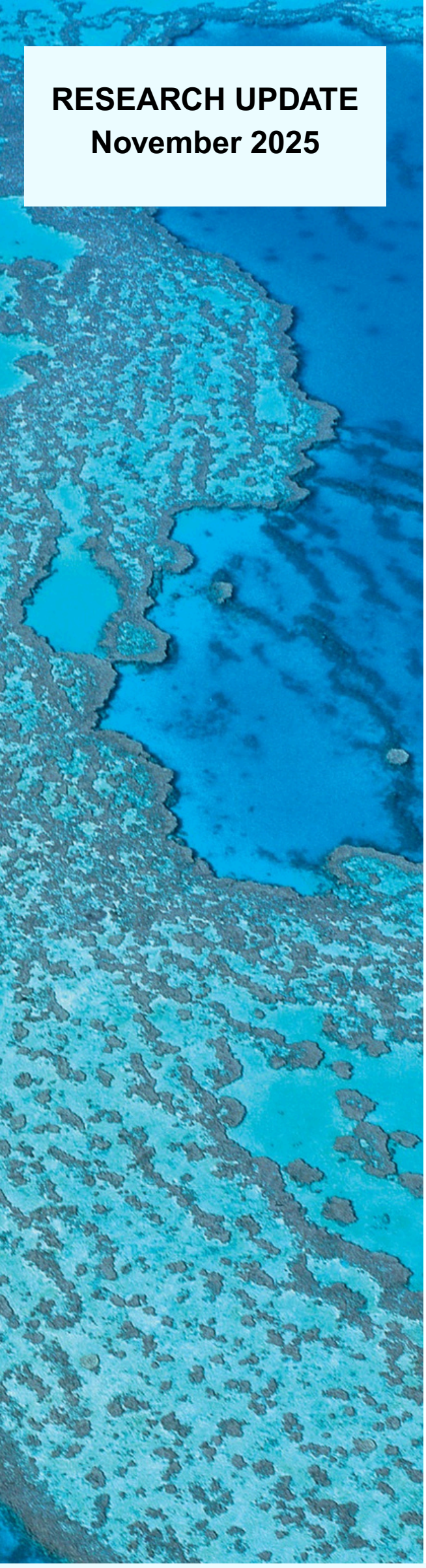

RESEARCH UPDATE
November 2025

Ecological projections of the Great Barrier Reef under an uncertain warming future

A rapidly closing window for coral persistence under global warming

Newly published research uses eco-evolutionary modelling to evaluate how future warming, adaptation, and refugial dynamics interact to influence coral persistence.

Bozec et al. (2025). A rapidly closing window for coral persistence under global warming. *Nature Communications.* DOI: 10.1038/s41467-025-65015-4

The Reef Restoration and Adaptation Program (RRAP) is a research and development collaboration that aims to provide reef managers and decision-makers with novel scientific solutions to help the Great Barrier Reef (GBR) and other coral reefs survive in the decades ahead, as global warming is gradually arrested.

The Program's Modelling and Decision Support (MDS) capability was established to understand the potential benefits, costs, risks, and uncertainties associated with these new management solutions. To help identify strategies that maximise intervention success, the potential impact of intervention must also be considered relative to a baseline, a 'counterfactual', in the absence of any new solution.

RRAP MDS teams used a sophisticated ecosystem model, *ReefMod-GBR*, to explore how corals on the GBR might respond to various future warming scenarios, without the added intervention of RRAP scientific solutions. **This briefing note outlines key insights from these simulations, and recently published research.**

Led by the University of Queensland, the research brings together expertise from across the RRAP partnership.

How the model simulation works

Simulation of multiple coral species across >3,800 reef environments accounting for heat stress (bleaching), cyclones, Crown-of-thorns starfish outbreaks, larval connectivity and recovery processes.

The model uses new methodology to simulate coral adaptation to warming through natural selection, with successive marine heatwaves driving the survival and inheritance of heat-tolerance. Heatwave accuracy is enhanced by refining global climate projections to daily heat stress at 10-km resolution, incorporating local oceanography and bathymetry.

Key Takeaways

Model projections

- Rate of warming is critical: if temperatures rise too quickly, corals may not be able to adapt fast enough to survive.
- Under current emissions pathway (+2.7°C) the model projects that corals on the GBR would become heavily degraded.
- The majority of reefs would have low coral cover (<5%) but some vitality in the system would remain, with some reefs faring considerably better.
- If emissions become worse the model projects collapse of coral populations on the GBR.

Recovery is possible...

- Global adherence to the Paris Agreement's aspiration SSP1-1.9 or SSP1-2.6 (keeping warming below 2°C), is the best-case future for Great Barrier Reef corals.
- If global warming is limited to <2°C, some reefs could partially recover after mid-century, due to the natural adaptive capacity of corals.
- The window for meaningful action is rapidly closing, but coral recovery is still possible if global emissions are reduced and local stressors are addressed and managed.

Insights for Reef Management

Thermal refugia matter
Reefs in thermal refugia, where the water doesn't heat up so dramatically because it is well mixed, fare better than others.

Larval connectivity matters
Better connected reefs, with good access to larval replenishment from elsewhere, are healthier on average.

Management efforts to safeguard these strategic parts of the coral reef network can have a tangible benefit for promoting reef health.

Proactive reef management remains critical even on the current global emissions trajectory.

Model Uncertainties

- This is the most sophisticated coral reef modelling exercise to date, covering most of the key processes driving large-scale reef dynamics, including genetic adaptation.
- All complex ecosystem models are subject to uncertainty and limitations of empirical data, and for this model, outcomes remain uncertain particularly after mid-century.
- Sources of uncertainty include:
  - future temperatures under various emission scenarios
  - adaptive capacity of corals
  - potential effect of temperature on coral growth and reproduction

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Reef Resilience Symposium 2024 Keynote

REEF RESTORATION & ADAPTATION PROGRAM

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