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Connectivity modelling at local scales identifies sources and sinks of coral recruitment within reef clusters

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Abstract: The Great Barrier Reef (GBR) is under pressure from the impacts of climate change and other human activities. The deteriorating health of the GBR has increased the urgency of understanding how this unique ecosystem will respond to future environmental changes. Ocean currents in the GBR transport marine organisms from one site to another, allowing exchange between their populations. The exchange of marine organisms between sites — also known as connectivity — can enable the recovery of populations following disturbances, such as coral bleaching and tropical cyclones. Connectivity also allows genetic mixing between organisms from different populations and the spread of organisms to new reefs, facilitating range expansion. Therefore, connectivity models are also essential for testing the efficacy of interventions proposed to improve the resilience and persistence of the GBR.

Coral larval connectivity is a function of physical connectivity (ocean currents at the time of larval production) and larval behaviour (larval development rates, mortality and settling behaviour). Larval dispersal in the GBR can occur on length scales ranging from metres to hundreds of kilometres. The small size of larvae makes it difficult to physically track their dispersal. However, biophysical models can be used to simulate larval dispersal in either hindcast or projected future conditions. In this study, we used Ocean-Parcels (Delandmeter and Van Sebille 2019), a particle tracking simulator, with 2D velocity outputs from a 200–250 m resolution hydrodynamic-biogeochemical marine model (RECOM — Relocatable Coastal Model; https://research.csiro.au/ereefs/models/models-about/recom/) — nested within a 1 km grid resolution hydrodynamic model of the Great Barrier Reef Marine Park — to simulate the dispersal and settlement of larvae from broadcast spawning corals in the Moore Reef cluster of reefs following the annual mass-spawning in 2015, 2016 and 2017.

Our results identify important source and sink locations for coral larvae within the Moore Reef cluster and highlight the need to consider different environmental conditions when assessing connectivity. Some locations were consistently important across different spawning years and environmental conditions, while other locations were only important in some years. Our findings could help identify reef locations with high potential for interventions within reef clusters. For example, source locations could be important for maintaining coral populations and for the dispersal of offspring (e.g., heat adapted) generated by restoration efforts whereas sinks maybe more resilient to local and global stressors. Understanding local scale connectivity is critical for developing efficient spatial management plans for improving GBR resilience.

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