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PRELIMINARY FEASIBILITY STUDY FOR THE IMPLEMENTATION OF AN ARTIFICIAL SURF REEF IN ALBANY, WESTERN AUSTRALIA

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INTRODUCTION

An artificial surf reef (ASR) is an engineered structure that alters the natural bathymetry of the area in a specific shape to improve the wave's quality or "surfability" (Rendle & Rodwell, 2014) by enhancing existent swell conditions which promotes recreational activities, particularly surf-based tourism. Several ASRs built in the past have generally been unsuccessful in terms of wave conditions and negatively influencing the local beach morphology and dynamics (erosion, accretion, rip currents). Despite this, the Council of Albany, a city in the South-West of Australia, has proposed an ASR at Middleton Beach (MB), Albany, Western Australia (Figure 1). This decision being due to the positive implications of surfing as a recreational activity that has influenced cultures and enhanced tourism throughout regional communities in Australia. This research is addressed to characterise the physical aspects of the region in order to support a mathematical model with the objective of investigating the feasibility of an ASR at a specific zone of this beach. Therefore, the present study does not intend on determining whether an ASR will work at the determinated location or not.

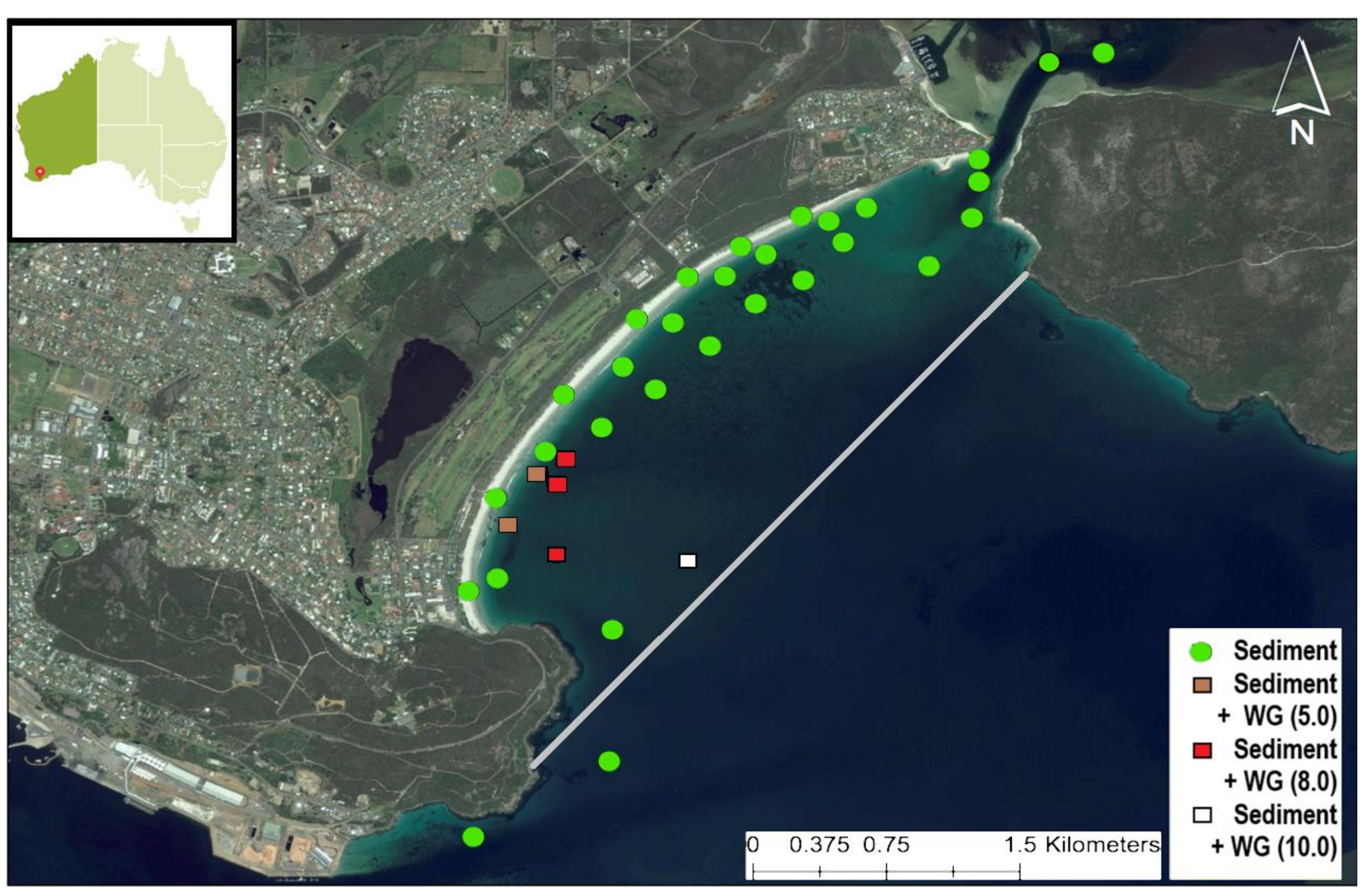

Figure 1. Study site. Location of sediment samples represented by green circles. Brown, red and white squares located at stations where wave gauges were placed at 5, 8 and 10 meters depth, respectively. Modelling boundary limit represented by a grey line.

METHODOLOGY

This research was divided in two study fronts, the first aims to analyse the ASRs applicability whilst the second analyses the possible impacts caused by an ASR on the local environment. A literature review was made to acknowledge potential reef designs to be implemented at MB (Black & Shaw, 2001, van Ettinger, 2005; and Henriquez, 2004; Rendle and Rodwell, 2014). The designs selected were tested using the modelling software Delf3D, using a high resolution grid from the shoreline to