INDONESIA DISSERTATION/THESIS PROJECT

IN42 Reach for the stars: coral reef restoration in Indonesia's national parks

Dr Dan Exton | Head of Research | dan.exton@opwall.ac.uk

Increasingly, coral reef research efforts have focused on the need to address the catastrophic loss of corals around the world. Reef building corals are the key ecosystem architects that provide habitat for the many different species that inhabit reef systems. Their loss will significantly impact biodiversity and the ability of a coral reef to support the livelihoods of the many millions of people who depend on them. The Wakatobi, at the heart of the famed coral triangle, has some of the most diverse coral reefs on the planet. But despite still being in good condition, they have not escaped the increasing pressures from overexploitation and damaging fishing practices. It represents the perfect location to trial and test new restoration techniques aimed at actively and aggressively protecting the worlds reefs.

The field of coral reef restoration is relatively new, but most researchers and governments around the world now recognize it to be a key part of the conservation toolkit without which the fate of reefs is in immediate danger. Globally, there have been a number of advances in the field of coral reef restoration, as techniques continue to be refined but much research is urgently required to ensure going forward conservationists are best equipped to make a real difference in protecting these incredibly important systems. By joining this project you will be part of a larger team investigating key aspects of restoration the results of which will help to inform future practices.

Much of the literature makes a clear distinction between the 'restoration' and 'rehabilitation' of coral reef ecosystems, mainly to distinguish between different types of active human interventions. Restoration usually indicates the accelerated recovery of damaged habitats through these interventions, while rehabilitation generally is viewed as the partial replacement of an ecosystem's diminished structural or functional characteristics, or their substitution with alternatives providing more social, economic or ecological value. The semantics of this debate, however, should be seen as secondary to the fact that essentially both approaches aim to bring back healthy coral cover to previously degraded areas of the reef complex.

An increasingly obvious shift in focus over the last decade has seen active restoration transformed into a major conceptual and practical approach in its own right, rather than merely a support act to traditional conservation practices. While it is acknowledged that these traditional forms of passive conservation, such as the removal of local stressors and the creation of Marine Protected Areas (MPAs), are still necessary to ensure the success of restoration efforts, the PhD research being conducted on Hoga Island is centred on the belief that these efforts are not enough to redress the balance and that active restoration is a necessary tool to try and improve and maintain coral reef health in many areas.

The coral restoration programme on Hoga was established following the degradation of complex branching corals on specific sections of the home reef. Corals of opportunity (COPs) have, up to this point, been collected for placement on a mid-water rope nursery to avoid detracting from the

diversity and biomass of coral of the reef as a whole. Collection has focused on small *Acropora* fragments already broken off naturally from parent colonies that likely have limited chance of survival on the unconsolidated rubble slopes. The rope nursery acts as a biomass production system which promotes coral growth from the placed fragments which can then be harvested annually to place back on to the reef. The rate limiting factor in most restoration projects is the actual out-planting, which in the majority of the case has had limited success especially on large sections of mobile coral rubble which are common on many reef systems. A further step in the process is needed in such loose rubble beds and the Operation Wallace team have been working closely with the Mars Sustainable Solutions team to test the success of their reef star structures used to transplant corals on to loose substrata. Currently 15 coral fragments are attached to each reef star and then numerous reef stars are tied together forming a web like structure across the rubble zone. The rubble quickly consolidates, corals firmly attach and growth can be rapid. The environmental setting where reef stars are placed will undoubtedly influence the rates and possibly survival of attached corals however to date this success has not been quantified across different habitats experiencing different environmental conditions. Spreading restoration efforts across different environmental settings is key to decrease the risk that restorations failing in the long term due to stochastic impacts.

Students will have access to Operation Wallacea's unique monitoring data with the aim of investigating how branching coral abundance has changed across reefs and habitats. Researchers will also have access to historical data on the time period and changes in coral fragment size over time on the reef stars and coral nursery. Specific projects can then dive deep in to the detail and could be developed along the themes of investigating the survival and growth rates of *Acropora* sp. fragments transplanted on to the Reef Stars compared to natural conspecific growth from neighbouring areas, or could compare the growth and survival of nursery-reared fragments transplanted on the Stars with that of directly transplanted conspecific COPs, or could examine the implications of placing reef stars in different environments for the successful restoration of corals. This project represents an opportunity to be part of a research team focused on the active conservation of coral reefs using innovative techniques that will inform global practices.

