# Trialling Coral Restoration to Build Resilience

## A Framework for Experimental Research, Co-Design, and Management in the Case of Ningaloo

Great Barrier Reef Foundation

COLUMBIA UNIVERSITY
Center for Resilient Cities and Landscapes

*Trialling Coral Reef Restoration to Build Resilience: A Framework for Experimental Research, Co-Design, and Management in the Case of Ningaloo. Columbia University Center for Resilient Cities and Landscapes, Great Barrier Reef Foundation. April, 2022.*

*Front and Inside Cover Images. Joel Johnsson*

# PROGRAM TEAM

**RESILIENT REEFS INTIATIVE**
Joel Johnsson, Ningaloo Coast Chief Resilience Officer
Amy Armstrong, Director, Resilient Reefs Initiative, Great Barrier Reef Foundation
Sarah Castine, Associate Director, Resilient Reef Initiative, Great Barrier Reef Foundation
Vivian Cumbo, Senior Program Manager, Resilient Reef Initiative, Great Barrier Reef Foundation

**CENTER FOR RESILIENT CITIES AND LANDSCAPES, COLUMBIA UNIVERSITY**
Johanna Lovecchio, Associate Director (Project Lead)
Thaddeus Pawlowski, Managing Director
Alexandra Grant-Hudd, Graduate Research Assistant

**RESILIENT CITIES CATALYST**
Sam Carter, Principal
Shail Joshi, Associate

# CONTRIBUTORS AND ADVISORS

Special thanks to the experts and stakeholders who shared invaluable insights, experiences, and knowledge in the form of case studies, workshop participation, and technical guidance:

**Coral Nurture Program**
Prof. David Suggett

**CSIRO**
Sam Stone-Jovich
Bruce Taylor

**Great Barrier Reef Foundation**
Eliza Glasson
Jennifer Loder
Mel Rodgers
Liz Wren

**Great Barrier Reef Marine Park Authority**
Neil Mattocks

**Gunggandji Traditional Owners**
Brian Murgha

**James Cook University, Dept. of Marine and Aquaculture Sciences**
Dr. Leanne Fernandes

**James Cook University, The Cairns Institute**
Prof. Stewart Lockie

**Mars Sustainable Solutions**
Alicia McArdle
Freda Nicholson

**MER Research & Consulting**
Dr. Margaux Hein

**Reef Restoration and Adaptation Program**
Dr. Ian McLeod
Prof. Peter Mumby
Dr. Cedric Robillot

**University of Miami Rosensteil School of Marine and Atmospheric Science**
Dalton Hesley
Dr. Diego Lirman

**The Nature Conservancy**
Kristen Maize
Dr. Elizabeth Shaver

**Nature Seychelles**
Nirmal Jivan Shah
Luca Saponari
Roshni Yathiraj

**Reef Catchments**
Johnny Gaskell

**Reef Magic Cruises**
Eric Fisher

**Yirrganydji Traditional Owners**
Brian Singleton
Gavin Singleton

# TRIALLING CORAL RESTORATION TO BUILD RESILIENCE

Great Barrier Reef Foundation

COLUMBIA | Center for Resilient Cities and Landscapes

A Framework for Experimental Research, Co-Design, and Management in the Case of Ningaloo

## WHAT IS CORAL REEF RESTORATION?

**Coral reef restoration describes *"an active intervention aimed to assist the recovery of reef structure, function, and key reef species in the face of rising climate and anthropogenic pressures, promoting reef resilience and the sustainable delivery of reef ecosystem service."***[i]

While significant resources are being invested to design and test large-scale adaptation strategies, the majority of restoration projects currently include three main types of smaller scale techniques:

- **Asexual propagation (e.g., coral gardening)**
- **Sexual propagation (e.g., larval seeding)**
- **Substrate manipulation (e.g., rubble stabilisation)**

These techniques are being tested at hundreds of sites worldwide to determine their cost-effectiveness, biophysical outcomes, design and monitoring protocols, and socio-economic benefits.

## WHY CONSIDER IT AS A MANAGEMENT TOOL?

Climate impacts are expected to soon overwhelm the natural recovery and adaptation capacity of reefs. Coral reef **recovery is generally estimated to take 10 - 15 years under ideal conditions** from events like bleaching.[ii] Meanwhile, under current emissions projections, severe bleaching is expected in global reefs **twice-per-decade by 2040.**[iii] Further, **coral adaptation to these risks**, such as through migration or genetic mutations that increase thermal tolerance, is generally estimated to take **20-50 generations (or 100-250 years).**[iv]

**While reef restoration cannot replace climate mitigation**, it can provide **opportunities for reefs to recover** more quickly from disturbances like storm damage, help maintain their **core structure and function**, and potentially provide them **more time to adapt** to changing environmental conditions. Restoration efforts can also **re-activate the ecosystem after degradation** from other stresses, like land-based runoff and heavy visitation, assuming those stresses have been adequately managed.

**Effective restoration efforts have the potential to support reef ecosystems as well as social, economic, management, and cultural outcomes in the communities that depend on them.** A resilient coral reef restoration trial engages all of these dimensions and tests how interventions might support the resilience of people and reef ecosystems in increasingly uncertain times. In so doing, trials inform the complex and critical management decisions that lie ahead.

i Hein MY, Vardi T, Shaver EC, Pioch S, Boström-Einarsson L, Ahmed M, Grimsditch G and McLeod IM (2021) Perspectives on the Use of Coral Reef Restoration as a Strategy to Support and Improve Reef Ecosystem Services. Front. Mar. Sci. 8:618303. doi: 10.3389/fmars.2021.618303

iiEakin, C M., Sweatman, H.P.A. & Brainard, R.E. The 2014–2017 global-scale coral bleaching event: insights and impacts. Coral Reefs 38, 539–545 (2019). https://doi.org/10.1007/s00338-019-01844-2

iii Heron et al. 2017. Impacts of Climate Change on World Heritage Coral Reefs : A First Global Scientific Assessment. Paris, UNESCO World Heritage Centre.

iv Matz MV, Treml EA, Aglyamova GV, Bay LK (2018) Potential and limits for rapid genetic adaptation to warming in a Great Barrier Reef coral. PLoS Genet 14(4): e1007220. https://doi.org/10.1371/journal.pgen.1007220

# KEY LEARNINGS

This Framework offers a set of principles to guide the development of management protocols, engagement strategies, and trial design for managers inclusive of Traditional Owner (TO) joint management bodies and reef managers, researchers and proponents, and thought leaders.

## DESIGNED FOR RESILIENCE

- Trials designed in context of both current conditions and **future climate scenarios and tested over long time scales** may support **long-term adaptation and increase success of future interventions**
- Trials designed **to enhance social, economic, and cultural outcomes** can build resilience in communities in light of increasing uncertainty and risk
- **Adaptive management principles** that underpin trial design, planning, implementation, and monitoring can support **decision-making**

## CLEAR OBJECTIVES

- Trials with a **clear hypotheses and articulated objectives** that inform design and monitoring can increase the chance that **findings build the evidence base for management decisions**
- Trial objectives that are **co-designed with Traditional Owners, stakeholders, partners, and end-users** increase the likelihood of resilience outcomes

## ROBUST RISK ASSESSMENT

- Trials should be **assessed for ecological, socio-economic, and management risks** in order to ensure that they are adequately mitigated
- **Engagement of trials** with a range of stakeholders, partners, end-users, researchers, and managers can **uncover real and perceived ecological, social, political, and economic risks** of trials and future interventions

## STRATEGIC SITE SELECTION

- Site selection should be **coordinated closely with Traditional Owners** to ensure that **traditional knowledge** is incorporated into design and planning and attention is paid to **sacred or culturally significant sites**
- Sites that are **selected in alignment with aspirations of the community, operators, and Traditional Owners partners** have the greatest likelihood of building social resilience
- Trial site selection should be informed by **proximity to other trials** and monitoring sites, current and projected **environmental and climatic conditions**, location-specific conditions related to **technique, scale and logistics** in order to ensure coordinated set of learnings and inform future management decisions

## MEANINGFUL ENGAGEMENT

- Restoration trials offer an opportunity to **build the cultural competency of western scientists** and are vehicles for non-extractive, two-way learning with Traditional Owners whose knowledge has been built over millennia
- **Free Prior Informed Consent (FPIC) should be adequately resourced to address access to benefit sharing and ensure co-production of knowledge and outcomes.** Simply obtaining consent does not necessarily provide benefit to TOs.
- **Researchers should engage managers** early in trial design phase to ensure learnings, site selection, risk management, and engagement processes are coordinated
- Trials should incorporate the goals and values of stakeholders and partners to enhance **social license**, **buy-in** for future interventions, and **funding pathways**
- Trials should seek to **manage expectations of possible successes and failures to build a culture learning** between managers, Traditional Owners, stakeholders, end-users, and partners
- Stakeholders and Traditional Owner partners engaged early in planning processes are best positioned to **co-design education, implementation, and stewardship activities**
- Engagement and communications of planning and outcomes should be **timely, appropriate, inclusive, and transparent** in order to build trust

## INTEGRATED ASSESSMENT AND LICENSING

- Trials that are evaluated across the **stages of design, planning, implementation, monitoring and evaluation, and post-trial** increase the chances that **risks are mitigated**
- Evaluation for resilience-based design offers opportunity to **maximise the ecological, social, economic, and cultural benefits** of trials
- Approval and licensure of any one trial should be made in relation to the objectives, sites, scales, and techniques of other trials to **ensure a mix of techniques, minimise undesirable interactions or confounding effects among trials, and maximize learnings**


## PROGRAM PARTNERS

### RESILIENCE ACCELERATOR PROGRAM

The Resilience Accelerator (the Accelerator) is a program of the Center for Resilient Cities and Landscapes (CRCL) at Columbia University. The Accelerator works with partners to build capacity for climate resilience and adaptation. The program generates investment opportunities; deepens relationships between local government and community leaders, researchers, and practitioners; and advances climate actions that center natural systems and social justice. Since the launch of the program in Spring 2018, the Resilience Accelerator has partnered with:

- 17 local site partners (national, state, and municipal governments)
- Researchers and educators across 8 academic institutions globally
- Global programs including WWF Natural Capital Project, 100 Resilient Cities, and the Resilient Reefs Initiative
- Hundreds of students, faculty, practitioners, and expert facilitators

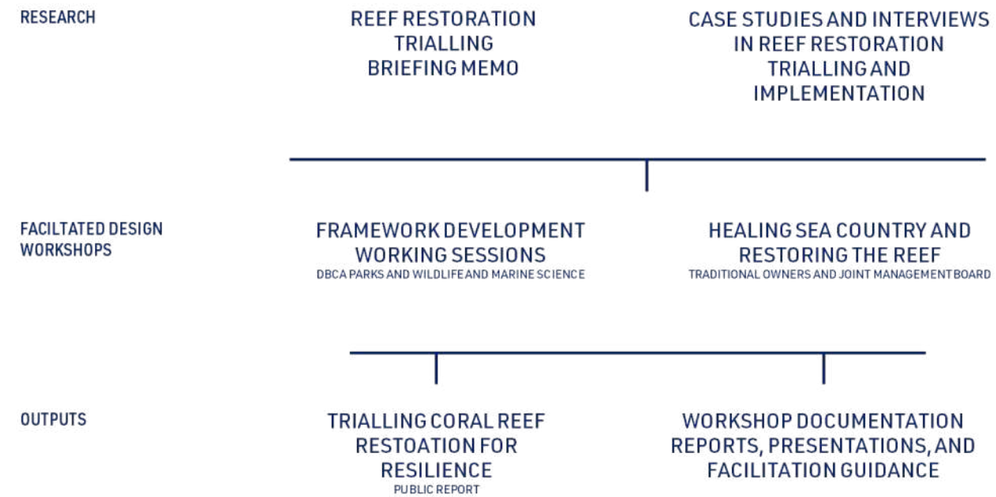
Multidisciplinary expertise from Columbia, when matched with local knowledge and relationships, advances place-based and transformative projects using two key methods:

- **Research, Preparation, and Constituency Building**: Delivering synthetic research, analyses, visualization of risk and vulnerability, and design support
- **Workshop Leadership and Facilitation:** Facilitating workshops that convene multi-disciplinary teams to advance strategy, project design, and implementation

These methods culminate in key outputs and outcomes at the local level. They include, for example pilot project concepts and funding proposals, workshop documentation, public and press attention, policy and decision-making frameworks, advocacy collateral, project term sheets, and training materials.

### RESILIENT REEFS INITIATIVE

The Resilient Reefs Initiative is partnering with communities across four World Heritage Reef Sites to respond to climate change and local threats. Established by the Great Barrier Reef Foundation, this six-year, $AUD14 million program is a collaboration with The Nature Conservancy's Reef Resilience Network, Columbia University's Center for Resilient Cities and Landscapes, Resilient Cities Catalyst, UNESCO, and AECOM. The program is enabled by the BHP Foundation.




## ACCELERATOR PROCESS IN NINGALOO

As a part of the Accelerator program, the Ningaloo Coast Chief Resilience Officer, the Great Barrier Reef Foundation, and the Center for Resilient Cities and Landscapes *(the Accelerator Team*) worked together to develop this Framework. It is informed by facilitated discussions with managers; a review of global practices as they relate to the ecological, socio-economic, and governance contexts in Ningaloo; and a workshop with Traditional Owners and Joint Managers: *Healing Sea Country and Restoring the Reef: Workshop with Traditional Owners at Ningaloo (Appendix I)*.

This resulting output, *Trialling Coral Restoration to Build Resilience: A Framework for Experimental Research, Co-Design, and Management in the Case of Ningaloo* (hereafter referred to as *the Framework* or *Framework for Trialling Coral Restoration to Build Resilience*), while generally applicable to similar reef sites around the world, is strongly grounded in the particular context, challenges, management approaches and opportunities at Ningaloo. Each case study, for example, explores implementation learnings as they relate to a set of core objectives for restoration trialling: Safely and methodically trialling new techniques, engaging with the community, learning alongside Traditional Owners, and supporting livelihoods of tourism operators.

*Image. Joel Johnsson*

# CONTENTS

*Image: Joel Johnsson*

# 1 INTRODUCTION

**Coral reefs are a critical asset to our global ecosystem and the communities and economies that rely on them. Around the world, 500 million people rely on reefs for food, coastal protection, and livelihoods with nearly 30 percent providing the tourism sector with $36 billion (USD).**[1] Reefs are also natural protective infrastructure against coastal storms, with the capacity to attenuate up to 97 percent of incoming wave energy.[2] Recent estimates have found that the loss of 1 metre of height of a healthy reef can double financial losses on the land, damage the tourism industry, and increase beach erosion.[3]

**Protection of coral reefs is critical for biodiversity, ecosystem function, infrastructure, livelihoods, the wellbeing of coastal communities, and our global food supply.** However, climate change impacts like ocean warming and marine heatwaves, which are having the greatest impact on coral reefs, as well as sea level rise, increasing intensity and frequency of coastal storms and flooding, and ocean acidification present significant risks and challenges for management agencies. Local pressures such as agricultural runoff, overuse of tourism, invasive species and disease, and overfishing, may further inhibit reef's natural capacity to adapt and recover from extreme events like storms or marine heatwaves. As the impacts of climate change and local pressures on reefs and coastal communities intensify, managers require a broad spectrum of tools to support the resistance, recovery, and resilience of reef ecosystems and the communities which depend on them.

**As climate impacts accelerate, natural adaptation is anticipated to be insufficient to ensure coral and reef ecosystem survival.** Natural adaptation of corals depends on the rate of genetic evolution and the rate of spread of that evolution among populations.[4] And while some corals have the capacity to migrate and adapt to new temperature regimes under gradual climate warming, recent experiments suggest that it can take 100-250 years (or 50 coral generations) to do so. Meanwhile, severe bleaching events are expected twice-per-decade in global reefs by the 2040s.[5] Increasing frequency and severity of extreme events, such as bleaching or cyclones, makes adaptation an even greater challenge.[6] Between the 1980's and 2016, bleaching events have become five times more frequent, with the average reef being affected once every six years. This hampers the ability of a reef to naturally recover and adapt before the next bleaching event occurs.[7]

**Coral restoration is being trialled and tested around the world as a tool to build resilience and assist recovery where natural recovery and adaptation is no longer possible**. Coral restoration describes an active intervention that "assists with the recovery of reef structure, function, and key reef species in the face of climate and anthropogenic pressures, therefore promoting reef resilience and the sustainable delivery or reef ecosystem services." [8] Restoration interventions that assist reefs in adaptation (as well as recovery) are also being tested and piloted globally. Early learnings suggest that the recovery of damaged or degraded coral reef sites can be enhanced with a variety of techniques and methods.

| | |
|---|---|
| **TRIAL** | **An experiment that identifies new techniques or innovates on existing methods to test restoration goals** |
| **TRIAL FRAMEWORK** | **Goals, objectives, and expectations, and protocols that guide the design, engagement, implementation, and policy related to multiple trials and ensure collective learning and supported decision-making** |
| **RESTORATION INTERVENTION** | **An action implemented for the specific and primary purpose of restoring ecological function and condition** |

**Trialling restoration presents an opportunity to test and optimise the design and implementation of potential restoration interventions within a particular ecological context at a given site, while also enhancing socio-economic resilience and adaptive governance.** Restoration trialling is one vehicle for managers to engage with community and historically marginalized people and knowledge, such as Traditional and Indigenous Owners, in co-producing research, co-designing projects, and jointly implementing future management interventions. The most effective and successful cases of coral restoration are those that have deeply engaged with stakeholders and partners and have integrated governmental agency management, academic research, community activism, local businesses and tourism operators, and Traditional Owners with private and philanthropic interests.