approximately 1,3km offshore. Physical parameters (e.g. wave period, height and direction) were obtained by a total of six wave gauges (Figure 1) and from the Bureau of Meteorology (e.g. wind speed and tide). The error of the model was calculated based on wave gauge data and the model's output. Once the model had been validated using wave gauge data, the ASR applicability was performed based on wave parameters.

In order to analyse possible impacts of an ASR in the surrounding area, field work was performed between 9th April and 11th April 2015. Waves with 0.002 to 0.3 Hz are the subject of study in terms of wave surfability. In addition, high precision drifters were launched for around 15 minutes close to Emu Point Channel (EPC), and in the southern portion of MB, where the reef could be constructed. Finally, 37 sediment samples (Figure 1) were obtained from specific sites in order to obtain the sediment's overall distribution and its dynamic process in the study area. 30 samples were collected offshore using a Van Veen grab sampler at different depths and 7 samples along MB and EPC.

RESULTS AND DISCUSSION

An average error of 10.2% was obtained with input parameters such as swell angle of 120 degrees; significant wave height of 0.85m; wave period of 10 sec; and no wind input (analogue to a swell condition). When considering the influence of the wind, the average error increased to >30%. Therefore, the wind parameter was not considered in the modelling process.

Among all ASR shapes tested, the most successful design consisted of two submerged structures separated by one rip channel (Figure 2.a). This reef design reduces rip currents on both sides of the reef. A wave height of 1.5 m (increase of 0.3-0.35 m) is generated (Figure 2.b-c), which provides enough evidence to suggest further research about the use of this design. The reef also produces a left and right breaking wave over the left and right structures. The percentage of the waves breaking over the reef was also analysed. Approximately 30% of the waves with 1 m height would break in the ASR at low tide level (Figure 2.d). This value increased to 60% if waves of 1.5 m height were considered for the same scenario (Figure 2.e).