Recommended Reading

Afiq-Rosli L, Huang D, Toh TC, Taira D, Soon C, Ng L (2019) Maximising genetic diversity during coral transplantation from a highly impacted source reef. Conservation Genetics 1–9

Bayraktarov E, Stewart-Sinclair PJ, Brisbane S, Boström-Einarsson L, Saunders MI, Lovelock CE, … Wilson KA (2019) Motivations, success and cost of coral reef restoration. Restoration Ecology rec.12977

Bender M (2018) As nature evolves, so too does MPA management need to evolve. Biodiversity 19(1-2): 131-136

Benjamin CS, Punongbayan AT, dela Cruz DW, Villanueva RD, Baria MVB, Yap HT (2017) Use of Bayesian analysis with individual-based modelling to project outcomes of coral restoration. Restoration Ecology 25(1): 112–122

Boch CA, Morse ANC (2012) Testing the effectiveness of direct propagation techniques for coral restoration of *Acropora* spp. Ecological Engineering 40: 11–17

Cabaitan PC, Yap HT, Gomez ED (2015) Performance of single versus mixed coral species for transplantation to restore degraded reefs. Restoration Ecology 23(4): 349–356

De la Cruz DW, Villanueva RD, Baria MVB (2014) Community-based, low-tech method of restoring a lost thicket of Acropora corals. ICES Journal of Marine Science 71(7): 1866–1875

Edwards AJ, Guest J, Shafir S, Fisk D, Gomez ED, Rinkevich B, … Wells S (2010) Reef Rehabilitation Manual. In: Coral Reef Targeted Research & Capacity Building for Management Program (Vol. 25)

Exton DA, Ahmadia GN, Cullen-Unsworth LC, Jompa J, May D, Rice J, Simonin PW, Unsworth RKF, Smith DJ (2019) Artisanal fish fences pose broad and unexpected threats to the tropical coastal seascape. Nature Communications 10: 2100

Fox HE (2004) Coral recruitment in blasted and unblasted sites in Indonesia: assessing rehabilitation potential. Marine Ecology Progress Series 269(4): 131–139

Fox HE, Harris JL, Darling ES, Ahmadia GN, Estradivari, Razak TB (2019) Rebuilding coral reefs: success (and failure) 16 years after low-cost, low-tech restoration. Restoration Ecology 1–8

Ng CSL, Toh TC, Chou LM (2017) Artificial reefs as a reef restoration strategy in sediment-affected environments: Insights from long-term monitoring. Aquatic Conservation: Marine and Freshwater Ecosystems 27(5): 976–985

Pendleton L, Edwards P (2017) Measuring the human 'so what' of large-scale coral reef loss? Biodiversity 18(1): 13–15

Possingham HP, Bode M, Klein CJ (2015) Optimal conservation outcomes require both restoration and protection. PLoS Biology 13(1): e1002052

Rinkevich B (2005) Conservation of coral reefs through active restoration measures: Recent approaches and last decade progress. Environmental Science and Technology 39(12): 4333–4342

Rinkevich B (2008) Management of coral reefs: We have gone wrong when neglecting active reef restoration. Marine Pollution Bulletin 56(11): 1821–1824

Rinkevich B (2014) Rebuilding coral reefs: does active reef restoration lead to sustainable reefs? Current Opinion in Environmental Sustainability 7: 28–36

Rinkevich B (2015) Climate change and active reef restoration—ways of constructing the "Reefs of Tomorrow." Journal of Marine Science and Engineering 3(1): 111–127

Villanueva RD, Baria MVB, de la Cruz DW (2012) Growth and survivorship of juvenile corals outplanted to degraded reef areas in Bolinao-Anda Reef Complex, Philippines. Marine Biology Research 8(9): 877–884

Williams SL, Sur C, Janetski N, Hollarsmith JA, Rapi S, Barron L, … Mars F (2019) Large-scale coral reef rehabilitation after blast fishing in Indonesia. Restoration Ecology 27(2): 447–456

Yanovski R, Abelson A (2019) Structural complexity enhancement as a potential coral-reef restoration tool. Ecological Engineering 132: 87–93