**To test applications of a new, but rapidly advancing field, Ningaloo Reef in Australia serves as a test case for how the latest research and practices might inform a set of restoration trialling principles and support preparation for the future management decisions that lay ahead.** In some parts of the world, like the Great Barrier Reef and the Caribbean, restoration has advanced quickly and in reaction to catastrophic bleaching, stony coral tissue loss disease, and other stressors. In others, like Ningaloo, where the reef is still relatively healthy, the question becomes: How might we anticipate future losses and be prepared for them with a robust decision-making framework that may include restoration in a suite of management tools?

**Furthermore, without a comprehensive strategy, management agencies risk future decisions that are ad hoc and reactionary; technically or geographically inappropriate to site conditions; inappropriate for projected future climate conditions, recovery capacity, and genetic diversity of the reef; ecologically, socially, and economically risky; inefficient in terms of labour and resources; and unresponsive to the needs, histories, aspirations, and values of Traditional Owners.** Lack of coordination and integrated planning can also result in a lack of standardised measurement, drive misperceptions and negative media coverage about the state of the reef, expose management agencies to the consequences of unmanaged expectations, and fail to capture opportunities for partnership across key stakeholders and partners, including philanthropic and private funders.

**This Framework can be used to set expectations about design, implementation, and coordination of trials internally and externally to a management agency.** Furthermore, it can be used by community members, Traditional Owners, tourism operators, researchers, and funders seeking to advocate for, set expectations around, and co-design restoration research and trialling efforts. It might be used for example, to:

- Begin conversations between the managers and multiple scales of government involved in policy-making and operations impacting the reef
- Inform and understand perspectives, expectations, understanding, and positions about restoration and trialling amongst a range of stakeholders
- Co-produce research, evaluation, design, implementation, and measurement strategies with Traditional Owners Guide decision-making and licensing assessments with project proponents
- Proactively develop restoration trialling procedures or policies

**This document is intended to inform an ongoing discussion around these principles and support of reef managers, communities, local partners, Traditional Owners, operators, and researchers around the world in their pursuit of a coordinated, transparent, and meaningfully engaged approach to coral restoration planning. These efforts can together drive ecological, social, and economic outcomes and resilience to shocks and stresses on the reef, on land, and in communities.** The opportunity at Ningaloo and in sites grappling with these same complex decisions is to plan well and learn through experimentation. Together, robust and equitable decision-making frameworks can be in place before the decline in coral cover and health accelerates faster than reefs themselves can recover in our lifetimes.

*Image. Rescue a Reef, Gammon Koval*

# 2 CORAL REEF RESTORATION FOR RESILIENCE

## WHAT IS CORAL RESTORATION?

**Coral restoration describes an active intervention that "*assists with the recovery of reef structure, function, and key reef species in the face of climate and anthropogenic pressures, therefore promoting reef resilience and the sustainable delivery of reef ecosystem services*"**[9]

This document explores recovery of damaged or degraded coral reef sites that can be enhanced with a variety of not mutually exclusive techniques and methods, including the following:[10, 11]

**ASEXUAL PROPAGATION**

- ***Direct transplantation*** of coral colonies or fragments without a nursery phase.
- ***Coral gardening***, involving transplanting of colonies or fragments with a nursery phase either in the ocean or aquaria. Can also include Assisted Gene Flow (AGF) among populations of the same species.

**SEXUAL PROPAGATION**

- ***Larval propagation*** achieved through collection and holding of larvae and subsequent deployment to a restoration site.

**SUBSTRATE MANIPULATION**

- ***Substrate additions*** such as artificial reefs which support coral settlement and recruitment.
- ***Substrate manipulation,*** *such as stabilisation of rubble or algae removal.*
- ***Re-orienting corals,*** *such as overturning (righting) corals that have been upended by cyclones.*



While this effort focuses on restoration, interventions which encourage mitigation and adaptation are also emerging among the suite of options and management decisions. These efforts aim to strengthen coral resilience to particular stressors, and include techniques such as assisted gene flow to establish heat resistant species (e.g., lab-grown corals that address physiology, genetics, and epidemiology).* Large-scale mitigation, such as reef scale cooling and shading through cloud brightening or surface films, are also being tested. The *Reef Restoration and Adaptation Program (RRAP),* for example, is testing these methods at-scale and is explored in *Section 4: Perspectives from Global Practice.*

**"This approach aims to enhance the spread of naturally warm-adapted genes [across the Great Barrier Reef]to buffer populations on cooler reefs against continued warming and bleaching. The success of this approach relies on pre-existing genes for local temperature adaptation and parental transmission ("heritability") of temperature tolerance."*
*Australian Institute for Marine Science. https://www.aims.gov.au/reef-recovery/assisted-evolution*

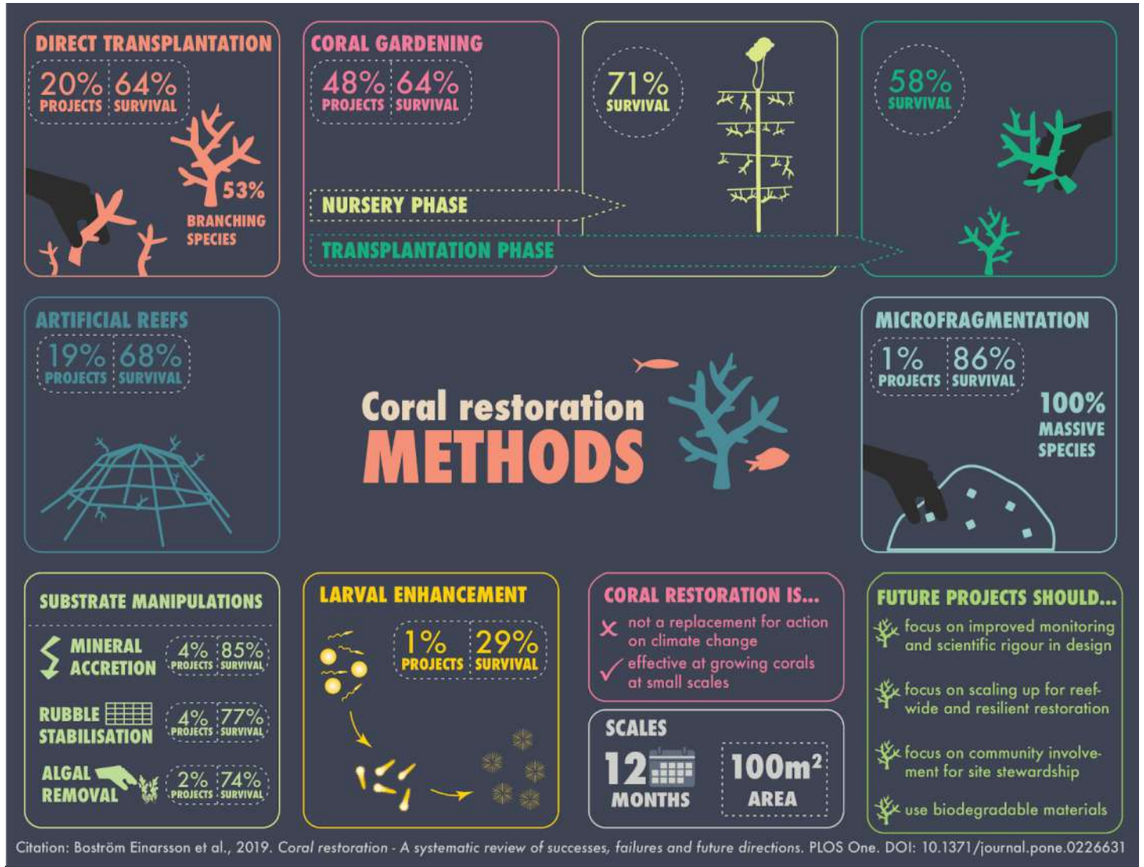
## WHERE HAS IT BEEN PRACTICED?

Coral restoration is being trialled and implemented globally. In the Caribbean, Mesoamerica, Florida, and the Great Barrier Reef, trials and active management interventions are underway in response to decades of damage and widespread losses of coral cover. Restoration as an area of research and practice is growing rapidly around the world as climate change impacts accelerate and stresses on reef ecosystems, like urban development and agricultural runoff, undermine their survival

A recent comprehensive and global review of **362 case studies** derived from primary literature, grey literature (e.g., scientific reports and technical summaries), online descriptions, and an online survey targeting practitioners identified that:[12]

- Restoration projects are occurring in **56 countries** (40% of which were in the USA, Philippines, Thailand, and Indonesia)
- Most projects utilise a **range of intervention methods** (asexual propagation, sexual propagation, and substratum enhancement), with transplantation being the most common
- A diverse range of species are being restored, with **229 different species** from **72 genera**
- **72 percent** reported using more than one coral species in projects
- **59 percent focus on fast-growing branching corals**, and the top five species include *Acropora cervicornis*, *Pocillopora damicornis, Stylophora pistillata, A. palmata, and Porites cylindrica*


*Image. Location of coral restoration studies in Bostrom-Einarrson et al. 2020. Studies were from scientific literature, grey literature and survey responses. doi: https://doi.org/10.1371/journal.pone.0226631.g001*




**Access the updated 2020 article, database, and visualization HERE**

*Image. Infographic derived from Bostrom, L., et al. 2019 highlighting average coral survival for different restoration methods. Average survival was calculated across an array of unstandardized studies, over a median monitoring time of 12 months, and median area of 100m2. Data was extracted from 329 restoration projects, and the percentage of project using a specific method are indicated. It is important to note that a mismatch between relatively short monitoring times and the temporal scale at which disturbances occur may artificially inflate the growth or survival rate. Graphic accessed through http://www.lisa-bostrom-einarsson.com/publications, April 2022.*

## HOW IS SUCCESS MEASURED?

**Restoration has been demonstrated to effectively increase coral cover around the world at localised-scales (e.g, generally from 10's - 100's sq. m) over generally and relatively short time frames.** A recent review of projects found coral cover and structural complexity were consistently greater at restored sites when compared with unrestored sites, but changes in diversity, recruitment, and coral health (healthy, diseased, and/or showing signs of predation) were highly variable, depending on experimental design.[13] This highlights that **the effectiveness of coral restoration is dependent on clear management objectives, appropriate design and technique selective relative to the site specific conditions, and standardised metrics of success.**

Based on a global review of cases, the above rates of survival of restoration actions have been found to have the following percent survival over a median restored area of 100m² over a median project length of 12 months. These results do not measure outcomes of adaptation or mitigation measures.

***"While these authors reported this event in their publication, other practitioners may not know a major mortality event occurred if it happened after the project monitoring ceased, or have little incentive to publish a failed experiment. We argue that short monitoring times are problematic and may inflate the apparent survival rates of corals, as the likelihood of significant stress events causing mortality should increase over time. While there was no evidence of survival declining with increasing length of studies in the data, this could reflect the relatively low numbers of studies exceeding 12 months of monitoring."[16]***

**FRAGMENTS OF HOPE, BELIZE**
Replenishment Sites, In-Situ Nurseries

- **82,000 corals planted**
- **Increased Acroporidae corals from 6% to 50%**
- **Survival rate of 89% after 13 years**
- **23 in situ nurseries**
- **26 in-water nurseries across 7 MPAs**
- **70 local Belizeans trained**

**Restoring Coral Reefs: Guidelines, Best Practices and Success Stories, ICRI, June 11 2021**

**While it's important to highlight success and contributing factors, failures are as important to balance expectations,** increase the chance of a successful outcome, and inform future decisions. One study, recognizing high post-settlement mortality or larval seeding onto denuded substrate, explored two potential strategies to mitigate losses including choosing more favourable substrate and caging of settled spat. Ultimately, these approaches did not significantly influence high mortality rates, underscoring a need to identify mortality factors to guide decision-making around techniques.[14] In another example, three years following the implementation of an artificial reef in Indonesia, coral cover, diversity, and fish abundance all improved.[15] Then, 6 months following the conclusion of the study, nearly 100 percent of these corals died following heat stress that caused coral bleaching.

**Cases like this inform two important learnings as it relates to outcomes and decision-making.** First, it's important to choose genetically diverse, temperature resistant coral fragments during the establishment period of the project because these will increase the resilience of the coral community to bleaching and should result in the propagation of temperature resistant recruits. Second, local restoration projects, while serving an increasingly important role in management, are sometimes no match to large scale temperature anomalies caused by climate change. Expectations must be therefore set accordingly.

**While survival over short time frames is the most commonly reported indicator of success, the social and economic costs and benefits of restoration projects at any scale are rarely assessed.[17] Future research should therefore monitor coral survival relative to suitable controls over longer time frames, consider all costs and benefits for both small and large scale project.** Taken together, standardisation of reporting metrics, reporting time frames, and spatial scales that capture both the biophysical indicators of projects as well as their social and economic costs and benefits is increasingly important to inform applications and advancement of the field and reliability of restoration as an effective tool.

*Image. Belize Fragments of Hope*

**CORAL REEF RESTORATION TRAINING COURSE**
Reef Resilience Network

This course is designed to provide coral reef managers and practitioners with best practice guidance for common coral reef restoration techniques. This course includes six lessons that discuss strategic planning and decision-making for coral restoration, enhancing coral populations through gardening and larval propagation, restoring reef structure for coastal protection services, rapid restoration response after acute disturbances, and monitoring for restoration success. A new update will include seven lessons on land-based nurseries.

Coral Reef Restoration Training

# WHEN SHOULD CORAL RESTORATION BE USED (OR NOT USED)? WHAT IF THE CAUSE OF DEGRADATION IS STILL OCCURING?

Traditionally, restoration is used to assist ecosystems to recover from disaster events, or when stressors (such as ship groundings, pollution, or nitrogen loading) have been removed. In these circumstances, restoration is not intended to be an ongoing activity for the maintenance of that ecosystem, but instead used to return the ecosystem quickly to a more desirable and stable state. However, in the face of accelerating climate change and its impacts, restoration may also be used to 'buy time' for coral to adapt to changing conditions.

Restoration is generally cost and labour intensive, and therefore effective at relatively small scales. It is typically practical for localised sites that have high ecological, recreational, or commercial value. This might include focusing efforts in a critical area of reef that is the source of coral larvae for other reefs in the area or high-value tourism sites. It is also a tool to support areas where coral recruitment is limited and disturbances can be mitigated. In doing so, restoration may support the following outcomes, for example:[18]

| SOCIAL, CULTURAL, ECONOMIC | ECOLOGICAL | DISTURBANCE-DRIVEN |
|---|---|---|
| • Sustain or enhance local tourism and livelihoods<br>• Preserve high-value areas<br>• Promote local stewardship<br>• Preserve critical ecosystem services (e.g., coastal protection)<br>• Protect culturally and spiritually significant sites | • Re-establish reef ecosystem function and structure<br>• Mitigate population decline<br>• Prevent species extinction<br>• Assist migration of species to new locations<br>• Improve genetic diversity and potential to adapt to climate change (through thermal tolerance or disease prevention) | • Respond to disturbances, (e.g., storms, predator outbreaks, ship groundings)<br>• Mitigate anticipate coral loss prior to disturbance |

*Examples of General Restoration Goals. Adapted from: Shaver E C, et al., 2020. A Manager's Guide to Coral Reef Restoration Planning and Design. NOAA Coral Reef Conservation Program. NOAA Technical Memorandum CRCP 36, 128 pp.*

**LARGE SPATIAL SCALE OUT PLANTING, OKINAWA, JAPAN**

A combination of asexual reproduction, fragment propagation and sexual inoculation at scale

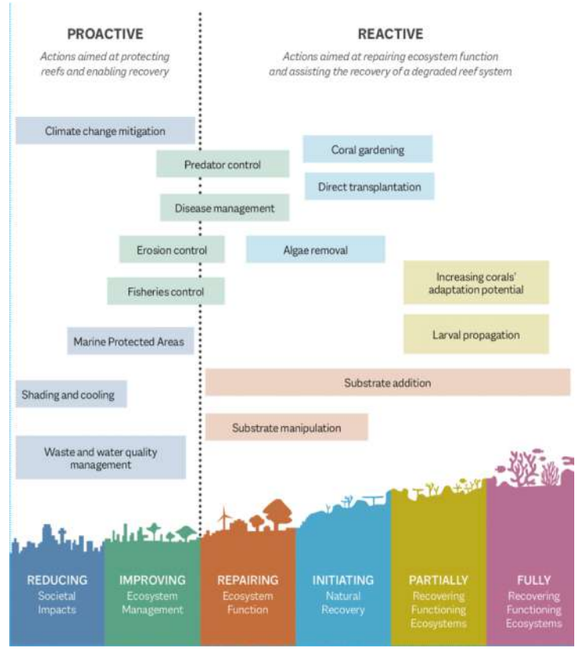
- 20,000 colonies of 50 species planted in 20 years
- 50-80% survival rate
- Low cost of <$20/colony
- Maintained genetic diversity and avoided disturbances
- Methodology carried out by local fisherman, citizens, businesses, and governments

Restoring Coral Reefs: Guidelines, Best Practices and Success Stories, ICRI, June 11 2021

*Image. Yuna Zayasu*

One of the key challenges posed by anthropogenic climate change is the speed at which change is occurring. Coral are extremely adaptable and resilient organisms, and reefs in the distant past have successfully weathered significant changes in sea level and water temperatures. However, in the past, these changes occurred over hundreds, or even thousands, of years, giving these slow-growing corals time to evolve and migrate. The pace of change that is driven by anthropogenic climate change is highly accelerated in that changes that took thousands of years are now predicted to occur within decades. Scientists are concerned that corals won't have sufficient time to adapt, evolve, and relocate.

**Restoration is only appropriate as a part of a broader management strategy that reduces impacts from other stresses, like climate change, on the reef. It should only be considered once threats have been identified and mitigations strategies actioned.** Restoration interventions, themselves not a solution on their own, must be integrated on a continuum of strategies that also address local stressors, like water quality management.




