MORPHOLOGICAL RESPONSE OF A REEF-FRONTED BEACH TO SEA LEVEL RISE AND REEF DEGRADATION

Tom Baldock, University of Queensland, t.baldock@uq.edu.au
William Ginzo, University of Queensland and Imperial College, London.

INTRODUCTION

The morphological response of reef-fronted beaches to sea level rise and reef degradation is investigated by physical modelling. Coral barrier and fringing reefs limit the wave energy reaching sandy beaches, providing protection to many communities worldwide (Ferrario et al., 2014). Sea level rise and loss of reef flat elevation through coral mortality are expected to alter water levels over such reefs in the future. Assessing the morphological response to these processes in the field is very difficult due to the timescale involved, and lack of data for current conditions. Numerical modelling of beach profile response is also poor, even for open coast sandy beaches, and there is limited work modelling of reef fronted beaches, although hydrodynamics can be modelled reasonably well (Buckley et al., 2014). Here, new experiments on beach response to rising water levels and reducing reef flat elevation without tides are presented and compared to a conceptual model that links total sediment transport to the wave height landward of the reef (Baldock et al., 2015). A summary of recent numerical modelling of 2D planform changes for the same scenario will also be presented.

WAVE FLUME AND WAVE CONDITIONS

Experiments were conducted in a medium scale 20m long wave flume using random waves and two sand beaches, with initial slopes 1:10 and 1:15, utilising a high resolution 8 channel laser bed profiling system for the overall setup. Grain size was 0.28mm, with a settling velocity ω=0.04m/s. Experiments were conducted with stationary water levels and reducing reef elevation, rising water levels with constant reef elevation. The reef was constructed from sandbags and 20mm thick paving slabs, simulating a smooth degraded reef flat, allowing the reef flat elevation to be varied, figure 1. The lagoon width (reef edge to the shoreline) varied with water level, and was typically 1.5m. Significant wave heights (H) range from 0.1-0.15m, with a wave period (T) of 1s, which is erosive on an unprotected beach with these wave conditions, and with a tide range in the model of 0.05m. Water level over the reef varied from 0.02m-0.14m. Wave heights and water levels offshore, on the reef and in the lagoon were measured with standard wave gauges.

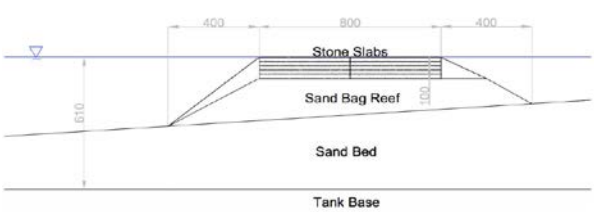

Figure 1. Reef structure and dimensions (mm).

RESULTS

With a constant reef flat elevation and series of rising water levels the shoreline receded in-line with Bruun rule estimates. With a constant water level and lowering reef flat elevation the beach response shows a "reverse Bruun rule" effect, where the setup in the lagoon is decreasing while the wave height in the lagoon is increasing. This leads to accretion of the beach and a maximum in the total shoreward sediment transport. Further reductions in reef crest elevation do not alter the setup, but allow larger waves to impact the beach, reversing the onshore transport and triggering erosion. This process is a function of the relative settling velocity (H/ωT, Gourlay number) inside the lagoon. At the initial reef crest level lagoon waves are small due to strong breaking, with wave height increasing monotonically as the reef crest elevation is lowered. Figure 2 illustrates the total sediment transport as the wave height continually increases, matching the conceptual model proposed by Baldock et al. (2015).

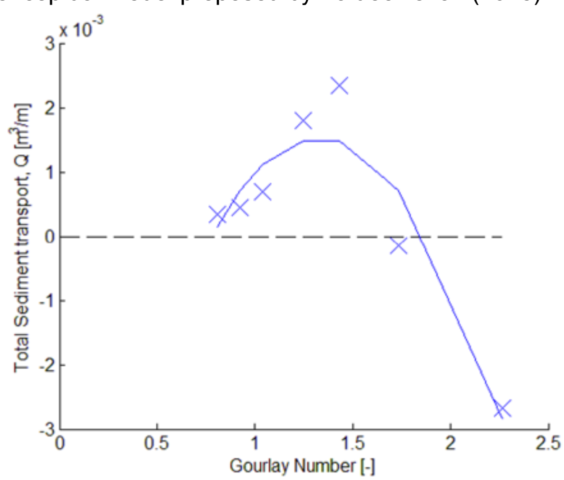

Figure 2. Total bulk sediment transport on the beach face as a function of Gourlay number (cross) and conceptual model (line).

REFERENCES

Baldock, et al. (2015). Impact of sea-level rise on cross-shore sediment transport on fetch-limited barrier reef island beaches under modal and cyclonic conditions. Mar. Poll. Bulletin, 97, 188-198

Buckley, Lowe, & Hansen (2014). Evaluation of nearshore wave models in steep reef environments. Ocean Dynamics, 64(6), 847-862.

Ferrario, et al., (2014). The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Nature Communications, 5.