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Reef depth as a robust reef characteristic for intervention planning

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Abstract: The Great Barrier Reef (GBR) is experiencing cumulative stressors and increasingly severe declines in coral cover from thermal stress events. Understanding drivers behind reef resilience to climate impacts is critical for conservation planning and intervention strategies. A scenario-based population modelling approach was adopted with larval connectivity dynamics, thermal adaptation, and environmental factors to assess coral reef resilience across GBR locations under future climate projections.

Time series of reef coral cover was analysed as a proxy for the ability of reefs to maintain positive carbonate production budgets through to 2075 under projected conditions indicated by five Global Climate Models (GCMs) spanning Equilibrium Climate Sensitivities from 2.5°C to 4.66°C (Dixon *et al.*, 2023). The ADRIA-CoralBlox framework (Iwanaga *et al.*, 2023; Ribeiro de Almeida, Tan and Iwanaga, 2025) was used to explore coral population dynamics across 2,429 GBR reefs under 20,480 scenarios under varying environmental and ecological assumptions. Reefs were clustered into Low, Medium, and High categories based on temporal coral cover behaviour using Complexity-Invariant Distance clustering methods (Batista *et al.*, 2014). Random Forest classification was subsequently used to identify reef characteristics that predict cluster assignment.

Partial dependence analysis revealed that reefs with estimated median depths > 10 meters had substantially higher probability of assignment to the High category, with sharp increases in probability between 8 and 12 meters depth. High incoming connectivity enhanced performance of deep reefs (>10m), contrasting with shallow reefs where thermal stress appears too severe for connectivity benefits to manifest. Protective depth refugia, and corals well adapted to associated environmental conditions at those depths, are then necessary for connectivity-mediated recovery processes to be effective under simulated climate conditions. The analysis suggests intervention efforts could benefit from targeting the 8-12 meter depth range where accessibility may remain feasible while substantially improving long-term outcomes.

Despite differences in projected trajectories across climate models, the relative importance of depth remained consistent across scenarios. As depth is a straightforward reef characteristic to assess on location, and the uncertainties present in projecting connectivity patterns across large spatial scales, it is suggested that depth represents a robust reef characteristic of interest for intervention planning under climate uncertainty. These results indicate that depth refugia should be prioritised in intervention strategies to maximize coral survival under continuing climate change.

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