*Continuum of Actions Coral Conservation and Restoration Strategies. (Hein, MY. et al., UNEP 2021)*

The reality is that many managers are forced to intervene to support the survival of reefs and ecosystem function in the short- and medium- terms before climate action and emission reductions catch up, reef stressors are managed and mitigated, and repeated and robust experimental methods create certainty around use. In this respect, **restoration can be utilised to manage transition as part of an adaptive management framework,** rather than attaining a pre-disturbance steady-state. While restoration will not return reef ecosystems to their original state in the face of climate change, it may still support retaining values at acceptable levels as adaptation and evolutionary processes progress or until more sustainable interventions are developed. One recent study found that interventions could extend survival of the Great Barrier Reef by at least one- to two- decades in the face of climate change by modelling interventions including reduction of flood plume impacts, mitigation of CoTS, restoration through rubble stabilisation, management of solar radiation (cloud brightening), and introduction of heat tolerant corals.[19] Furthermore, restoration action can and must account for climate change especially as it relates to design and site selection. For example, siting restoration in areas of lower vulnerability to bleaching or cyclone damage (i.e., 'refugia'), selection of coral species for genetic diversity and thermal tolerance, or selection and placement of materials and structures that can withstand and protect corals from storm or thermal events.

**Restoration will not address the underlying cause of reef degradation**. The long-term survival of coral reefs depends upon significant and rapid declines in global emissions and the adaptation of corals to changed environmental conditions. **While it is absolutely essential to see action on climate change, reefs can no longer wait.** Though stressors (e.g., warming water temperatures) are still occurring, restoration may support maintainance of the survival of reefs for long enough to allow natural or assisted adaptation and evolution to occur. In areas such as the Great Barrier Reef, which has already lost over 50 percent live coral cover as a result of 2016 and 2017 mass bleaching events, and where there is significant local, national and international pressure for managers to respond, **restoration could be the most powerful management tool currently available to buy time while corals adapt to changing climate conditions, mitigation is implemented, and adaptation techniques are tested**.

***Localised vs. broad-scale restoration:*** Broad-scale restoration (i.e., restoring entire reef systems) has not yet been demonstrated to be viable, due to the high cost and effort required. However, **localised restoration can be used to maintain specific sites with high ecological, commercial, visitor, or cultural value.** At these small scales (in the order of 10's of metres in contrast to broad-scale in the order of 100's of kilometres), the cost and effort of restoration may be justified by a number of ecological, social, or economic reasons.

## INTERVENTIONS LIKE CORAL GARDENING ARE CONSIDERED REACTIVE AND APPROPRIATE ONLY IN COMPLEMENT TO BROADER MANAGEMENT ACTIVITIES AND WHEN RECOVERY TIME IS NOT POSSIBLE


*Image. Coral Nurture Program, John E, Opal Reef Wavelength*

**Risks of restoration efforts are dependent on both the technique used, knowledge of project impacts, and the availability of mitigation strategies.**

## WHAT ARE THE RISKS OF CORAL REEF RESTORATION?

Risks are broadly categorised in terms of:

- Impact on biosecurity and potential for introduction of disease (depending on the source and location of corals);
- Direct impacts to existing coral reefs from extraction of "seed" corals; and,
- Direct and indirect impacts that result from the placement of restoration equipment or materials, including on water quality, sedimentation, and shading and debris if impacted by storms.

| LOW | MEDIUM | HIGH | VERY HIGH |
|---|---|---|---|
| Removal of sediments, overturning and algae removal, coral predator removal, transplanting, larval seeding within the same reef. | Translocation between different sites, small artificial reefs, Assisted Gene Flow, ultra-thin film shading. | Medium/large artificial reefs, infrastructure (e.g., pontoons), biological or chemical controls for predators, geo-engineering, large scale aquaculture, hybridisation, coral feeding and probiotics, assisted migration, genetic engineering. | Introduction of non-native species, natural or bioengineered pathogens or viruses, or artificial increase of endemic species to outbreak. |

*Summary of Interventions by Risk Level, Application for Restoration/Adaptation Projects to Improve Resilience of Habitats in the Great Barrier Reef Marine Park, October, 2018 . Doc No. 100472*

**There are also social and political risks related to the successes and perceived failures of restoration trials for reef managers that may, for example, impact the reputation of management agencies or visitor perception of the health of the reef. Disillusionment and hopelessness of community and visitors is also a risk.** In the case of trialling, failures are important inputs to future management decisions, which further enforces the need for management agencies to be involved in designing, managing, and communicating about restoration trials to manage community expectations and perceptions. Expectation setting is particularly important as it relates to the potential for projects to be initially considered successful, then impacted by an event such as bleaching or cyclone damage in the future. Finally, it is essential that restoration trials are not perceived as setting precedent for other types of "conservation infrastructure" in marine parks, such as Fish Aggregating Devices or offsetting inappropriate real estate or infrastructure development. These risks must be communicated to and with the public, especially volunteers and local stewards who are energized to support the reef and climate change impacts in their communities and around the world.

# WHAT IS THE COST OF RESTORATION TRIALLING AND IS IT SCALABLE?

There are valid concerns about the effectiveness, scalability, and cost of restoration at broad-scale levels (whole reef restoration). However, the most successful restoration projects currently in operation are not intended to restore whole reef systems.

Rather, they focus on **localised, small-scale restoration of high value (visitor, commercial, ecological) sites**. Emerging technologies and techniques are seeking larger scales of intervention, such as through reef-scale cooling and shading through cloud brightening. However, the outcomes of these trials are not yet known and some require intensive investments in on-land facilities and infrastructure as well as at-scale deployment capacities such as engineering firms. The feasibility of these strategies are being tested through the *Reef Restoration and Adaptation Program* see *Section 4. Perspectives from Global Practice.*

The cost of restoration varies widely depending on methods and location, with estimates ranging from $1,717 up to $2,879,773 USD per hectare.[20] Trialling and piloting projects is therefore crucial to ensure that they are cost-effective in terms of labour, resources, time, and outcomes. When considering the cost of restoration, managers and communities should be explicit about **the cost-benefit considerations of action or inaction**. Cost and benefit factors might include, for example, expense relative to the economic value of the site, costs of inaction in terms of loss of a cultural or recreationally amenity, loss or gain of revenue within the local economy, and the relative costs and benefits of intervening in the short- or long-term in order to determine phasing of restoration actions.

In many cases, restoration is funded through grants, shared revenue, or co-funding arrangements. **Funding and financing opportunities for coral restoration projects are significantly increased when social and economic benefits are built into the design and implementation of the project.** Financing for reef restoration can be achieved through range of strategies, including:

- Federal disaster response and preparedness programs
- Ecosystem services payments
- Improvement of markets, such as reforms to environmentally harmful subsidies
- Cost-sharing with local business, stakeholder, and private landholders
- Parametric reef-based insurance to quickly fund restoration following storms or heatwaves
- Innovative blended-finance approaches, such as the Global Fund for Coral Reefs

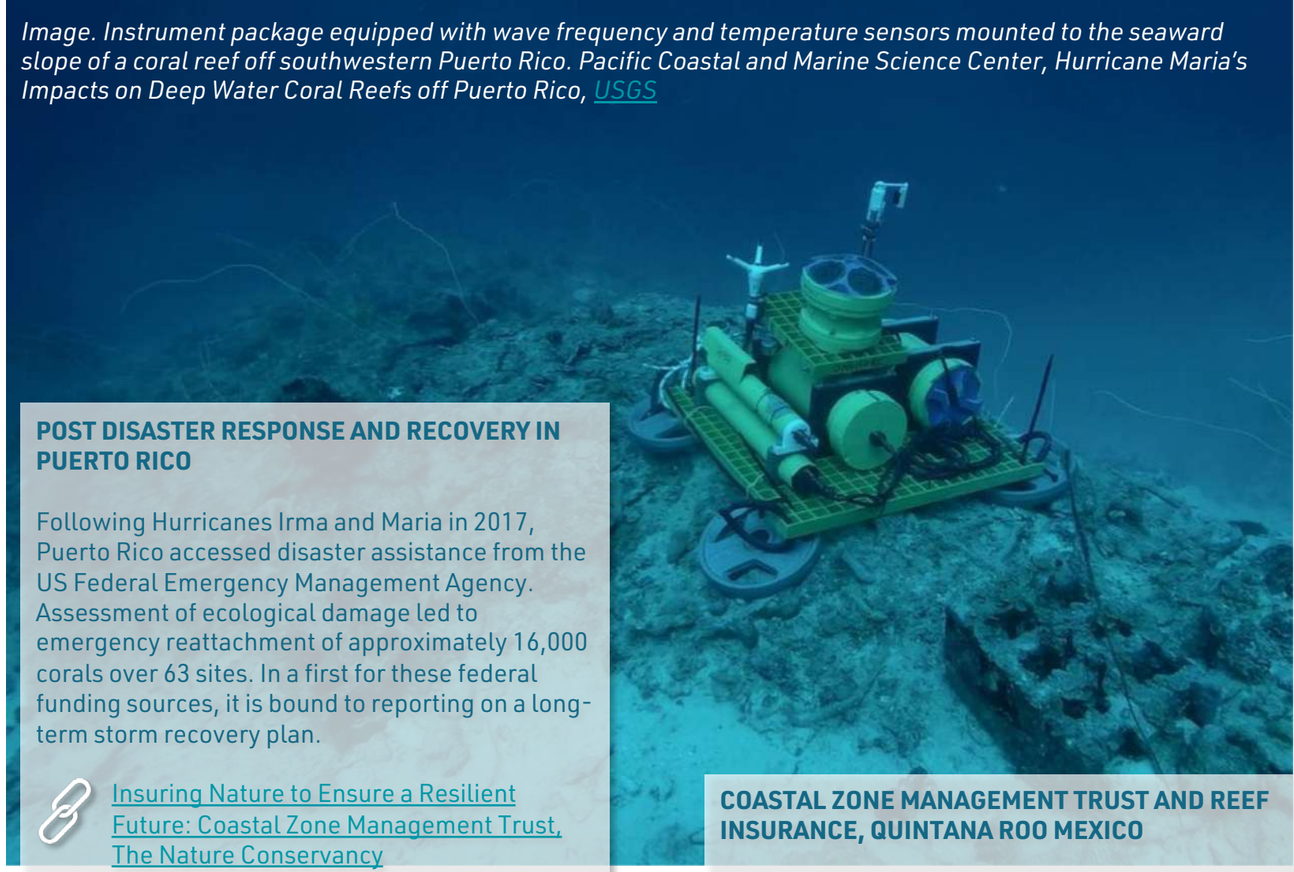


*Image. Instrument package equipped with wave frequency and temperature sensors mounted to the seaward slope of a coral reef off southwestern Puerto Rico. Pacific Coastal and Marine Science Center, Hurricane Maria's Impacts on Deep Water Coral Reefs off Puerto Rico, USGS*

### POST DISASTER RESPONSE AND RECOVERY IN PUERTO RICO

Following Hurricanes Irma and Maria in 2017, Puerto Rico accessed disaster assistance from the US Federal Emergency Management Agency. Assessment of ecological damage led to emergency reattachment of approximately 16,000 corals over 63 sites. In a first for these federal funding sources, it is bound to reporting on a long-term storm recovery plan.

Insuring Nature to Ensure a Resilient Future: Coastal Zone Management Trust, The Nature Conservancy

### COASTAL ZONE MANAGEMENT TRUST AND REEF INSURANCE, QUINTANA ROO MEXICO

A local tourist tax is levied to pay for beach and reef maintenance, as well as insurance coverage against damage from severe hurricanes for a 60 km area. A recent payout was made following two severe hurricanes in 2020, which is funding restoration action to ensure continued storm surge protective service of the reef to the coastline.

Post Disaster Coral Reef Assessment and Restoration, NOAA

*Image. The Yucatan Times, The Weather Channel*

Many cases of restoration efforts around the world involve engagement with multiple stakeholders across sectors and constituencies, including government agencies, academic research, community, local businesses and operators, Traditional Owners, and private and philanthropic interests. With proper planning and coordination, restoration trials can deliver a range of outcomes that are central to the effectiveness of reef management agencies, which:

- Address stakeholder expectations that **managers respond effectively to a severe climate event** and demonstrate proactive management practices that support the agencies' social licence to operate;
- Address stakeholder expectations that managers protect ecological values in ways which retain the **aesthetic, recreational, economic, and cultural values** of the asset (preserving amenity for the benefit of visitors, creating new tourism products or opportunities etc);
- **Empower the community** to participate in managing reefs in the face of change and disturbances, and manage the grief or anguish that may arise from a sudden deterioration in reef health;
- Create opportunities for **local employment or new tourism products** based around volunteerism;
- Promote **education** for visitors and locals about reef health, management, and environmental issues;
- Work with **Traditional Owners** in joint management and decision-making over conservation activities; and,
- **Catalyse public-private partnerships and external funding** to support conservation activities.

## WHY SHOULD REEF MANAGERS BE ACTIVELY INVOLVED IN TRIALS?

***"Restoration is carried out to satisfy not only conservation values but also socioeconomic values, including cultural ones. Without considering these values, particularly relationships between a site and its stakeholders, a restoration project may not gain the social support needed for success and may fail to deliver important benefits to ecosystems and to society…The practical implications for restoration are that restoration planners and project managers need to genuinely and actively engage with those who live or work within or near a site to be restored, as well as with others who have a stake in the area's goods, services or values…Social engagement, interpretation and education regarding the benefits of restoration to stakeholders are therefore essential components of a restoration project and need to be planned and resourced alongside the physical or biological project components."***[21]

Trialling restoration methods give managers an understanding of what works and why in specific social, ecological, and economic contexts, as well as **provides the basis for informing policy and investment in the future.** Management agencies have a key role to play in standardising objectives, methods and metrics; coordinating activities and funding to maximise efficiency and impact; and developing clear protocols and decision-making criteria for approvals, design, planning, management, and monitoring of outcomes. In doing so, management agencies can ensure that restoration trials are **relevant to management decisions, consistent with management objectives, and deliver benefits to the local community and economy**.

## WHAT'S NEEDED TO ADVANCE THE FIELD AND INFORM DECISIONS?

### SCALING
Understanding of impacts at scales

Cost efficiencies and ease of scaling spatially and temporally

### SCIENCE
Studies to determine relationships with adaptation and protections measures

Additional studies of engineering and technical options

### STANDARDS
Streamlined permitting structures

Frameworks for proactive local response

Consistent monitoring and measurement of approaches and outcomes

### SOCIETY
Sufficient socio-cultural considerations

Opportunities to leverage stewardship for conservation and education

*Source. Adapted from Hein MY, et al,. UNEP 2020; Boström-Einarsson L. et all.*

*Image. Johanna Lovecchio*

*Image. Coral Nurture Program, E.Camp*

# WHAT CAN WE EXPECT FROM RESTORATION?

**Social, Cultural, Economic**

✓ Sustain or enhance local tourism and fisheries

✓ Preserve high-value areas

✓ Promote stewardship

✓ Preserve critical ecosystem services (e.g., coastal protection)

✓ Protect culturally and spiritually significant sites

**Ecological**

✓ Re-establish function and structure

✓ Mitigate population decline

✓ Prevent species extinction

✓ Assist migration

✓ Improve genetic diversity and potential to adapt to climate change

**Disturbance-Driven**

✓ Respond to storms, predator outbreaks, ship groundings

✓ Mitigate anticipate coral loss prior to disturbance

# WHAT CAN'T WE EXPECT FROM RESTORATION?

× Does not reduce climate impacts or stresses on the reef, like poor water quality due to wastewater pollution

× Does not replace management of stresses or climate mitigation

× Not yet proven to recover large-scale ecosystems without high risk

× Typically not implementable quickly, inexpensively, or with consistent or comparable results across techniques, geographies, and scales

*Image. Ocean Sewage Alliance (link)*

# 3 TRIALLING FRAMEWORK

**As a part of the Resilient Reefs Initiative, the Resilience Accelerator program supported the development of this draft *Framework for Trialling Coral Restoration to Build Resilience***. Using Ningaloo Reef as a test case, this draft framework aims to identify and articulate key factors of reef restoration trials. It considers how restoration efforts can be designed to ensure coordination, transparency, and meaningful engagement between management, researchers, community, Traditional Owners, and tourism operators, which emerged as key constituencies at Ningaloo. Further, the framework aims to inform similar reef, marine park, and coastal resource management agencies worldwide. It is informed by facilitated internal discussions with managers; a review and application of global best practices to the ecological, socio-economic, and governance contexts at Ningaloo; and a workshop with Traditional Owners: *"Healing Sea Country: The Role of Restoration?"*

## HOW IS A TRIAL DISTINGUISHED FROM AN INTERVENTION?

This Framework draws a distinction between restoration trialling and intervention, and it's important to note that these protocols are related to the former. Trialling is an experiment to determine appropriate methods, while interventions are actions made for the specific purpose of restoring ecological condition and function. Trials are needed to effectively plan intervention, but are often smaller scale, limited duration, and may not result in lasting outcomes. To that end, this Framework provides recommendations on trialling restoration, rather than on implementing restoration actions for management purposes.

| | |
|---|---|
| **TRIAL** | An experiment that identifies new techniques or innovates on existing methods to test restoration goals |
| **TRIAL FRAMEWORK** | Goals, objectives, and expectations, and protocols that guide the design, engagement, implementation, and policy related to multiple trials and ensure collective learning and supported decision-making |
| **RESTORATION INTERVENTION** | An action implemented for the specific and primary purpose of restoring ecological function and condition |

## WHY A DRAFT TRIALLING FRAMEWORK?

**Coral reef restoration is a rapidly developing are research and intervention that raises questions around risk, feasibility, governance, and engagement.** At Ningaloo, coral bleaching events are anticipated to accelerate to two events per decade by 2040.[22] Coral restoration trials have the potential to test and develop a management intervention which assists important reefs to recover from these events where natural recovery is insufficient to maintain ecological condition and function.

