Functioning of coral reef networks under climate change

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This project aimed to identify regions of Australia's Great Barrier Reef (GBR) most resistant to climate change by combining environmental and larval dispersal models with network theory. Ocean currents transport larvae of marine organisms that inhabit the individual reefs of the GBR, and this influx of larvae helps populations grow and recover. Network models that represent the flow of larvae among the reefs make it possible to identify important reefs that have the capability to replenish large sections of the ecosystem, as well as those that have a higher potential to be replenished, due to their connectivity. These connectivity models can then be combined with disturbance exposure maps to assess the risk faced by and recovery potential of individual reefs. The integrated outputs of these models will therefore highlight reefs that are not only highly connected sources of larvae that can help with the replenishment of areas affected by disturbances, but are also likely to have adult stocks necessary to provide replenishment due to their relatively low exposure to disturbances. The identified larval sources that can facilitate system-wide recovery will therefore be primary targets for conservation, as management efforts can work in synergy with these natural replenishment processes in order to help the GBR recover from large-scale disturbances.

To achieve this, Karlo developed, through collaboration with CSIRO, high resolution numerical models that represent marine larval connectivity across the entire GBR region for a variety of taxa, including habitat-building coral species as well as their predator and a prominent cause of coral cover decline on the GBR, the coral-eating crown-of-thorns starfish (CoTS). Karlo then analysed the obtained connectivity networks in order to identify the most important larval sources that can consistently replenish populations of a diversity of organisms across large portions of the GBR. In order to develop analytical methods suitable for characterising dynamic connectivity typical of marine systems, this work also involved developing and publishing several methodological innovations in both pure and applied aspects of network theory. By estimating the exposure to disturbances like bleaching-inducing thermal stress and CoTS population explosions/outbreaks, Karlo compiled a list of important larval source reefs that are likely to have reduced exposure to the impacts of combined disturbances. This is a key outcome of Karlo's fellowship, as these reefs figure as high priority sites for local conservation actions. This outcome makes it possible to provide an updated set of recommendations for spatial conservation planning on the GBR, which has already attracted attention from the relevant management agencies. A publication with these results has been submitted. The final part of Karlo's work during the Fellowship involved mapping spatial scales of disturbance against predicted spatial scales of connectivity-driven recovery on the GBR in order to estimate the potential for resilience across different GBR regions faced with the disturbance regimes that are becoming increasingly unpredictable due to climate change. A publication with these results in in preparation.

Karlo's work has already attracted attention from key stakeholders, including the Great Barrier Reef Marine Park Authority (GBRMPA) and Queensland Park and Wildlife Service (QPWS) as the agencies responsible for managing the GBR, as well as the pertinent industry bodies such as the Association of Marine Park Tourism Operators (AMPTO). Contacts and collaborative activities with key partners that Karlo established during the Fellowship will be essential for his future research and career. Karlo's work has already been taken up by GBRMPA and QPWS to inform their planning of the management response to the threat of ongoing CoTS outbreaks, and his coral connectivity estimates have been used in GBRMPA's Recovery Plan for the Mackay-Whitsunday-Isaac Reef region of the GBR. Notably, since the GBR is currently in the middle of the major series of CoTS outbreaks, Karlo's network models of CoTS connectivity have been identified by the stakeholders as decision-making tools that can make an immediate impact by informing the management policy. Karlo's work on network analysis in marine systems has also been already incorporated into several ongoing collaborative projects that prominently feature partnership between science and industry, and he has been participating in projects with the National Environmental Science Programme's Tropical Water Quality Hub, Great Barrier Reef Foundation, Queensland Government's Accelerate Partnership, and Gladstone Healthy Harbour Partnership.