and direction at Haycock Point (Figure 3). The modelled current speed generally aligns with the depth averaged mooring speed. Additionally, there was a reasonable match between modelled vectors and measured currents along ADCP transects. Although there were some discrepancies in the precise location of flow separation and current magnitudes, the model demonstrates to a reasonable degree the overall spatial dynamics observed in Merimbula Bay.

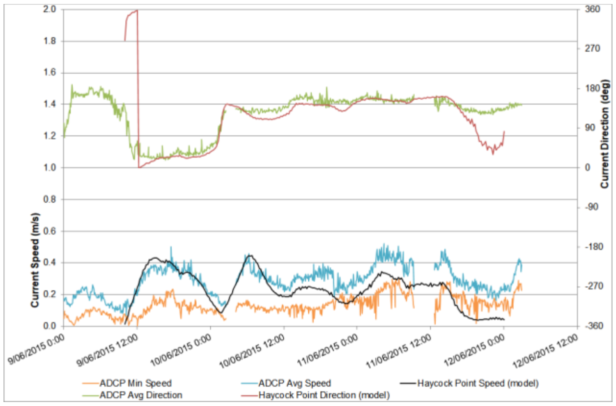

Figure 3 - Haycock Point current speed and direction (model vs observations)

MODEL LIMITATIONS

Limitations of the model and calibration due to the adoption of design boundary conditions include:

- The model is prescriptive and not responsive and largely restricted to simulating known (observed) behaviours.
- Design boundary conditions are not perfectly compatible and as such produce anomalies and instabilities (although restricted away from areas of interest).
- For 2-dimensional model calibration, observational data is simply depth averaged for comparison to model results.
- Design boundary conditions and calibration will include any inherent limitations/errors with observational data (human error, equipment calibration, loss of data requiring interpolation etc.).

KEY CONSIDERATIONS

This study has demonstrated a complication involved in choosing a regional model product for specific event calibration. Projects are subject to timeline and budget constraints, hence the following are suggested key considerations from the outset regarding model boundary conditions and development:

- If adopting boundary conditions from a regional ocean model, consider those models with higher grid resolution, higher temporal inputs and outputs and those that incorporate data assimilation (not just hindcasting).
- Most importantly, if adopting regional ocean model boundary conditions, conduct preliminary simulations to test if the large-scale boundary effects in conjunction with local processes within the coastal model are able to reproduce observations.
- Obtain a deep ocean mooring data set if there is the possibility of adopting a sloping water level algorithm or Elevation Gradient Boundary Condition (EGBC).
- Obtain sufficient high-quality ocean current data (fixed and spatial) for event calibration.

CONCLUSIONS

Numerical models are not an exact science as they approximate very complex processes. However, if the forcing of the model is flawed there is little chance of getting useful results. In developing and verifying this model it became apparent that we could not rely on broad scale regional models to drive processes that occur nearer to shore. Rather a data collection program was required to obtain meaningful boundary conditions that could be used for calibration and development of reference conditions.

The incorporation of data assimilation, as well as higher grid resolutions and improved model physics, will present a greater opportunity to develop representative boundary conditions for future projects. This would nevertheless entail testing of specific event calibration in order to adopt the appropriate product.