**Researchers and management agencies are already planning, designing, and implementing restoration practices globally.** Trialling and experimentation to determine the most appropriate techniques at a given site supports management decision-making and increases the likelihood that ecological, social and economic outcomes will be realised. For example, in addition to supporting ecosystem health and functioning, restoration has the potential to support meaningful stewardship and livelihood outcomes for communities and tourism operators, building ecological and socio-economic resilience. Furthermore, restoration trialling, and ultimately any restoration activity, is inherently a management decision and requires meaningful engagement with Traditional Owners. At Ningaloo, for example, restoration trialling is inherently a joint-management decision made between the Joint Management Body, Traditional Owners, and the Department of Biodiversity, Conservation, and Attractions (DBCA). It therefore offers a legal and governance construct within which to ensure a thoughtful and equitable approach to restoration trialling decisions.

**Restoration trialling is a part of a learning process, and knowing what doesn't work under certain conditions is as important as knowing what does.** Testing models for implementation in partnership with researchers, management, Traditional Owners, community members, and tour operators offers important learnings around how restoration actions down the line might be modified so that they are sustainably replicated, scaled, cost-efficient, and delivering outcomes beyond the biophysical outcomes.

**A comprehensive approach to trialling reef restoration will drive outcomes that transcend any single trial.** This *Framework for Trialling Coral Restoration to Build Resilience* is intended to help support conversations about the role of restoration including goal-setting, risk evaluation, siting, engagement, licensing and permitting, monitoring, and resilience building in a management agency, like the DBCA at Ningaloo. Altogether, a coordinated approach to trialling efforts is intended to ensure:

- **Realistic expectations of restoration outcomes**
- **Systematic learning to inform future intervention decisions**
- **Resilience of the reef, community, operators, and traditional owners**
- **Increased opportunities for partnership and funding**
- **Scaleable and translatable learnings worldwide**

*Image. Joel Johnsson*

# TRIAL ELEMENTS TO BUILD RESILIENCE

**Resilience is defined as the capacity of reef ecosystems and the individuals, businesses and communities that depend upon them to survive, adapt and recover from the stresses and shocks that they experience.** Trialling of coral reef restoration can be designed to build resilience across the ecosystem, community and governance domains. In this regard, reef restoration design will consider how to maximise benefits and engagement across all three domains and across the life of the project - from early design and assessment, to implementation, and through monitoring and evaluation.

As trials are planned and implemented, researchers and management agencies should consider the following elements of any trial and ensures that risks are assessed and mitigated, stakeholders are meaningfully engaged, resilience is supported in the reef and people, and that a set of learnings inform future management decisions:

*Image. Rescue a Reef, Gammon Koval*

1

## DESIGNED FOR RESILIENCE

Design elements of trials ensure reef resilience to future climate conditions; build socio-economic resilience in community, with Traditional Owners, and through livelihoods; and support adaptive management to dynamic and uncertain conditions.

2

## CLEAR OBJECTIVES

Trials have a clear hypothesis that build the evidence base for active intervention, produce findings that inform knowledge about structure and function of the reef, and are co-designed with management and key stakeholders.

3

## ROBUST RISK ASSESSMENT

Trials are assessed for ecological, socio-economic, and management risks and are adequately mitigated.

4

## STRATEGIC SITE SELECTION

Trial siting is considered in the objectives of the trial as well as the aspirations of the community, operators, and Traditional Owners; proximity to other trials or monitoring sites; current and projected environmental conditions; location-specific conditions related to technique, scale and logistics; and future climate projections.

5

## MEANINGFUL ENGAGEMENT

Trials consider messaging and engagement strategies that support co-management and two-way learning with Traditional Owners. Engagement strategies serve to manage expectations, ensure transparency, empower key stakeholders and leverage community support and assistance. Engagement is transparent, timely, inclusive, and appropriately communicated.

6

## INTEGRATED ASSESSMENT AND LICENSING

Trials are evaluated by management, inclusive of Traditional Owner joint management bodies and reef managers, across the stages of design, planning, implementation, monitoring and evaluation, and post-trial.

# 1 DESIGNED FOR RESILIENCE

Resilience is the capacity of reef ecosystems – and the individuals, businesses, and communities that depend upon them – to survive, adapt, and recover from the stresses and shocks that they experience or may experience in the future. Restoration trials should be designed to be robust and adaptable in the face of changing environmental conditions (particularly in relation to climate change projection scenarios), as well as strengthen the resilience of communities, livelihoods, and governance systems which rely on the reef in the long term.

While trialling is a fundamental step in building the biophysical resilience of the reef ecosystem, it also provides opportunities to deliver outcomes that support the resilience of communities, Traditional Owners, and tour operators who depend on the reef. These outcomes could include diversifying livelihoods, honoring the cultural and spiritual significance of the reef, building trust in management, and increasing capacity through volunteering and partnerships. Trials can also be a testing ground for management and governance structures that support adaptive management today and under future climate conditions.



| DESIGN OBJECTIVES | MANAGER ACTIONS | PROPONENT ACTIONS |
|---|---|---|
| ROBUST CONSIDERATION OF CHANGING ENVIRONMENTAL CONDITIONS | ✓ Obtain downscaled climate change projections for marine protected area<br>✓ Undertake vulnerability analyses and integrated mapping that identifies exposure to climate hazards (e.g., marine heat waves) and environmental hazards and stressors (e.g., sedimentation and nutrient loading), as well as sensitivity of reef species, vulnerable communities and economic risks under future scenarios<br>✓ Consider environmental and socio-economic risk over long term time scales when assessing proposals *(see Section 3.3, 3.6)* | ✓ Respond to vulnerability analyses and projected future conditions when proposing trialling sites<br>✓ Consider site conditions and trial design in context of existing degradation and stresses, such as poor water quality or overfishing<br>✓ Locate in coral reef refugia, where reefs possess physical, biological, and ecological characteristic that make them likely resilient to climate change or acclimatise to conditions like poor water quality[23]<br>✓ Ensure that attachment methods and materials do not exacerbate coral sensitivity to climate impacts |
| MAINTENANCE OR ENHANCEMENT OF ADAPTIVE CAPACITY AND CONNECTIVITY | ✓ Encourage research that identifies resistant species<br>✓ Coordinate trials to ensure that genetic diversity is maintained<br>✓ Encourage selection of source and sink reefs to increase chances of natural scaling and potential for economic benefits | ✓ Consider future climate projections to inform species selection, such as thermal tolerant species or corals that can withstand storm damage<br>✓ Maintain diversity of coral species, genetics, phenotypes, and growth types to enhance adaptive capacity<br>✓ Consider ecological factors of resistance and recovery beyond corals, such as processes and populations of non-coral species that support reef functional recovery (e.g., herbivory) |
| FACILITATION OF SOCIAL AND CULTURAL OUTCOMES | ✓ Coordinate educational activities and communication about reef condition, sea country history, climate change, and the global and local stresses that impact the reef<br>✓ Encourage and coordinate (if appropriate) stewardship and citizen involvement in implementation or monitoring<br>✓ Create opportunities for ongoing stewardship and citizen involvement | ✓ Build awareness of the integrated relationship between the marine and reef ecosystems, terrestrial environments and local communities<br>✓ Build relationships with and leverage resources for community partners and local organisations to participate, particularly those working with vulnerable populations<br>✓ Communicate results and findings to the community in appropriate and meaningful ways<br>✓ Create avenues for artistic, spiritual, and creative expression related to the land- and sea-scape such as through storytelling and cultural events |
| ENSURE THAT ECONOMIC AND LIVELIHOOD BENEFITS ARE SUPPORTED | ✓ Consider or explore opportunities for a diversified tourism sector, such as eco-tourism product development or revenue generation through grants that support trial implementation alongside trial proponents | ✓ Create opportunities to support local livelihoods of local tour operators and others who are economically dependent on the reef, like subsistence and small-scale fishers<br>✓ Engage industries and labour markets most vulnerable to sudden climatic or economic shocks in design, such as small-scale tour operators and fisherman<br>✓ Build skills and capacities to support jobs and training of vulnerable populations, (such as dive training, data gathering and analysis, and education and communications) |
| INSTITUTIONALIZE INCLUSIVE GOVERNANCE AND ADAPTIVE MANAGEMENT | ✓ Build cross-sectoral partnerships, such as between scientific researchers and trial proponents, philanthropy, social scientist, and eco-tourism investors<br>✓ Coordinate trialling in ways which can facilitate adaptive and informed decision-making<br>✓ Actively engage Traditional Owners through governance, decision-making structures, and legal structures (e.g., joint management) | ✓ Engage with Traditional Owners in co-design of project objectives and outcomes, as well as obtaining Free Prior Informed Consent |

# 1 DESIGNED FOR RESILIENCE

## OPPORTUNITIES AND RESOURCES

### Researchers and Trial Proponents

> Identify key species, attributes and functional processes which are fundamental in maintaining and regenerating coral reef ecosystems, at physiological (population and species levels), ecological and evolutionary scales.

> Develop integrated environmental models at a reef-system scale, incorporating hydrodynamic, biogeochemical, climatic, benthic, remote sensing, connectivity, temperature variability and predicted climate risk models, as well as observational data related to resilience mapping and local stressors/human impacts.

### Thought Leaders and Coordinating Bodies

> Continue to develop practical applications of resilience-based management through proof-of-concept and sharing of lessons learned.


## RESOURCES

**Coral Reef Restoration as a Strategy to improve Ecosystem Services,**
Hein, MY. et al., UNEP 2021

"Aims to assist practitioners, managers, and decision-makers to consider whether and how to use coral reef restoration as a strategy to protect coral reefs locally, regionally and globally."



**Coral Reef Restoration Hub**
ICRI Forum

"The Restoration Hub has been designed to be a centre point for all information, whether that is the latest guidelines, new and existing initiatives, recent news and events related to the restoration of coral reefs and their related ecosystems (mangroves and seagrass)."

**Coral Reef Restoration Toolkit**
**Reef Resilience Network**

"This Coral Reef Restoration Toolkit compiles the latest scientific guidance and tools to help managers, researchers and practitioners ensure the maximum success of a coral reef restoration project and the most efficient use of limited resources."

# 2 CLEAR OBJECTIVES

Trialling restoration is a fundamental step in determining the feasibility, potential effectiveness, magnitude of risks and benefits, and scalability of methodologies and techniques at a given site. At a strategic level, trialling also offers the opportunity to ensure that projects inform or incorporate a broader set of management strategies, engagement, and stewardship approaches.

Effective trial design and implementation can support the resilience of both the reef system, the people who depend on it, and future management and policy decisions. However, robust experimental design, risk assessment and planning of outcomes all rely on clearly stated objectives which guide experimental design. They frame what a trial is seeking to achieve or test and position how any given trial relates to a broader set of strategic objectives that inform future decisions.

| STRATEGIC TRIALLING OBJECTIVES | MANAGER ACTIONS | PROPONENT ACTIONS |
|---|---|---|
| BUILD THE EVIDENCE BASE FOR FUTURE MANAGEMENT DECISIONS AND RESPONSES | ✓ Develop a policy or guidance on restoration trials which articulates management goals<br>✓ Coordinate trialling to assess the value of a mix of potential restoration methodologies, tested across a range of environmental and geomorphic conditions, scales and coral species/groups | ✓ Clearly articulate the objectives and hypothesis of the trial (to inform site selection, risk assessments, monitoring, licensing and other aspects of planning and implementation)<br>✓ Differentiate between localised and broad-scale restoration hypotheses<br>✓ Disclose all risks and articulate all costs to inform assessment and scaling potential see *Section 3.3* |
| ENSURE TRIALS ARE CO-DESIGNED WITH REEF MANAGERS AND ENGAGED ACROSS PARTNERS AND STAKEHOLDERS | ✓ Engage with proponents to provide information on management needs and objectives<br>✓ Assess whether engagement has been adequate during licencing/approvals | ✓ Formulate goals in consultation with the end users (e.g., reef managers)<br>✓ Meaningfully engage with Traditional Owners, community members and tourism operators early in the design and planning process to uncover risks, opportunities, and impacts on end users |
| PRODUCE FINDINGS ABOUT ECOLOGICAL FUNCTION AND ADAPTATION | ✓ Synthesise and make findings available to future proponents, reef managers and community members | ✓ Measure indicators of rehabilitation of structure and diversity and/or recovery of endangered populations<br>✓ Measure indicators of recovery potential in the context of future climate projections, response to sudden disturbances, and adaptation of species<br>✓ Evaluate baseline and changes to ecosystem services and benefits of restoration at various scales (e.g., reduction of erosion)<br>✓ Present findings in ways that are relevant to managers, such as by articulating how findings inform future decisions in the context of proactive and ongoing management of pressures |

# 2 CLEAR OBJECTIVES

## OPPORTUNITIES AND RESOURCES

### Managers and Public Agencies

> Create a research platform that can organise trialling efforts and ensure a mix of methods, consistent monitoring, and coordination with policy decisions.

### Thought Leaders and Coordinating Bodies

> Create a research hub that supports place-based and cross-institution coordination of research questions and promotes resource sharing and learning.

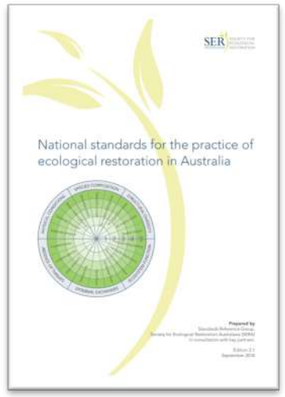
> Publish examples of restoration trial objectives and research hypothesis and trial plans globally.

> Coordinate research agendas within particular disciplines, methods or technologies, identifying critical gaps, catalytic funding opportunities and 'exit points.'


## RESOURCES

**Reef Restoration and Adaptation Program: Engagement and Regulatory Dimensions**
Taylor, B. et al, 2019

"Presents principles of responsible research and innovation as they relate to the social acceptability, efficient community engagement, and robust regulatory systems of reef-based interventions."


**National Standards for the Practice of Ecological Restoration in Australia**

"Identifies the need and purpose of ecological restoration, explains it in relation to other forms of repair, and provides standards for planning and implementation."

# 3 ROBUST RISK ASSESSMENT

As with any experiment or intervention, there are risks that need to be well understood, evaluated, and mitigated to an acceptable level. Risks of restoration trialling efforts are dependent on the technique used, knowledge of project impacts, trial scale, and the availability of mitigation strategies of identified risks and relative sensitivities.

As trialling efforts become more frequent, a range of risks should be evaluated and mitigated in order to ensure that unintended consequences are controlled, ecological damage is prevented, and value to the community, Traditional Owners, and operators is preserved. Managers and proponents should work together to evaluate and mitigate a spectrum of risks from environmental, to social, economic, and political.

| TYPES OF RISKS | EVALUATION FACTORS | | | |
|---|---|---|---|---|
| | Low Impact | Medium Impact | High Impact | Very High |
| ECOLOGICAL [24] | • Removal of sediments, up-righting overturned corals following storms or collisions, algae removal, coral predator removal, transplanting, larval seeding within the same reef | • Translocation between different sites, small artificial reefs, Assisted Gene Flow, ultra-thin film shading | • Medium/large artificial reefs, infrastructure (e.g., pontoons), biological or chemical controls for predators, geo-engineering, large scale aquaculture, hybridisation, coral feeding and probiotics, assisted migration, genetic engineering | • Introduction of non-native species, natural or bioengineered pathogens or viruses, or artificial increase of endemic species to outbreak. |
| SOCIAL AND ECONOMIC | • Perception of the reef as 'degraded', resulting in a reduction in visitation<br>• Likelihood of increasing pressure and visitor and researcher usage, such as unplanned increases in recreational fishing activities should restoration trials result in increased fish presence<br>• Loss of aesthetic value of the reef<br>• Loss of cultural value from activities like moving corals | | | |
| MANAGEMENT AND POLITICAL | • Loss of momentum, hope, and confidence in management strategies<br>• Risks to health and safety of visitors, staff, and implementers<br>• Inadequate monitoring capacity to support research and understand impacts and outcomes<br>• Reputational risk of trial "failures" and perception of restoration as mismanagement of public funds<br>• Possible inappropriate placement of trials resulting in overcrowding at trialling sites and cross-site contamination<br>• Ad-hoc, informal, or unstandardised research that does not contribute to learnings<br>• Inexperienced research teams that can potentially damage the reef and/or exclude community | | | |

3

# ROBUST RISK ASSESSMENT

## OPPORTUNITIES AND RESOURCES

### Managers and Public Agencies

> Release guidance to researchers that sets clear expectations in working with other agencies to standardise risk assessment or evaluation criteria.

> Develop a risk assessment policy for trials that situates techniques based on risk and mitigation options.

### Thought Leaders and Coordinating Bodies

> Develop a holistic risk evaluation criteria and sample policy template that ensures physical, social, economic, and management risks are accounted for and addressed through engagement, technical assistance, and communications.

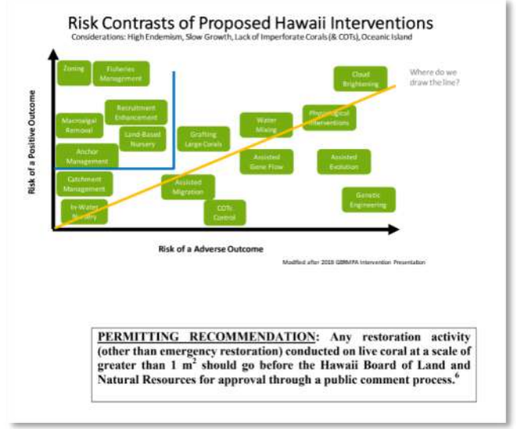
***"Uncertainty, in the context of assessing risks, comes from a range of sources. Uncertainty can be addressed by clearly defining the scope of the assessment, using plausible scenarios, setting specific assumptions and parameters, estimating the degree of uncertainty and the probable range of predictions based on that uncertainty."*** – *Great Barrier Reef Marine Park Authority Interventions Policy*




## RESOURCES

**Coral Restoration Implementation Guide, State of Hawaii Division of Aquatic Resources**
Gulko, D. et al. , 2019

Gives guidance on the sourcing of corals, transport risks including vector ecology impacts, holding and maintaining of corals, acclimatising prior to reintroduction, modifications to the restoration site, impacts of out planted corals on ecosystem services gained or lost, and demonstrations of expertise.