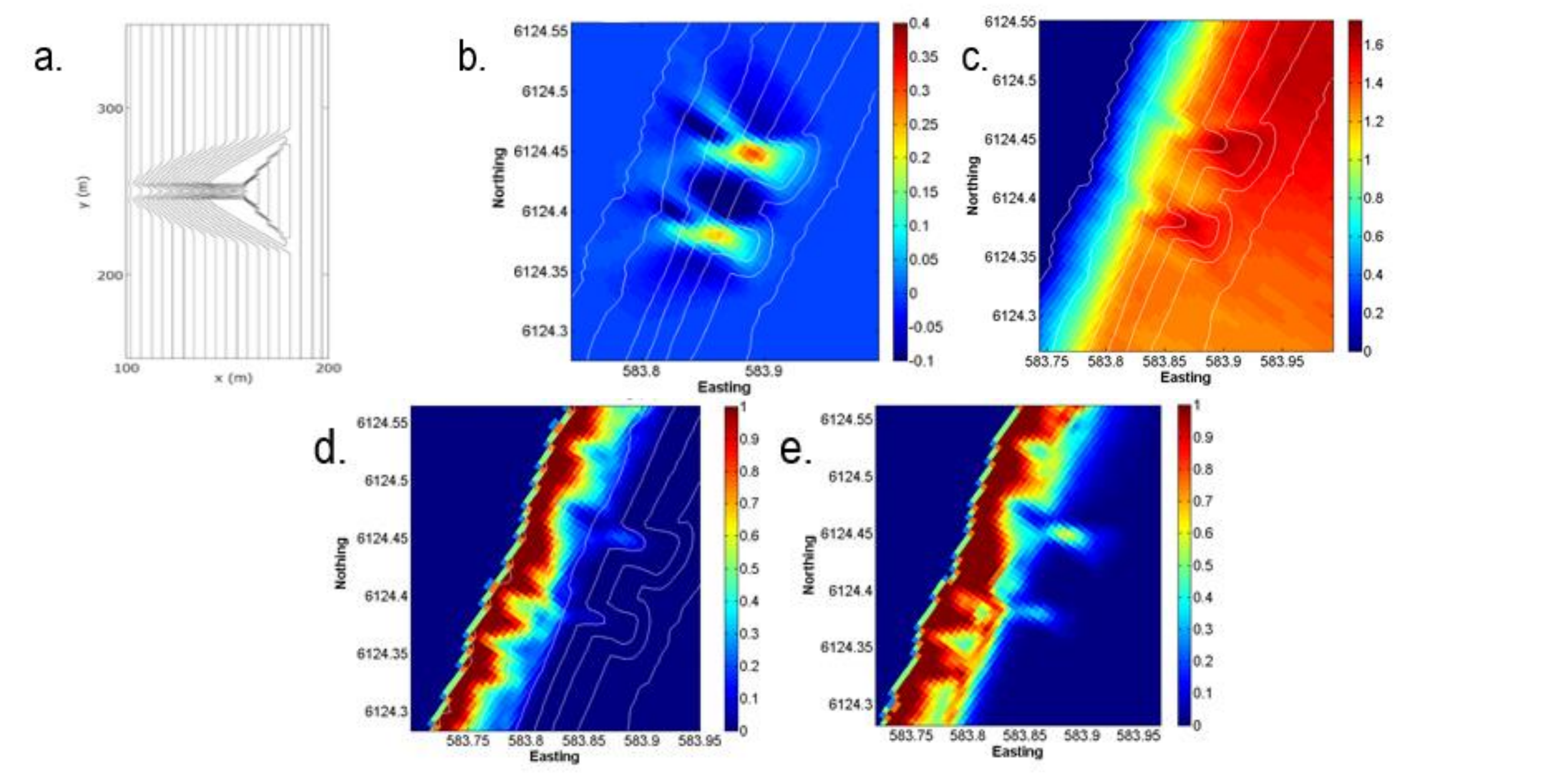

Figure 2. ASR development process. Models's output based on a) ASR design selected. B) increment on the significant wave height, and resultant (c). Fractions of wave breaking above ASR at low tide with 1.0m and 1.5m significant wave height are shown (d and e, respectively).

The drifters flowed southward, reaching velocities of almost 0.5 m/s during ebb tide in the middle of the EPC. During the flood tide, the drifters flowed northward from the mouth of EPC, reaching values of approximately 0.8 m/s. On the other hand, when deployed near the breaking area, drifters flowed southward (northward), reaching velocities close to 0.5 m/s (0.4 m/s), during the ebb (flood) tide.

The drifters were highly influenced by the action of the wind in the breaking area, which is supported by Paterson & Close (2015). The tidal current is dominant only inside the EPC, the wind acts as the principal vector when the channel ends. The pattern observed during ebb tide in the breaking area can be classified as an exception.

Regarding sediment size (not shown), higher values were found in EPC (between 800 and 899 µm). The coarse sand could be found in both sides of the channel opening. As EPC is strongly influenced by tidal currents, an accumulation of suspended sediment has formed ebb and flood deltas. Tidal and wind driven currents cause an oscillatory flow within the channel allowing suspended sediments to be transported alongshore. Along MB, the values vary from 400 to 699 µm (medium to coarse sand). Finer sediment tend to be observed in the shallower areas in which there is increased wave energy, stirring up and suspending sediments with wave movement.

