THE INFLUENCE OF CORAL REEF SPUR AND GROOVE MORPHOLOGY ON WAVE ATTENUATION

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BACKGROUND

Wave energy dissipation on coral reefs provides protection from coastal hazards to over 200 million people globally (Ferrario et al. 2014). The mechanisms of wave energy dissipation over the complex morphologies of the fore-reef slope have typically been overlooked (Duce et al. 2016). Here we focus on wave attenuation by the elongated troughs and depressions typical of fore-reef slopes known as spurs and grooves (SaGs).

QUANTITATIVE MORPHOLOGY OF FORE REEFS

A morphometric analysis of 215 SaGs was undertaken at One Tree Reef of the southern Great Barrier Reef, Australia, using 50 cm resolution LiDAR bathymetry data. Novel methods of morphometric analysis including Fast Fourier Algorithms are applied to define morphometrics in spurs and grooves.

WAVE TRANSFORMATION MODELLING

A numerical model, XBeach, calibrated and validated with field data obtained by Duce et al. (2022) was produced with LiDAR bathymetry (0.5 m res) of the fore-reef and wave data obtained from a 33-year analysis of satellite altimeters accessed via the RADWave package (Smith, et al., 2020). The effects of SaGs on wave energy dissipation are examined under various climate change scenarios to elucidate their role in preventing future coastal hazards. In this paper we present an innovative numerical model of wave transformation on SaGs that directly incorporates remote sensed bathymetry and hydrodynamic data. Our findings suggest SaGs play a critical role in dissipating wave energy, increasing wave dissipation by bed friction by 75%.

CLIMATE CHANGE AND FORE REEF DISSIPATION

The influence of SaGs in dissipating wave energy was reduced under future climate scenarios which incorporate relative sea level rise, loss of reef structural complexity and coral growth rates. Comparing present day scenarios to the year 2100 under representative concentration pathway (RCP) 8.5 results in a decrease in dissipation by bed friction of 48% compared to total wave energy dissipation at exposed sites.

Our results demonstrate that a decrease in wave energy dissipation results in an exponential increase in wave overtopping with storm waves producing overtopping > 3 m under RCP 8.5. Additionally, the high bathymetric gradients in SaGs increase dissipation by wave breaking by up to 52% under RCP 8.5, leading to a 71% increase in mean wave energy dissipation despite an 89% reduction in bed friction factor (f_w) and a 1 m increase in relative sea level.

In summary, under future climate change scenarios, the key mode of wave energy dissipation shifts from bed friction to wave breaking with implications for reef erosion and coral breakage due to increased stresses on the reef (Figure 1). Significant fore-reef morphological adjustment including increased groove development may continue to promote high levels of dissipation in the future. These findings have implications for future wave energy dissipation modelling techniques necessary to assess the future inhabitability of atoll nations and inform adaptation strategies.

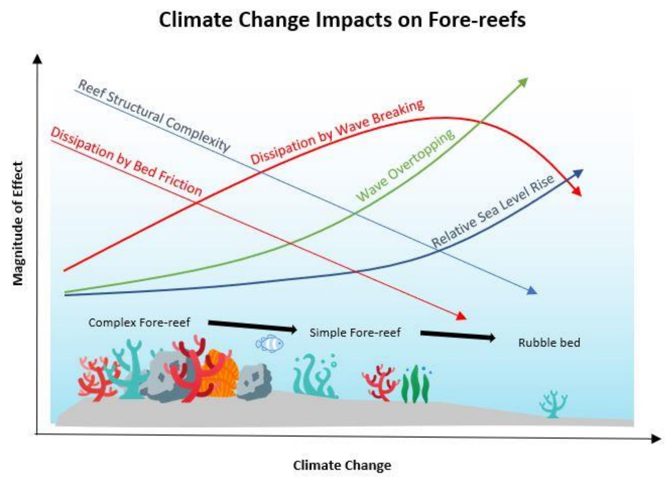

Figure 1 – A conceptual diagram of changes to wave transformation on fore-reefs under increasing climate change impacts.

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