**Applications for Restoration/Adaptation Projects to Improve Resilience of Habitats in the Great Barrier Reef Marine Park**
GBRMPA, 2018

Provides guidance to regulators and applicants when considering an application for permission to conduct restoration and / or adaptation projects to improve resilience of habitats in the Great Barrier Reef Marine Park and the Great Barrier Reef Coast Marine Park.

# 4 STRATEGIC SITE SELECTION

Decisions about the location of restoration trials should be made with reference to a number of interrelated factors that are dependent on: The objectives of the trial; the aspirations of the community, operators, and Traditional Owners; proximity to other trials or monitoring sites; current and projected environmental conditions; and location-specific conditions related to technique, scale and logistics. At Ningaloo, for example, trials should be expected to demonstrate consideration of a range of spatial factors and conditions.

## SITE SELECTION CONSIDERATIONS

| | |
|---|---|
| ECOLOGICAL CONDITIONS AND BIOPHYSICAL CONTEXT | • Disease<br>• Overfishing<br>• Biodiversity areas<br>• Substrate stability (e.g., to inform consideration of technique selection)<br>• Hydrodynamic residency in lagoons (i.e., proxy for temperature)<br>• Coral predators (e.g., COTS)<br>• Coastal erosion<br>• Winds and tides<br>• Strong currents<br>• Land-based runoff<br>• Watersheds<br>• Geomorphology<br>• Ecological connectivity<br>• Loss of function relative to the trial goal |
| CLIMATE RISKS | • Recovery rates longer than 10 years<br>• Cyclone damage<br>• Historical and future project bleaching<br>• Coastal flooding, SLR, and surge projections<br>• Coral refugia areas |
| SOCIAL AND ECONOMIC BENEFITS | • Visibility/accessibility of the project and sites (e.g,. feasibility for demonstration and education)<br>• High importance to Traditional Owners and their aspirations<br>• High social and/or aesthetic value (e.g., tourism sites, high-visitation nodes)<br>• High tourist traffic or overuse<br>• Nearby community members and residents interested in trial activities<br>• Significant historical use |
| MANAGEMENT AND LOGISTICS ELEMENTS | • Logistical access points (e.g., launches, shore based)<br>• High boat traffic<br>• Research centres<br>• Existing in-water monitors and sensors<br>• Other research trials and studies<br>• Existing management areas |

4

# STRATEGIC SITE SELECTION

## OPPORTUNITIES AND RESOURCES

### Managers and Public Agencies

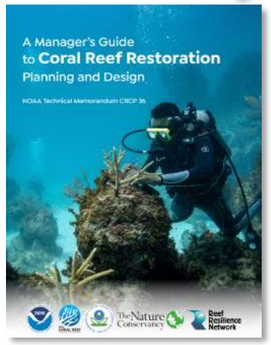
> Design and coordinate resilience mapping and spatial research to identify high-value resilience sites. Ensure that findings are integrated into decision-support systems, spatial planning (i.e., zoning), monitoring, management of disturbances (such as bleaching or cyclones) and interventions (such as restoration activities).

### Researchers and Trial Proponents

> Undertake resilience mapping and spatial research to identify high-value resilience sites (coral reefs and macroalgal nurseries), including those sites which have a positive impact on network connectivity, enhanced levels of resistance or recovery, and/or reduced exposure or sensitivity to multiple stressors. This mapping should integrate local human pressures which may operate within the area and known species physiological tolerance limits.

> Engage with managers to undertake cultural assessments with local community and Traditional Owners


## RESOURCES

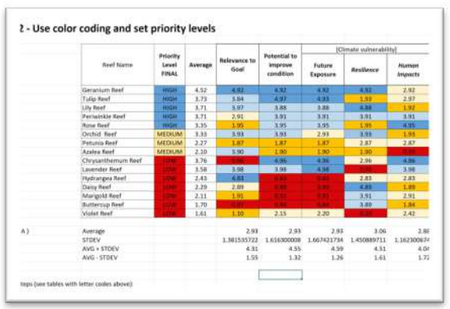



**A Manager's Guide to Coral Reef Restoration Planning and Design,**
Shaver, EC., et al. NOAA, 2020

"Supports reef resource managers and conservationists, along with everyone who plans, implements, and monitors restoration activities with a six-step, adaptive management planning process. It helps managers gather relevant data, ask critical questions, and have important conversations about restoration in their location."

**Tutorial and Complete Example: Site Selection**
SymbioSea for NOAA, TNC, EPA to Suport a Manager's Guide to Coral Reef Restoration Planning and Design (Shaver, EC., et al 2020)

Excel spreadsheet template that "presents a worked example of how to compile, sort, and analyze data to assist in selection sites for restoration.'



# 5 MEANINGFUL ENGAGEMENT

For restoration trialling to be meaningful, it must produce a set of learnings that inform management. Critically, it must also empower the community, Traditional Owners, and operators and design and implementation should be authentically engaged to meet the diverse stakeholder needs at Ningaloo or any reef site. For managers, 'success' of a restoration project should be judged on the basis of multiple criteria which include social and economic criteria, not just ecological see *Section 3.6.* Engaging with stakeholders serves to manage expectations and design projects in a way that achieves multiple resilience outcomes, which include forming partnerships to implement and monitor projects and ensure that restoration interventions are ultimately feasible and sustainable over time.

Appropriate and effective messaging and stakeholder engagement serves to manage expectations, ensure transparency, empower key stakeholders and leverage community support and assistance. Engagement around trialling should embrace the following principles in order to maximise learning outcomes and minimise risks, ensure that the social licence for trialling is well understood, and that trust is built and maintained. Above all, engagement takes time and is only as effective as the process allows for trust.



## MEANINGFUL ENGAEGEMENT COMMITS TO DEEPLY UNDERSTANDING AUDIENCE, INCLUDING:

| | |
|---|---|
| IMPACT | ... on a user group (e.g., a trial at Turquoise Bay would have great impact on users because of the high volume of tourists) |
| OBJECTIVE | ... of the research trial (e.g., if a goal is to maintain the tourism industry, then the trial needs to engage tourism operators) |
| OPPORTUNITY | ... for collaboration and participation (e.g., trial can support job or skill training of Traditional Owners) |

## QUALITIES OF MEANINGFUL ENGAGEMENT

| | |
|---|---|
| TRANSPARENT | • Engagement activities and documentation disclose all of the risks, benefits, timeframes, and scales of the trial to the public, management agencies, tourism operators, and traditional owners including:<br>  • End-point objectives and time frames of trials and potential future applications if successful;<br>  • Standardised evaluation metrics of biophysical, social, and economic outcomes;<br>  • Possible risks to the ecosystem, human safety, as well as aesthetics, social, spiritual, and economy value;<br>  • Possible risks of doing nothing and not learning through trial; and,<br>  • Potential to change the reef. |
| INCLUSIVE | • Engagement represents the range of community needs and perceptions and creates opportunity for input and participation. Engagement is seen as neither consultative nor extractive, but rather creates meaningful avenues for communication, learning, and respect across disciplines, perspectives, and values. |
| TIMELY | • Particularly where the level of impact of the project objectives on a user group is high and opportunity for engagement will improve outcomes (e.g,. employment, education), early dialogue and co-design is particularly important. Awareness building and information is made available, especially around end-outcomes and learnings of trials. |
| APPROPRIATE | • Materials and information are digestible and appropriate for non-technical audiences in addition to being relevant to the scientific community, management, and decision-makers. |

# 5 WORKING WITH TRADITIONAL OWNERS

Considering the unique histories, knowledge, traumas, rights, and governance structures of indigenous communities and Traditional Owners who have been the custodians of Sea Country for generations, special attention must be paid to engagement of these constituencies when trialling restoration. At Ningaloo, for example, a Joint Management Board with Traditional Owners representatives  makes decisions around marine park management activities, including but not limited to restoration trialling.

Opportunities for engagement with TO partners, joint managers, and communities, should consider the following possible outcomes to ensure meaningful representation in design, understanding, decision-making, and implementation:

## EXAMPLE OUTCOMES

- Empowerment of TOs to facilitate and lead discussion
- Engagement in the design process
- Awareness of impacts and trialling risks
- Expression of cultural values
- Identification of stewardship capacity, opportunities for skill development and employment
- Identification of new sites, areas of needs
- Understanding of social acceptability of techniques
- Preserved sites of cultural and spiritual significance
- Expectation management of trial outcomes and scale of possible changes
- Articulated aspirations for sea county broadly and consider how restoration is situated within those aspirations
- Identified opportunity for knowledge sharing on-country and intergenerational learning

## EXAMPLE METHODS AND FORMATS

### Awareness Building

- Early engagement during Joint Management Board meetings of project concepts
- Integrated updates into regular Joint Management Board meetings
- Public signage
- Demonstration projects
- Online portal or database to monitor progress
- Free Prior Informed Consent
- TO-led communication through cultural, artistic, and spiritual events

### Co-Design

- Workshops with Joint Management and Traditional Owner communities to identify opportunities and secure resources
- Engage in cultural and heritage mapping that informs site selection of all projects
- Design strategies using indigenous materials, totems, and motifs as determined by Traditional Owners

### Implementation Participation

- Resource Traditional Owner led projects from research and design phases and over the long term
- Train in direct deployment and maintenance
- Train and up-skilling of Traditional Owners (e.g., dive training)
- Integration into Ranger and jobs programs for ongoing and long-term maintenance and stewardship
- Storytelling and sharing with visitors through demonstration

5

# WORKING WITH TRADITIONAL OWNERS

## OPPORTUNITIES AND RESOURCES

### Managers and Public Agencies

> Work with Traditional Owners or Community Advisory Committees within or external to a joint management governance structure to establish design and engagement strategies of restoration trialling efforts.

### Researchers and Trial Proponents

> Undertake Free Prior Informed Consent (FPIC) process when designing trials and pursue resourcing for communities and Traditional Owners and ensure benefit sharing and compensation for time and knowledge.

### Thought Leaders and Coordinating Bodies

> Provide templates for bio-cultural protocols and their application to restoration strategies.

> Ensure sustained and long term funding and partnership support for effective Traditional Owner engagement and governance structures.




## RESOURCES

**Stakeholder, Traditional Owner and Community Engagement Assessment, 2019**
Taylor, B., et al. 2019

"A report provided to the Australian Government by the Reef Restoration and Adaptation Program"



**Healing Sea Country: Heart of the Reef – A Call for Healing**

Healing Country Statement by Great Barrier Reef Traditional Custodians - July 2021

**Guides to Free Prior Informed Consent**
Oxfam Australia

"FPIC entitles indigenous peoples to determine the outcome of decision-making that affects them – it is not merely a right to be consulted about projects that others will ultimately make decisions about."

# 5 WORKING WITH COMMUNITY MEMBERS

Engaging community in restoration trialling offers opportunities to build awareness about the condition of the reef, set expectations about outcomes, and empower local residents and the public to take action. Objectives and outcomes of this work depends on the scale, timing, resources, and possible impacts of the trial. It should also deeply consider the following principles to ensure that trials are not only well communicated, but also enabling collective action and stewardship:

## EXAMPLE OUTCOMES

- Engagement in the design process
- Awareness  of impacts and trialling risks
- Understanding of how trialling integrates with broader management
- Empowerment to participate in actionable stewardship
- Improved understanding of restoration as a management tool
- Articulation of aesthetic and cultural value of the reef
- Expectation management of trial outcomes and scale of possible changes

## EXAMPLE METHODS AND FORMATS

### Awareness Building

- Information sessions that communicate technical information to non-technical audiences
- Integrated trial updates into park management or local council meetings
- Public signage
- Demonstration projects
- Online portal or database to monitor progress

### Co-Design

- Public workshops
- Restoration and management curriculum in schools

### Implementation Participation

- Volunteer training and coordination of deployment of techniques
- Citizen science volunteer program to monitor
- Collaboration with local filmmakers and journalists for documentation and communications

5

# WORKING WITH COMMUNITY MEMBERS

## OPPORTUNITIES AND RESOURCES

## OPPORTUNITIES

### Managers and Public Agencies

> Institutionalise and integrate reef trial restoration updates and reporting into regular public meeting agendas.

> Work with local community based organisations to establish a Coral Reef Restoration Volunteer Corps and training program.

> Coordinate and present a consistent narrative about the goals and role of restoration within management to manage expectations.

### Researchers and Trial Proponents

> Integrate citizen science into monitoring and evaluation plans and evaluate learnings and social outcomes of participants.

> Present updates and findings of trials to local communities in meaningful ways (e.g., communications products should be co-designed with the end user).

### Thought Leaders and Coordinating Bodies

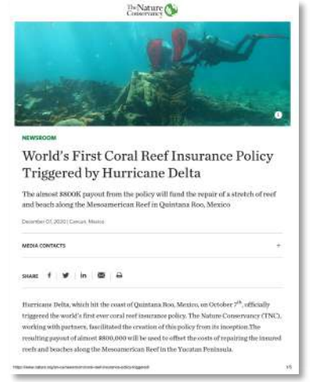
> Develop a graphic template for public reporting and signage of trial outcomes, placement, partners, and timelines.

> Support communication efforts by platforming trials and outcomes through media.



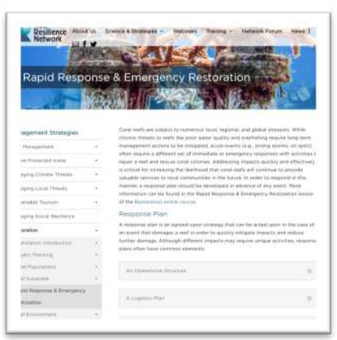

## RESOURCES

**World's First Coral Reef Insurance Policy Triggered by Hurricane Delta**
The Nature Conservancy, Dec 2020




"The almost $800K payout from the policy will fund the repair of a stretch of reef and beach along the Mesoamerican Reef in Quintana Roo, Mexico...

On the Sunday following the arrival of Hurricane Delta, **reef brigades** assessed the damage done to the reef and launched their planned rapid response. **During the first 11 days post-Delta these brigades, working in the Puerto Morelos Reef National Park, stabilized 1,200 large coral colonies that had been displaced and overturned.** The brigades also rescued and transplanted almost 9,000 broken coral fragments, some of which will now grow in to new coral colonies."




**Rapid Response and Emergency Restoration, Logistics and Operating Plan**
The Nature Conservancy, Reef Resilience Network

"A response plan is an agreed-upon strategy that can be acted upon in the case of an event that damages a reef in order to quickly mitigate impacts and reduce further damage."

# 5 WORKING WITH TOURISM OPERATORS

Engagement of tourism operators in restoration trialling not only offers an important avenue for partnership and awareness building, but also for scaling trials in high-economic value sites. Engaging local tour operators can provide mutual benefit to researchers and operators by providing researchers with scaling infrastructure like vessels, and providing operators with opportunities to design new eco-tourism experiences and products. To ensure this, the following objectives should be considered:

## EXAMPLE OUTCOMES

- Engagement in the design process
- Awareness  of impacts and trialling risks
- Identification of high-value sites, such as revenue generation, aesthetic value, or visitor interest
- Generated concepts for income diversification and high-value and eco-tourism products
- Expectation management of trial outcomes and scale of possible changes

## EXAMPLE METHODS AND FORMATS

### Awareness Building

- Information sessions that communicate technical information to non-technical audiences
- Integrated trial updates into park management or local council meetings
- Public signage
- Demonstration projects
- Online portal or database

### Co-Design

- Workshops with tourism board
- Prototyping of materials (e.g., equipment design to fit tour vessels)
- Business planning and joint-funding or venture proposals
- Standardised operating procedures of research and tour partnerships
- New eco-tourism, education, and demonstration product development

### Implementation Participation

- Ongoing maintenance training
- Data collection and reporting training
- Training of operators in deployment of techniques
- Training of operators in communicating trial methods and outcomes
- Storytelling and sharing with visitors through demonstration

# 5 WORKING WITH TOURISM OPERATORS

## OPPORTUNITIES AND RESOURCES

**Managers and Public Agencies**

> Establish a working group of local tourism operators to understand their training and resource needs and facilitate connection with researchers.

**Researchers and Trial Proponents**

> Establish standard operating and design procedures to resource and utilise tour vessels and/or staff during trial deployment and scaling.

**Thought Leaders and Coordinating Bodies**

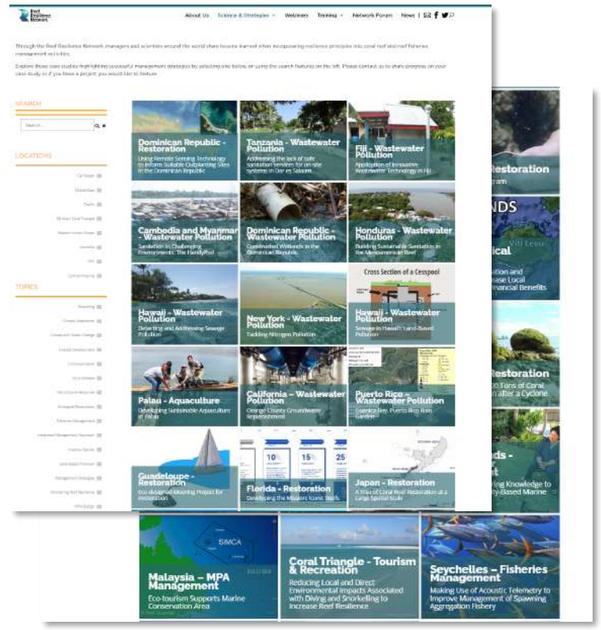
> Facilitate investment opportunities and grant-making to tour operators that supports up-skilling and vessel or equipment adaptation.