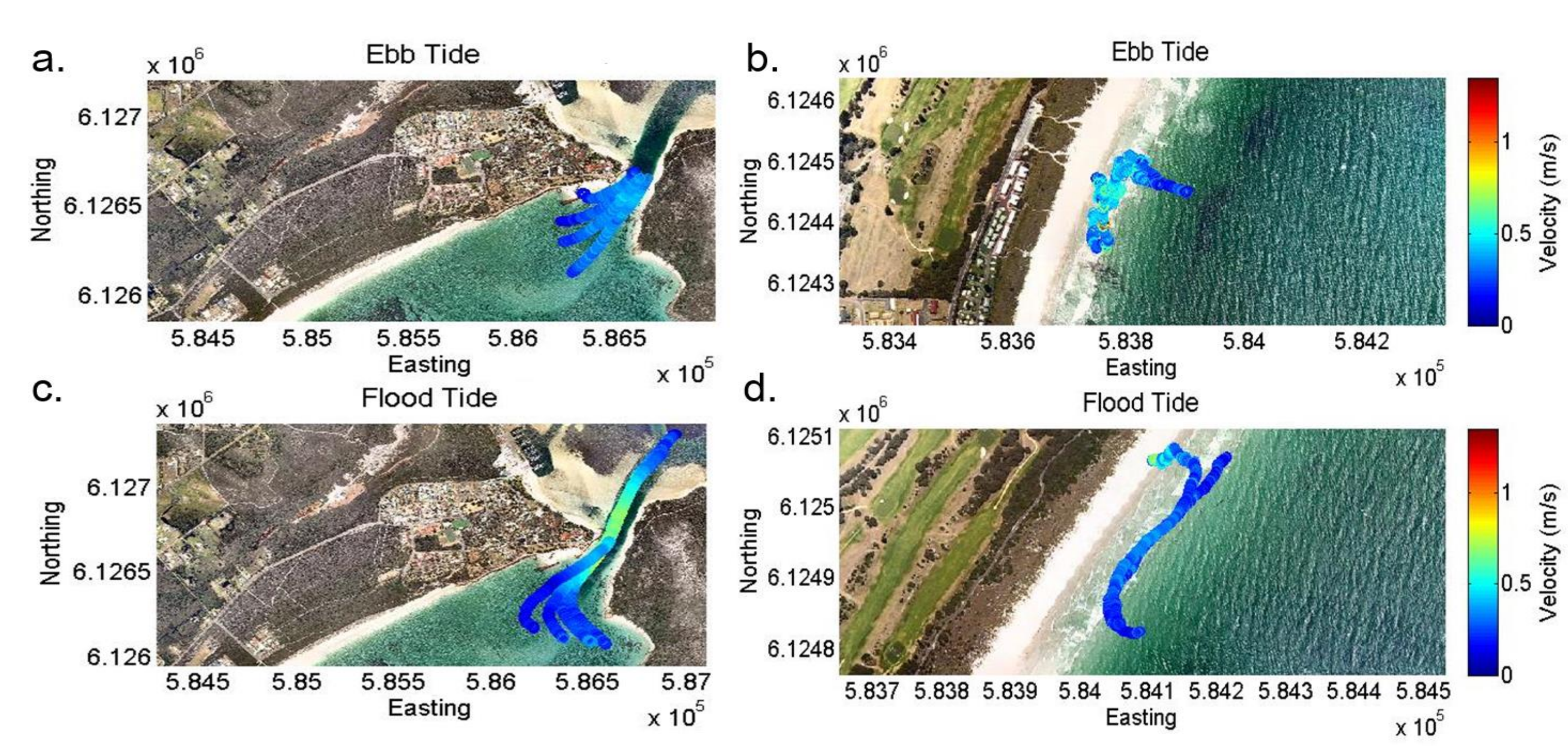

Figure 3 Path of drifters deployed during ebb tide at EPC and MB (a and b). The same occurred at EPC and MB during flood tide (c and d, respectively).

CONCLUSION

The present study obtained a series of positive results with promising reef designs and signs of surfable waves. A baseline study for the physical parameters of the region have also been attained which can be utilised as a comparison in future years to observe the change in local features. Data coverage was the main limiting factor in relation to environmental concerns. The seasonality of the local hydrodynamics and beach morphology cannot be accurately represented in a three day data acquisition period, and the effective features that drive local currents, waves, and transport could also not be identified.

The uncertainties associated with this conclusion are related to a limited methodology, both spatially and temporally. This restricts the importance of this study to a suggestive sphere in which decisions cannot be exclusively based on the data collected. However, its value will be in providing background information to guide future studies in the same region, since the available bibliography is limited for MB. For example, the present study can provide a baseline step in constructing a morphodynamical scenario for MB. This is an essential step because an ASR needs to consider the particularities of each coastal zone.

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