## RESOURCES

**Reef Resilience Network, Case Study Library**
The Nature Conservancy

Interactive case study database, highlighting management strategies sourced by managers and scientists around the world. Lessons learned include how resilience principles can be incorporated into coral reef and reef fisheries management activities.



# 4 INTEGRATED ASSESSMENT AND LICENSING

The permissions and licensing process of trials raises important questions around the role and capacities of management to steward research proposals, the public exposure of researchers, their responsibilities to engagement, and the flexibility of the process to respond to the scale and impacts of the trial (and ultimately, restoration intervention itself).

Trials should be evaluated across the stages of design, planning, implementation, monitoring and evaluation, and post-trial to increase the chances that risks are mitigated. Furthermore, approval and licensure of any one trial should be made in relation to the objectives, sites, scales, and techniques of other trials to ensure a mix of techniques, and minimise undesirable interactions or confounding effects between trials. Finally, evaluation for resilience-based design offers opportunity to maximise the ecological, social, economic, and cultural benefits and learnings of trials.

Review and licensing aspects of a trial by management should include the following inputs to ensure that trials have clear objectives, are evaluated for all known risks, meaningfully engaged with stakeholders and partners, and aligned with future possible management decisions:



| MANAGERS ASSESSMENT FACTORS | PROPONENT AND RESEARCHER DOCUMENTATION |
|---|---|
| DESIGN AND PLANNING STRATEGY | • Stakeholder engagement plan<br>• Ecosystem baseline<br>• Target goals and objectives<br>• Detailed rationale<br>• Maintenance and stewardship plan<br>• Possible risks (physical and non-physical)<br>• Logistical plan<br>• Precedent for trials or interventions using chosen technique<br>• Team experience<br>• Site map required and methods that will be used and species involved<br>• Clear sampling design, levels of replication that allows assessment of potential impacts |
| IMPLEMENTATION PLAN | • Demonstration of "no damage done" or minimal / allowable damage<br>• Demonstration of effectiveness<br>• Capacity to protect natural recovery<br>• Flexibility to adapt to unexpected conditions<br>• Compliance with occupational, health and safety protocols<br>• impacts on other users (e.g., public, commercial operators, other researchers)<br>• Logistics plan, including how and when activities will occur<br>• Approvals from relevant authorities |
| METRIC DEVELOPMENT, MONITORING, AND MEASUREMENT | • Dynamic monitoring plan towards specific targets as well as those that can evolve alongside project objectives over the long term<br>• Record maintenance plan to enable evaluation (data returns, what comes back is useless)<br>• Evaluation strategy that informs ongoing management |
| POST-TRIAL COORDINATION AND COMMUNICATION | • Removal plan and coordination with management<br>• Communication plan for findings and results |

4

# INTEGRATED ASSESSMENT AND LICENSING

## OPPORTUNITIES AND RESOURCES

### Managers and Public Agencies

> Establish publicly available research protocols and permitting guidance, such as a permitting questionnaire.

> Conduct a review to identify relevant legislative and regulatory requirements that trials would be required to meet.

> Identify roles and responsibilities for coordinating review, stewardship, and evaluation of trials.

> Explore a tiered system for assessment based on risk to ensure fit-for-purpose evaluations and expedited licensing of low-risk trials.

> Decide on a structure to maintaining a tracking portal for research trials, locations, partners, metrics, and stage of development, such as by decentralised system led by managers district or a independent research platform.

### Researchers and Trial Proponents

> Ensure that metrics and reporting of outcomes are cross-compatible with peer research institutions and proponents.

> Engage researchers across disciplines and sectors in trial design to broaden team capacity to deliver outcomes, such as social and behavioural scientists, community based organisations, fishers, or tour operators.

### Thought Leaders and Coordinating Bodies

> Promote best practice and lessons for permitting, exploring how to balance bureaucratic and procedural burden on under resourced management agencies with innovation and need for urgent action.

> Standardise metrics and reporting of outcomes based on trial or intervention type, size and scale, time scale, climate conditions, local stresses, and stakeholders engaged.


## RESOURCES

**Regulatory Implications of Coral Reef Restoration and Adaptation under a Changing Climate. Fidelman, P., et al. 2019**

"The regulatory environment is likely to be critical in determining the feasibility and viability of reef restoration and adaptation interventions. It influences what, where and how to restore, who should be responsible for, engaged in, and benefit from restoration."

**Coral Reef Restoration Monitoring Guide: Methods to Evaluate Restoration Success from Local to Ecosystem Scales**
Goergen, E. et al., NOAA, 2020

"Reference for restoration practitioners, managers, and scientists to guide metrics and monitoring of restoration projects. Guidance is categorised by restoration goals and identifies several Universal Metrics."

**Intervention Criteria Evaluation Tool**
TetraTech, Inc for NOAA, TNC, EPA to support A Manager's Guide to Coral Reef Restoration Planning and Design (Shaver, EC., et al 2020)

Excel spreadsheet template that "helps evaluate and then select restoration intervention options."

**"We are all in this together and aiming for the same outcome. None of us in the permitting space are looking to prevent intervention activities from occurring, our job is to manage the risks."**
Rohanna Rogan-Darvill, Acting Permits Manager at the GBRMPA

**Video: Permitting Advice for Coral Restoration Projects in the Great Barrier Reef**
RRAP, 2021

"A guide to the ins and outs of regulations and the permit process for research and restoration on the Great Barrier Reef. Hosted by Dr. Ian McLeod from James Cook University, featuring Rohana Rogan-Darvill, Acting Permits Manager at the Great Barrier"

# 4 PERSPECTIVES FROM GLOBAL PRACTICE

## IMPLEMENTATION CASE STUDIES

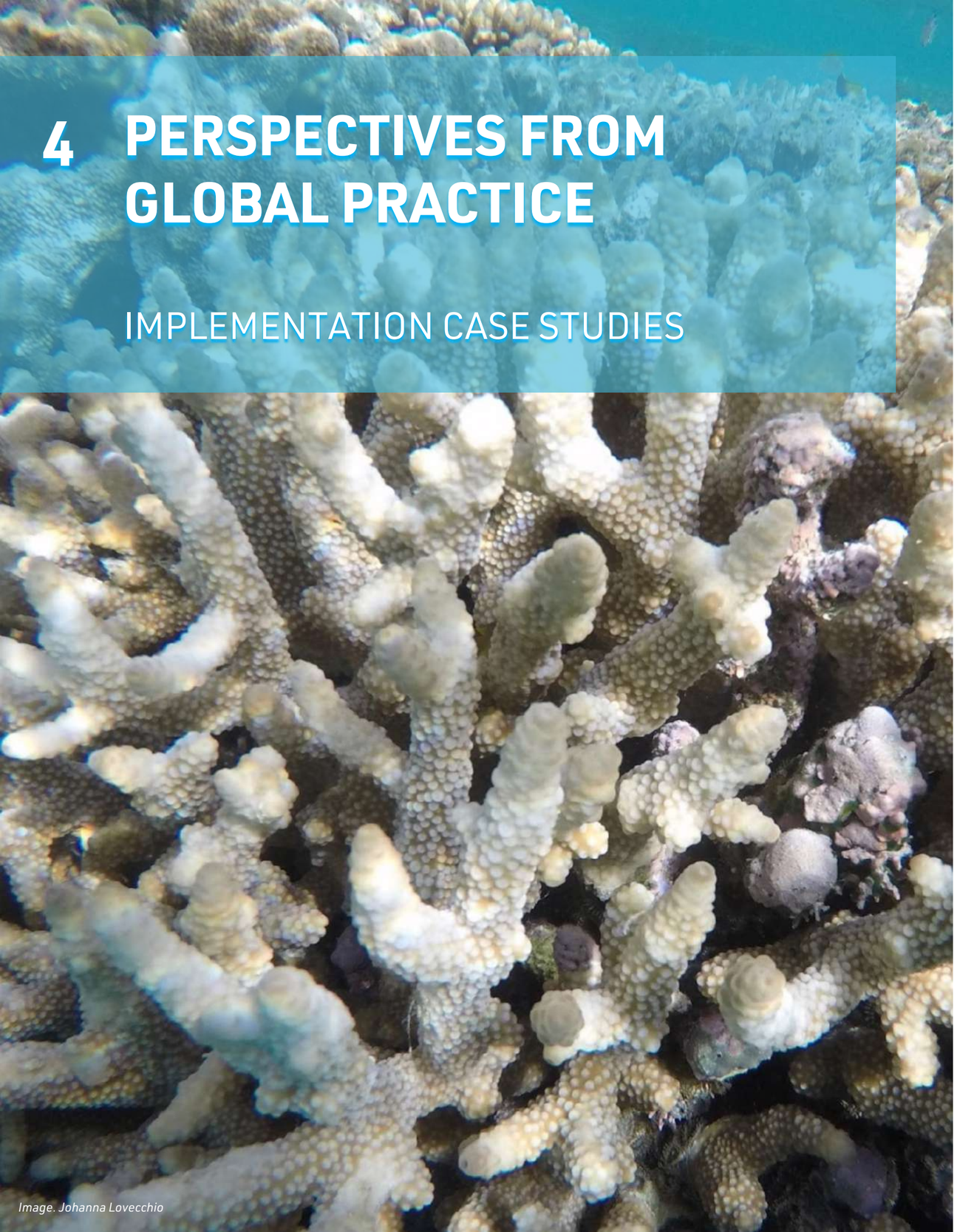


*Image. Johanna Lovecchio*

Case studies were prepared by the Resilience Accelerator Program in support of the Resilient Reefs Initiative. While these cases were prepared in the context the goals and questions emerging at Ningaloo (one of the four participating sites of the Resilient Reefs Initiative), the aim is for these case studies to serve as a living document that can be updated to share learnings in practice with practitioners worldwide.

**Special thanks to the following organisations and programs for their contributions to these case studies. A full list of all programmatic partners, contributors, and sources can be found within each case study.**

**Reef Islands Initiative**

**Reef Restoration and Adaptation Program**

## LESSONS FROM REEF RESTORATION ACROSS GLOBAL TRIALS

Restoration trials can be designed and implemented in ways which support social and economic resilience as well as adaptive governance. Restoration trialling provides critical opportunities for managers to engage with the community in designing and implementing management interventions. The most integrated coral restoration projects around the world are those that have deeply engaged across sectors and constituencies and have integrated governmental agency management, academic research, community members, local businesses and tourism operators, and Traditional Owners with private and philanthropic interests.

For these reasons, the case studies here illustrate implementation models which are integrated, collaborative and holistic in generating resilience outcomes. While the full range of outcomes of restoration projects can take years to materialise, theses projects are examples of those that are supporting community stewardship and the livelihoods of people who depend on the reef for sustenance or tourism operations, streamlining processes for review and approvals. These cases are also enabling platforms to build cultural competency of wester researchers in working with, listening to, and learning from Traditional Owners.

**Each case study is intended to share insights around the design, implementation, and engagement models of these projects particularly as they relate to topics that emerged through the Accelerator process at Ningaloo. The learnings and insights are intended to provide overarching perspective as it relates to these topics, rather than prescriptive protocols, for project proponents, managers, and researchers.**

**WORKING WITH TRADITIONAL OWNERS**

+ Great Barrier Reef Traditional Owner Technical Working Group, Reef Restoration and Adaptation Science Co-Design Group
+ Reef Magic Cruises, Sea Rangers, and Reef Stars at Moore Reef

**SCALING WITH TOURISM OPERATORS**

+ Boats4Corals Whitsundays
+ Coral Nurture Program

**EMPOWERING COMMUNITY**

+ Rescue a Reef: Citizen Science in Action
+ Seychelles Reef Rescuers Restoration Program

**TESTING NEW TECHNIQUES AND STRATEGIES**

+ Cairns-Port Douglas Reef Hub
+ Reef Islands Initiative Whitsundays
+ Reef Restoration and Adaptation Program
+ Great Barrier Reef Interventions Policy
+ Reef Rehabilitation at Green Island


*Source. Allen Coral Atlas , Satellite Reef Imagery, Accessed March 2022*

# WORKING WITH TRADITIONAL OWNERS

## INSIGHTS AND PERSPECTIVES FOR IMPLEMENTATION PARTNERS

**Working alongside Traditional Owners requires respect for traditional knowledge and cultural values, creating meaningful opportunities for co-design, and time and resources to build trust and genuine partnerships over the long term.**

+ **Be mindful of Traditional Owners having capacity, resources, and readiness to engage. For example, some TOs haven't been out on Sea Country for a long time, and might not have a boat or other resources**

+ **Some groups may not be ready to engage fully, but may still want to participate. Mindfulness of various activities, skills, capacities, levels of trust, and time frames of participation can ensure inclusivity across a range of readiness**

+ **Be mindful of language difference, for example "Restoration" may be better communication as a healing practice**

+ **Respect, listen, and integrate with all ways of knowing and ascribing meaning to the reef**

+ **Take the time to build trust and genuine partnership, with meaningful opportunities for co-design and co-delivery of projects**

+ **Some knowledge has not been shared for generations, ground all engagement in empathy for past trauma and agreements on knowledge sharing protocols**

+ **Traditional Owners are not a single voice and do not speak on behalf of one another**

+ **Clarify underlying cultural, health-based, and capacity obstacles that constrain communication and shared action between scientific community, public sector, Traditional Owners**

*Image. Whitsunday Reef Islands Initiative, Coral Nurture Site Survey*

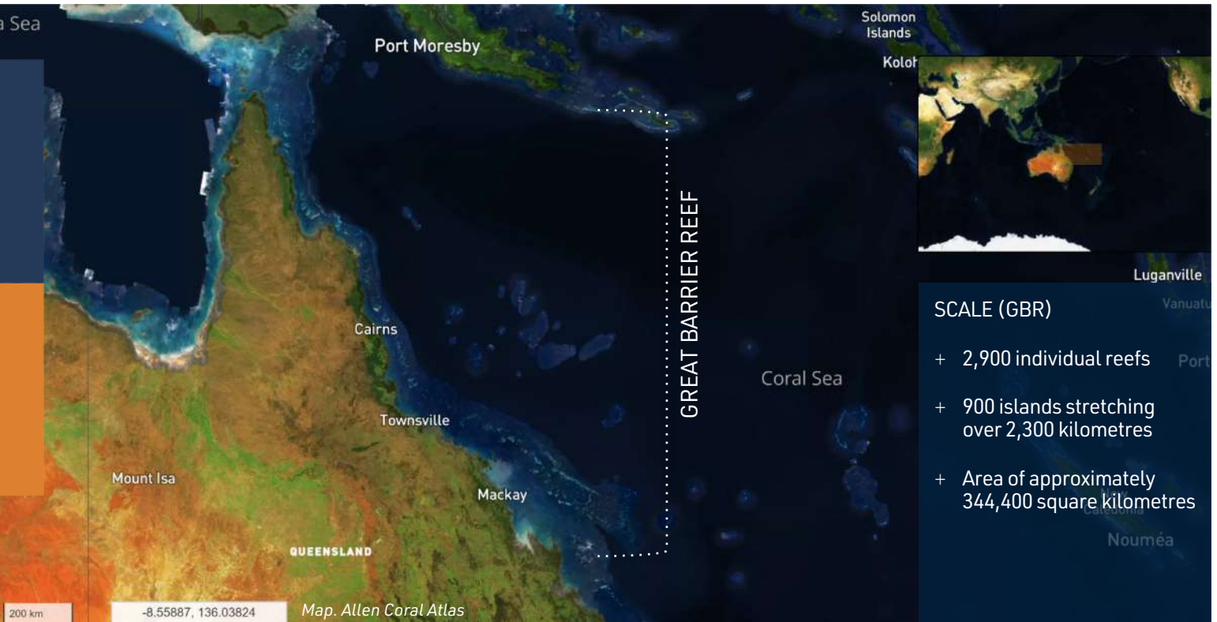
WORKING WITH TRADITIONAL OWNERS

# GREAT BARRIER REEF TRADITIONAL OWNER TECHNICAL WORKING GROUP

## REEF RESTORATION AND ADAPTATION SCIENCE CO-DESIGN GROUP

*Source: Brian Singleton, Yirrganydji of the Reef Restoration and Adaptation Science Co-Design Group; Eliza Glasson and Liz Wren Great Barrier Reef Foundation*

| | |
|---|---|
| PARTNERS | Traditional Owners from Woppaburra, Erub, Lama Lama and Nywaigi, and Yirrganydji, Great Barrier Reef Foundation Reef Trust Partnership, Australian Institute of Marine Science, Reef Restoration and Adaptation Program |
| COORDINATION | Great Barrier Reef Foundation |
| GOALS | + Provide advice to the Great Barrier Reef Marine Park Authority on the draft restoration policy<br>+ Support co-design and engagement for the Cairns-Port Douglas Hub and restoration pilots *(see pp. 93)*<br>+ Develop education and communication products<br>+ Contribute to Research and Development (R&D) of Reef Restoration and Adaptation Program (RRAP) Traditional Owner partnerships and engagement framework draft |
| SCALE | Entire Great Barrier Reef and sites related to the RRAP program Research and Development efforts |
| TECHNIQUE | Network-based engagement, knowledge sharing, policy, and consent-building |
| FUNDING | Reef Restoration funding available under the Reef Trust Partnership for TO Reef Restoration and Adaptation Science is $10M over 6 years |
| TIMESCALE | Established in 2020 for long-term planning |




## A DEEPER DIVE

There are 72 Traditional Owner groups on the Great Barrier Reef Sea Country, not including those with territory in the watershed. To ensure fair, equitable and active participation from Traditional Owners within the formal governance arrangements of the Partnership, the Foundation has established a strong Traditional Owner governance arrangement to underpin the co-design and co-delivery of the Reef Trust Partnership. This includes a Traditional Owner Advisory Group and component-specific co-design groups. In June 2020, the Great Barrier Reef Foundation established and recruited members for one of these co-design groups, the *Reef Restoration and Adaptation Science (RRAS) Traditional Owner Technical Working Group*. More about the application and selection process can be found on the GBRF website. The task of Technical Working Group members is not to represent their Traditional Owner groups, but to contribute their lived experiences, diverse skillsets and professional expertise to identify and create outcomes that have co-benefits to Traditional Owners of the Reef and Catchment areas.

The role of members of the RRAS TO Technical Working Group is to support the co-design and co-delivery of Traditional Owner-led activities, as well as contribute to the broader Research & Development program under the Reef Restoration and Adaptation Program. This has been made possible through a collaborative arrangement with the Australian Institute of Marine Science to enable two of the Traditional Owner staff to be on this Technical Working Group. Tasks that members are delivering are:

- **Design of a major grant program around Healing Country to meet the needs of TOs on the ground**
- **Supporting co-design and engagement for a local reef restoration pilot program as part of the Cairns/Port Douglas reef restoration hub**
- **Supporting co-design of the broader TO-led reef restoration program**
- **Supporting/ developing and implementing, with partners, an engagement process to communicate, engage and inform Traditional Owners about the RRAS Component**
- **Supporting/ developing education material in collaboration with partners to inform Traditional Owners about reef restoration and adaptation including findings, research, and opportunities**
- **Supporting/ developing bio-cultural protocols, principles and guidelines for the RRAS program, including ethics to inform resilience and restoration work, and adoption strategies to facilitate uptake by and education of partners**
- **Supporting/ mapping career pathways and training opportunities related to reef restoration**
- **Exploring innovations that may reside in Traditional Knowledge and practices to inform new ways to undertake Reef restoration and adaptation activities**
- **Establishing the framework for Traditional Owner Research & Development partnerships and engagement, to ensure that cultural competency of western scientists is built and that, restoration trials are designed, shaped, and rooted in Sea Country knowledge built over millennia**
- **Reviewing draft R&D plans and providing advice throughout the earliest phases of planning and prioritization of efforts**
- **Reviewing targeted communications products to be used to explain cultural competency to western scientists and proposed restoration projects to Traditional Owners**
- **Guidance on establishment of proposed partnerships and co-designed projects, achieving consent and ongoing Traditional Owner collaboration.**

*Image. Johanna Lovecchio*

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Traditional knowledge and practice is critical **to informing new ways of undertaking reef restoration and adaptation techniques** and requires building strong relationships with TOs who are willing to share their knowledge on specific sites
+ Traditional knowledge must be protected by **data sharing agreements** or similar protocols

**WORKING WITH TRADITIONAL OWNERS IN HEALING SEA COUNTRY**

+ A working group can be engaged across **multiple projects and programs**, including the Cairns Port Douglas reef restoration hub and co-design of specific projects.
+ A working group can develop **targeted communications, products, and education materials** to engage findings, research, and opportunities
+ **Cultural heritage mapping and discussion around biodiversity** led to insights into site prioritisation and selection of TO-engaged activities

**SCALING WITH TOURISM OPERATORS**

+ Technical review of projects and R+D supports **career pathways and training opportunities** for Traditional Owners related to reef restoration

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ **Free Prior Informed Consent (FPIC) should be adequately resourced to address access to benefit sharing**. Simply obtaining consent does not necessarily provide substantial benefits to Traditional Owners, such as involvement in-water activities or training, qualifications, employment outcomes, or incorporating known heritage values into practice and decision making
+ Achieving consent and ongoing collaboration is supported by the development of **bio-cultural and ethical protocols**
+ A **Framework for Traditional Owners Research and Development** ensures that TO input is prioritised and engaged early in research and development phases (R&D)

*TRADITIONAL OWNER ADVISORY GROUP REEF RESTORATION AND ADAPTATION SCIENCE CO-DESIGN GROUP, GREAT BARRIER REEF FOUNDATION*

*HEALING COUNTRY STATEMENT: HEART OF THE REEF – A CALL FOR HEALING, GREAT BARRIER REEF FOUNDATION*

## LEARN MORE

WORKING WITH TRADITIONAL OWNERS

# REEF MAGIC CRUISES, SEA RANGERS, AND REEF STARS AT MOORE REEF

*Source: Eric Fisher, Reef Magic Cruises; Brian Singleton, Yirrganydji to Reef Restoration and Adaptation Science Co-Design Group; Brian Murgha, Gunggandji Traditional Owners; Mars Sustainable Solutions;Queensland Government's Parks and Wildlife Service*

**PARTNERS**
Reef Magic Cruises, Mars Sustainable Solutions, James Cook University, Yirrganydji Land and Sea Rangers, Gunggandji Land and Sea Rangers

**COORDINATION**
Eric Fisher and Justin Bovery-Spencer, GBR Biology/Reef Magic Cruises, Alicia McArdle and Freda Nicholson, Mars Sustainable Solutions, Gavin Singleton, Yirrganydji Land and Sea Rangers

**GOALS**
+ Provide coral colonies with valuable time to adapt and increase their resilience
+ Increase reef stewardship
+ Trial innovative approaches to help support reef ecosystems at iconic sites like Moore Reef with tourism operators and Traditional Owners

**SCALE**
Up to 100 Reef Stars to be implemented every six months 40 km's offshore of Cairns

**TECHNIQUE**
Mars Assisted Reef Restoration System (MARRS) rubble stabilisation and out planting

**FUNDING**
Mars Sustainable Solutions funds the purchase of the Reef Stars and the JCU monitoring, in addition to in-kind staff time. Reef Magic contributes in-kind resources for vessel transfers to Reef Magic pontoon, dive tender use and staff time. Yirrganydji provide staff time. In 2019, Reef Magic self funded 3 Marine Biologist and Yirrganydji self funded two Rangers for travel and expenses to Indonesia for partnership and capacity building in the Mars Assisted Reef Restoration System.

**TIMESCALE**
Implemented in 2020 with regular installations expected through at least 2022, with a five-year measurement timeline post-installation

## OUTCOMES ON THE REEF

+ **53 species of coral used** across **4 build sites**
+ **348 Reef Stars** and **5,220 coral fragments** installed in the **first 2 years**
+ **Coral cover** at the first build has increased from **40 percent** (pre-install) to **78 percent** (18 months post-install)
+ **Coral fragment mortality has been 3 percent** or less for each installation

**Herbivorous fish** spotted at the site and are maintaining surfaces, as evidenced by the reduction of the need for diver maintenance with each subsequent installation

*Map. Allen Coral Atlas*

## A DEEPER DIVE

Mars Assisted Reef Restoration System (MARRS) and the Reef Stars were first used in Australia at Moore Reef as a collaborative effort between tourism operator, Reef Magic Cruises, and Mars Sustainable Solutions, who developed the rubble stabilisation technique. Reef Stars are hexagonal sand-coated steel structures which interlock, stabilise coral rubble and provide a stable base for coral fragments to grow. They have shown impressive results from the initial conception in Indonesia, where coral cover at sites has increased from 10% to over 60% within just two years. The system is based on rebuilding the reef from the bottom-up, with live coral fragments tied to them. More can be found about this technology and its implementation on Green Island *(see pp 107)*.

Reef Magic acknowledge and respect that the Gunggandji are the traditional custodians of Moore Reef and the rubble site chosen for the research trial was adjacent to the Reef Magic pontoon, which was created by Cyclone Yasi in 2011 and has struggled to recover naturally. Marine Parks permits and Sea Dumping Act exemptions were granted to install up to 500 Reef Stars across a 20x30m area over a five year period, utilizing coral fragments of opportunity. Reef Magic ensured a collaborative approach to this project, expanding their site stewardship framework to trial the technique by bringing in collaborators including James Cook University to assist with monitoring (which is undertaken on a six-monthly basis) and Indigenous Land and Sea Rangers to build capacity.

Of the many important lessons and outcomes at Moore Reef, this case offers a unique set of learnings around how tourism operators and Traditional Owners can work together. In this region, Queensland Indigenous Land and Sea Rangers care for Land and Sea Country across 24 regional communities in Australia. The Ranger program is key to the protection and monitoring of the health and resilience of the Great Barrier Reef, local waterways, and coastal lands, managing shore line clean up, pest control, visitor infrastructure, biodiversity monitoring, and education programs. Reef Magic have been working with Traditional Owners to access their Sea Country and provide a platform to share their culture and connection to Country and to the Global Village. Reef Magic also employs local Indigenous cultural guides to tell their stories and TO's are a regular part of education and site stewardship activities organized by Reef Magic. These relationships and programs were, and continue to be, important building blocks to the partnership between Reef Magic, Mars, and Traditional Owners at Moore Reef.

Moore Reef is on Gunggandji Sea Country, and although Reef Magic works closely with the Gunggandji Land and Sea Rangers, many of the staff lack dive training and so were unable to participate in in-water Reef Star implementation and monitoring activities. The Dawul Wuru Yirrganydji Land and Sea Country Rangers, custodians of the adjacent Sea County, have highly trained dive staff, necessary skills and were interested in maintaining partnerships with Reef Magic on the implementation of Reef Stars at Moore Reef. Recognizing and respecting that Moore Reef is on Gunggandji Country, conversations between both Gunggandji Rangers and Yirrganydji Rangers ensured trust and agreement that the Yirrganydji would work on Gunggandji Country through this project with the same care that they would their own.

The Yirrganydji Rangers have participated in all four Reef Star builds at Moore Reef as well as all monitoring trips. Conversations are underway between Reef Magic and Yirrganydji to train Gunggandji Rangers in diving and MARRS implementation. TO's from Kuku Yalanji to the north and Gunggandji to the South are also interested in restoration as well as Catchment groups, Djabugay and Yindinji. While the Yirrganydji Land and Sea Ranger Program's main focus is land-based, they are lead partners in the Kulbul project, a regional restorations and stewardship program that combines Traditional Owner Knowledge with regional monitoring, restoration and site stewardship activities, which operates weekly on Yirrganydji Sea Country. This programme at Moore Reef has been instrumental in capacity training for Rangers,enhanced opportunities for custodianship of their Country, and increased knowledge exchange between Ranger groups. The project also opened conversation about the differences in visitation areas that may be important to tourism operators versus sites that are of cultural significance to TO's, such as sacred sites, story places or hunting and fishing grounds. In reflecting on processes like this, Brian Singleton of the Yirrganydji shared: "TO's are often called on during or when a project is coming to end or when they are needed for their support or in a tokenistic role to sign off on things after the decisions have been made." Moreover, it is a model for how tourism operators and Traditional Owners can work together in reef restoration, stewardship, monitoring, and co-learning.

Image. MARRS Implementation at MOORE Reef, Mars Sustainable Solutions


Image. MARRS Implementation at MOORE Reef, Mars Sustainable Solutions

# IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ A **comprehensive plan for build logistics** (e.g., where and how to perform each task) is dependent on location and capacity of implementation teams to ensure optimal technique implementation
+ A **comprehensive monitoring program** measures eight metrics before and after each installation, and then every six months for five years. Measurement of indicators such as coral cover and fish presence as well as water temperature, presence of marine pests and coral bleaching and disease. This allows for both demonstration of project **success or failure as well as an understanding of the contributing factors**
+ While a **sequential installation** over a period of years at the site helps distribute resources for building, it then **requires separate monitoring on each site**. Moore Reef requires a minimum of four monitoring periods per calendar year, and therefore a large commitment of time and human resources
+ **Extra time for briefing teams and training** ensures teams are prepped for fragmenting, tying, shuttling, and vessel scheduling and operation is critical
+ **Regular monitoring requires collaboration** between Mars Sustainable Solutions, Yirrdanydji Sea Rangers, Reef Magic Cruises, and James Cook University and **regular contact between each organisation allows for testing of new monitoring strategies**, such as Remote Operated Vehicle Cameras (Yirrganydji) and photomosaic software (JCU)
+ The project added **control sites to accurately measure changes** and factors contributing to success or failure of the project.

**WORKING WITH TRADITIONAL OWNERS IN HEALING SEA COUNTRY**

+ **TO's support monitoring activities** and are developing a monitoring technique using a remotely operative vehicle (ROV)
+ **Acknowledge cultural barriers and varying levels of capacity** of Indigenous partners, which may arise from historic injustices and inequalities. For example, 32 people signed up for dive training but did not pass the medical test due to disproportionate public health impacts
+ Conversation amongst TO's and operators can lead to a improved cultural competence and deeper understanding and appreciation of site values and significance, such as sacred hunting and fishing sites or tourism visitation areas
+ Site selection must be mindful of Sea Country custodianship of Traditional Owner groups to ensure that participation amongst differing nations is respected and trusted

**EMPOWERING COMMUNITY**

+ Learnings from the project have been integrated into Reef Magic's **school education programs** and general visitor experience, demonstrating a model to scale awareness building

**SCALING WITH TOURISM OPERATORS**

+ Implementation of Reef Stars can be a part of a **comprehensive sustainable tourism model**
+ Integration with the GBR's only **Indigenous cruising operation**, Dreamtime Dive and Snorkel, showcase the reef through lens of science, sustainability, and Sea Country

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ Clear expectations and managed communications were needed to coordinate the multiple scales of government with influence over a project at this scale, including GBRMPA, the Federal Department of Environment, and State-level health and safety regulators
+ **Training programs need dedicated staff** including a Chief Scientist/Project Coordinators, Technical/Scientific Officers, Dive Leaders, and Boatman/Maintenance technicians

*CORAL RUBBLE STABLISATION AND TRAINING OVERVIEW , GBR BIOLOGY*

*MARRS REEF STARS IMPLEMENTATION VIDEO, CITIZENS OF THE GREAT BARRIER REEF*

*YIRRGANYDJI LAND AND SEA RANGER PROGRAM*

## LEARN MORE

# EMPOWERING COMMUNITY

## INSIGHTS AND PERSPECTIVES FOR IMPLEMENTATION PARTNERS

**Community members are eager to act. Education and training are key tools to engaging community members and mobilizing collective action at both international and local scales.**

+ **Restoration activities can create a sense of stewardship and support for further management. Restoration provides a positive narrative that can empower community members within the often disempowering messaging around climate change**

+ **Carefully managed messaging ensures that restoration is not perceived as a distraction from stress reduction, broader management activities, and climate mitigation**

+ **By training volunteers, researchers can house more corals in nurseries, focus resources on maintenance, and increase capacity to transplant more corals per year**

+ **Citizen science can be used as a tool for awareness building as well as scaling propagation efforts and data collection**

+ **When resources are dedicated to training, the success of propagation can be as effective when done by a volunteer as if done by a scientist**

*Image. Rescue a Reef, Gammon Koval*

EMPOWERING COMMUNITY

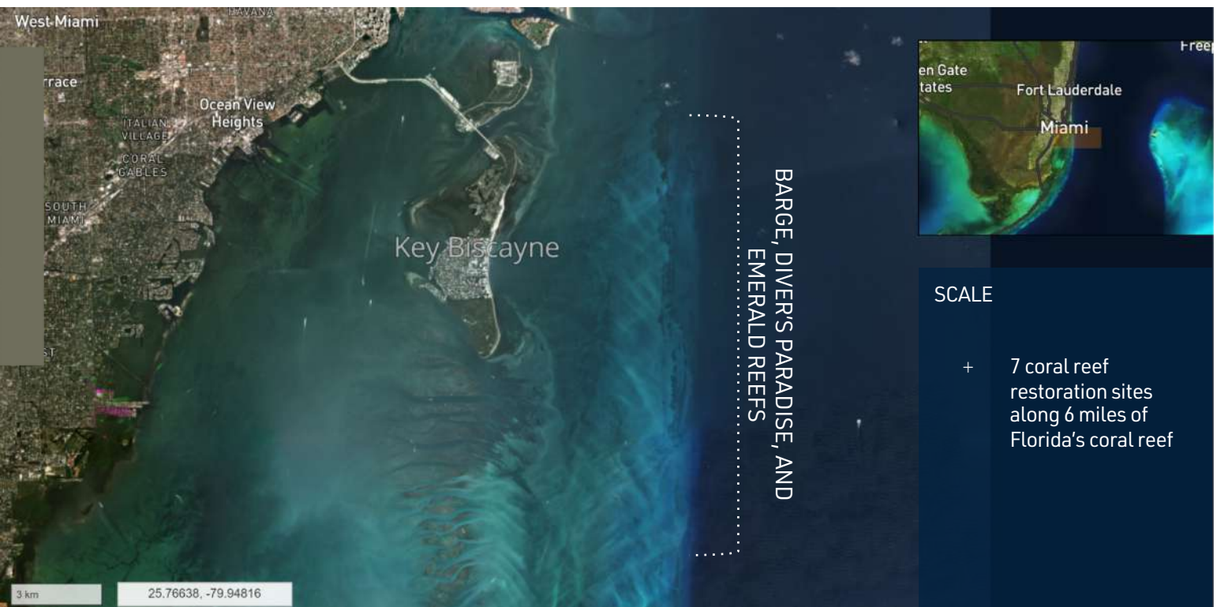
# RESCUE A REEF: CITIZEN SCIENCE IN ACTION

*Source: University of Miami*

| | |
|---|---|
| PARTNERS | University of Miami Rosenstiel School of Marine and Atmospheric Science |
| COORDINATION | Benthic Ecology and Coral Restoration Lab at the University of Miami Rosenstiel School |
| GOALS | + Raise public awareness, scientific literacy, and ocean stewardship towards coral conservation through education and experiential learning<br>+ Repopulate depleted reefs using nursery-grown, threatened coral species<br>+ Assist with scientific research, nursery maintenance, and implementation of restoration interventions |
| SCALE | 7 coral reef restoration sites including Rainbow, Emerald, and Paradise Reef to the city of Miami, FL. |
| TECHNIQUE | Coral Gardening Method using transplanted nursery-reared corals |
| FUNDING | The Rescue a Reef program raises funds through research grants, private donations, and funding partnerships from sources such as Canon U.S.A., Inc., Royal Caribbean Cruises LTD, and the Carolan Foundation. Program citizen scientists also provide critical in-kind donations through their volunteer time and efforts. Lastly, local dive shops and participants contribute to the program's sustainability through subsidised dive charters. The program's annual operating costs is roughly $75K - $100K USD per year, which includes staffing, materials, and boat charters |
| TIMESCALE | University of Miami coral gardening and restoration program established in 2009. Rescue a Reef program launched in 2015 |

## OUTCOMES ON THE REEF

+ **870 participants** engaged
+ **74 expeditions** completed
+ **7,000+ coral colonies out plants**
+ **80%** of participants able to identify the **management tools available** for reef recovery and protection, including restoration, education, regulation, and Marine Protected Areas
+ **Mortality rates of corals** out planted by volunteers after 1 month was **15.3%** compared with **17.8% planted by experts**




## A DEEPER DIVE

Coral losses in South Florida and the Caribbean have been among the most devastating globally in recent decades. Stony coral tissue loss disease, storm damage, temperature anomalies and urban development are key drivers of these losses, and have contributed to a loss of nearly 98 percent of coral across Florida Reefs. While restoration efforts have grown to respond to these declines, cost and manpower bottlenecks in reef restoration programs inhibit implementation at scale.[25]

With a mission to build community and coastal resilience through coral reef research, restoration and citizen science, Dr. Diego Lirman's Benthic Ecology and Coral Restoration Lab at the University of Miami is pioneering an education-based public awareness program to engage community directly with reef impacts and complement reef recovery research. This program, "Rescue a Reef", was developed by Dr. Lirman to both advance scientific research around coral reefs and leverage public participation in coral gardening and restoration. Working together, the program supports a wide range of research projects including learnings around genetic and genomic diversity within restored populations, factors influencing coral growth and survivorship, and impacts from climate change and local stressors. By utilising volunteers, the research team can house and maintain more coral in their nursery, increase their capacity to transplant more corals per year, and raise awareness and action on coral conservation tools.

Through the program, citizen scientists are trained by UM staff in underwater coral nursery maintenance, data collection, and out planting techniques. Participants must have Open Water SCUBA certification or strong snorkelling skills. Some expeditions are fully subsidised while others are only partially subsidised, and contributions of participants range from $0-$75. In one instance, partnering with The Mission Continues' Miami Platoon, 40 veteran and active duty platoon members participated in two dives, out planting over 225 corals. The collaboration was supported by Royal Caribbean Cruises LTD as well as Aquanauts, who provided discount dive gear rentals to the veterans.

These half-day citizen science expeditions take place about once per month and include two shallow water dives (up to 30 feet) led by UM researchers, the first at a nursery, then a coral reef restoration site. In return, participants become educated stewards of their local marine resources. To better understand these benefits, the Rescue a Reef team not only measured the biophysical outcomes on the reef, but also assessed the educational value of their activities through a survey as well as investigated the efficacy of coral transplantation conducted by scientists versus citizen scientists.[26]

*Image. Rescue a Reef*


*Image. Rescue a Reef, Gammon Koval*


*Image. Rescue a Reef, Albert Manduca*

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ **Monitoring is primarily done by professional research team**, while citizen scientists are utilised for out planting and maintenance tasks to encourage education and community
+ Massive corals (brain and star) are **mounted and cemented directly onto the sea bed,** allowing them to grow outward
+ **Both branching and massive corals are primarily out planted via cement** after study showed this methodology was more cost effective and efficient[27]
+ **Masonry nails are used to fasten branching corals** to the sea bed to encourage corals to secure to the reef floor and, eventually, overgrow attachments
+ **Transitioning from masonry nails to cement** increased volunteer out planting efficiency by 80%+

**EMPOWER COMMUNITY**

+ Volunteers can be **utilised for maintenance of coral nurseries** and restoration sites, such as scrubbing algae off nursery trees and marine debris removal off reefs
+ Citizen scientists can be trained to **practitioner-level standard** of coral out planting with 30 minute orientation and in-water demonstrations
+ **Supervision while working underwater** is required to increase safety and efficacy of the planting, (such as regulating breath while working, maintaining buoyancy, and not stirring up sediment)
+ Survey revealed experiential activities demonstrated a **measurable improvement in participant reported knowledge** of coral reef ecology and restoration
+ **Participant perceptions of reef health as degraded did not change following the expedition**, but perceptions around the importance of restoration increased significantly following expeditions
+ **Partnership with other community service-based organisations**, such as veteran and marine debris organisations, can expand audiences

**INNOVATING THROUGH FUNDING AND FINANCING**

+ Citizen scientists potentially serve the dual purpose of **lowering the cost of coral restoration and encouraging stewardship**. Participants commonly cover their own expenses or contribute funds directly to the hosting programs, who in turn provided hands-on, educational coral research and restoration activities
+ **10% of grant-funded** coral research experiment out plants are restored by citizen scientists

## LEARN MORE

*RESCUE A REEF PROGRAM SITE*

*"CITIZEN SCIENCE BENEFITS CORAL REEF RESTORATION ACTIVITIES", D HESLEY ET AL.*

*THE MIAMI SERVICE PLATOON RESCUES A REEF*

*UNDERWATER GARDENING: CORAL REEFS AND AQUACULTURE, SHAYNA KEYLES GOT SCIENCE.ORG*

*RESCUE A REEF: WHAT IS CORAL RESTORATION? WATERLUST FILMS*

*"100 YARDS OF HOPE", A FORCE BLUE FILM*

EMPOWERING COMMUNITY

# SEYCHELLES REEF RESCUERS PROGRAM

*Source: Nature Seychelles, Reef Rescuers Toolkit, The Reef Resilience Network at the Nature Conservancy*

| | |
|---|---|
| PARTNERS | Global Environment Facility (GEF), Nature Seychelles, United Nations Development Program(UNDP), United States Agency for International Development (USAID), Adaptation Fund (AF), Raffles Hotels Praslin, and CMA CGM |
| COORDINATION | Nature Seychelles |
| GOALS | + Undertake vulnerability assessments and stakeholder consultations on coral reef restoration<br>+ Generate a stock of coral colonies for the purpose of reef restoration<br>+ Initiate seascape restoration of selected coral reef habitats as a model for the Seychelles and the Region<br>+ Build stakeholder capacity in Seychelles and the Region and generate a pool of skilled persons for sustained coral reef restoration<br>+ Produce a Green Business Plan to ensure financing and long term sustainability<br>+ Enhancement of food security and reduction of risks from natural disasters through the restoration of degraded reefs |
| SCALE | Transplanting area of 5,225 m2 (.52 hectares) as of 2016 with a new goal of transplanting 1 hectare by 2026 |
| TECHNIQUE | Coral Gardening Method using live coral fragments |
| FUNDING | Approximately $1M in funding from USAID, GEF and UNDP, of which USAID contributed $513,825 for 2011- 2016; $1.2M in funding from Adaptation Fund for 2020 to 2026 ; In-Kind, over 60 volunteers from 11 countries trained between 2011 to date |
| TIMESCALE | Project launched in 2010 with recruitment monitoring timelines of 2-5 years, extended to 2016 |


*Map. Allen Coral Atlas*

## A DEEPER DIVE

The abundance of reef cover across the Indian Ocean was severely damaged by a series of catastrophic events; with 90% loss of coral live cover in 1998 following an El Nino event, the 2004 tsunami, and another 50% in a 2016 warming event. These events severely affected the coastal communities across western Africa and the Indian Ocean, whose livelihoods depend on the local fish species living in harmony around the reef sites. The reefs that were damaged in 1998 had shown a slow natural recovery process.

Reef Rescuers was developed by Nature Seychelles, a Seychelles based NGO, with the goals of restoring the fringing coral reef within Cousin Island Special Reserve, a no-take marine reserve. Nature Seychelles has successfully implemented, scaled, and developed detailed guidebooks for implementation and engaging and training volunteers in support of coral gardening. These learnings are applicable to engaging community members who are looking in direct action in support of restoration activities.

Through stakeholder engagement workshops, Nature Seychelles worked with local community members to introduce concepts and techniques for coral reef restoration. Participation of local people was embraced by the project as crucial to the success of the project overall and in the implementation of nursery filling and transplantation of colonies, and two were recruited as staff for the project and work as a part of the core implementation team today. A separate workshop also brought together representatives of the Seychelles National Parks Authority, Seychelles Fishing Authority, Seychelles Hospitality & Tourism Association, Praslin Development Fund, Seychelles Islands Foundation and local boat charters.

The effort involves divers or snorkelers who were interested in learning about reef conservation and restoration and provided a clear mechanism for volunteering and experiencing restoration in action. Over the course of three months, Volunteer Scientific Divers assist the Reef Rescuers team with the daily operations of the project on Praslin Island. Some of these activities include building, stocking, maintaining of in-situ coral nurseries, transplanting, and monitoring of coral diversity, growth, invertebrates, and fish communities. They also support data management and analysis as well as equipment management. The volunteer roles require scientific diving skills, high physical fitness, and are required to demonstrate previous experience working underwater.

## OUTCOMES ON THE REEF

+ **24,431** nursery-gown coral colonies transplanted to **5,225m2** between 2011 and 2014
+ **40,000** corals grown in **13** underwater nurseries from **32 species** and **24,000** successfully transplanted since **2010**
+ **8,300** coral are currently being grown in **3** new nurseries to be transplanted in **February** this year
+ **700%** increase in coral cover, up from **2%** in 2021 to **16%** by the end of 2014
+ **Five-fold increase in fish species** and **three-fold increase in fish density**, and **two-fold increase in coral settlement** and recruitment found at transplant sites
+ Transplants found to **respond better to stressful conditions**, such as increasing temperatures and algal blooms

*Image. Volunteers transplanting coral fragments, Nature Seychelles*

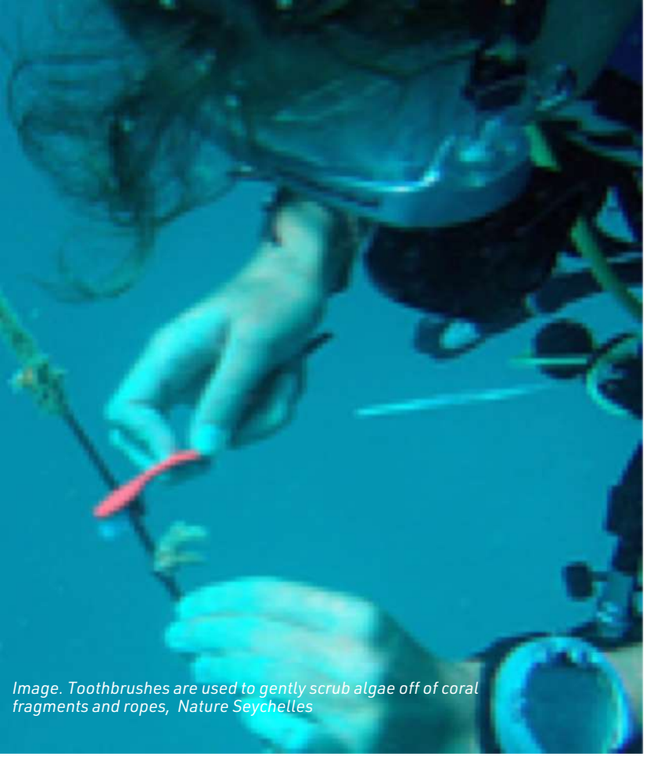


*Image. Toothbrushes are used to gently scrub algae off of coral fragments and ropes, Nature Seychelles*

*Image. Volunteers preparing to transplant coral fragment, Nature Seychelles*


*Image. Cousin Island Nature Seychelles*

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ **Effective site selection accounts for a range of factors**, including legislated protected area, dominance of substrate, evidence of degradation, depth gradient, low turbidity and hydrodynamics, and area size as well as threats like overfishing and pollution
+ **Control sites are necessary** to monitor changes in transplanted sites over time
+ Nurseries, such as rope and net nurseries, can themselves become **floating reef ecosystems**
+ **Ongoing cleaning of coral nurseries and ropes** increases transplantation success
+ To maximise resilience, the project **tested a hypothesis** that fragments that withstood 1998 El Nino-related bleaching event would improve resilience of transplanted area
+ To allow adequate time for assessment and validation, invest resources in monitoring and considering extensions to **assess impacts of unforeseen bleaching events**

**EMPOWERING COMMUNITY**

+ Reef Rescuers Training Program was delivered through a **workshop format** followed by field training, which has trained 60 volunteers to date
+ Citizen science garners **local and international interest** in coral restoration training
+ **Volunteers need diving skills** and time commitment of several months to participate

**SCALING WITH TOURISM OPERATORS**

+ Identifying partnerships with the tourism sector can provide for new products that can be incorporated as a part of industry environmental management programs and **Corporate Social Responsibility activities**, such as with Hotel Raffles Praslin

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ **Training programs need dedicated staff** including a Chief Scientist/Project Coordinators, Technical/Scientific Officers, Dive Leaders, and Boatman/Maintenance technicians
+ Cataloguing of all strategic, technical, logistical, training, material, and management strategies and learnings **promotes scaling and transparency in a shared** Reef Restoration Toolkit

**INNOVATING THROUGH FUNDING AND FINANCING**

+ Monitoring costs of large-scale reef restoration needs to include the **life-cycle of coral reef restoration technology**, which is estimated to be **$200K USD per year for 6 years to restore 1 hectare of reef** using both land- and ocean-based nursery techniques
+ Designating coral farms as a **mariculture enterprise** can reduce costs by reducing the legal barriers to entry and scale production of a commercial product

## LEARN MORE

*SEYCHELLES REEF RESCUERS REEF RESTORATION TOOLKIT*

*A DAY IN THE LIFE OF A REEF RESCUER*

*RESTORING CORAL REEFS IN THE FACE OF CLIMATE CHANGE IN THE SEYCHELLES, USAID, CASE STUDY*

*REINVENTING REEFS IN THE ANTHROPOCENE: RESTORING ECOSYSTEM SERVICES AND SCALING UP BLUE ECONOMY OUTPUTS, NATURE SEYCHELLES*

*"CORAL REEF PROJECT 'HISTORIC OPPORTUNITY,' AMBASSADOR SAYS"*

*REEF RESCUERS CORAL REEF RESTORATION IN SEYCHELLES*

# SCALING WITH TOURISM OPERATORS

## INSIGHTS AND PERSPECTIVES FOR IMPLEMENTATION PARTNERS

**Engaging tourism operators creates avenues for sustainable business models, widens outcomes for restoration projects, and may support scaling.**

+ **Projects are optimised by local knowledge and those who regularly visit sites**

+ **Tourism operators are an invaluable platform for communicating the threat and potential solutions to a wide range of visitors and building conservation literacy. Diversifying offerings like hands-on activities, demonstrations, and eco-tourism are vehicles for awareness building and economic development**

+ **Tour operators are on the frontlines and enable scaling efforts geographically and over time by upskilling the workforce**

+ **Tourism operators are a resource of skilled staff, equipment, and capacity that is critical for routine implementation and monitoring techniques**

+ **Tourism operators are motivated by strong sense of stewardship for the reef and are influential advocates in communities that ensure the reef retains its health and world heritage values**

*Image. Coral Nurture Program*

SCALING WITH TOURISM OPERATORS

# BOATS4CORALS WHITSUNDAYS

*Source: Mel Rodgers, Great Barrier Reef Foundation; Johnny Gaskell, Reef Catchments*

| | |
|---|---|
| Partners | Australian Institute of Marine Science, Southern Cross University, Great Barrier Reef Foundation, Reef Catchments, Local Tourism Operators (Ocean Rafting, Red Cat Adventures, SV Whitehaven, Southern Cross Sailing, Daydream Island), Ngaro Traditional Owners, Reef Check Australia |
| Coordination | Mark Gibbs, AIMS, Lead Operations; Peter Harrison, SCU, Lead Research; Johnny Gaskell, Reef Catchments, Project Manager |
| Goals | + Train Whitsunday tourism operators, vessel owners, and the community to collect coral spawn from the ocean surface during an annual spawning event<br>+ Conduct and implement research to deliver and support reef restoration and adaptation for the Great Barrier Reef<br>+ Capture coral eggs and sperm from healthy reefs to fertilise and rear millions of baby corals in enclosures on the Reef<br>+ Deliver larvae into small areas of damaged reefs to restore and re-populate |
| Scale | 3 priority, high tourism value sites in the Whitsundays; 5 pools deployed in October and November 2021 |
| Technique | Larval re-seeding and settlement prep if necessary (e.g., algae removal). |
| Funding | $4M in funding for Reef Islands from Lendlease, the Australian Government's Reef Trust, the Queensland Government and the Fitzgerald Family Foundation; Boats4Corals funding includes $900K over 5 years. |
| Timescale | Pilot stage |

## OUTCOMES ON THE REEF

+ **18M** coral larvae collected for deployment on to the reef through Boats4Corals
+ **Large number of corals deployed much faster on dead sites**


## A DEEPER DIVE

The Whitsundays tourism industry is leading the charge in tourism-led reef restoration, with local tourism operators joining the Great Barrier Reef Foundation and its partners to deploy Coral IVF on priority sites in the Whitsundays, a region of 74 islands that accounts for 40 percent of Great Barrier Reef visitation each year. In a world-first, tourism operators in the Whitsundays are learning to restore local reefs using the innovative Coral IVF technique pioneered by the Great Barrier Reef Foundation and researchers at AIMS and Southern Cross University. Coral IVF is a process to capture coral eggs and sperm, called spawn, from healthy reefs and rear millions of baby corals in specially-designed floating pools on the reefs. When they are ready, they are delivered onto damaged reefs to restore and populate them.

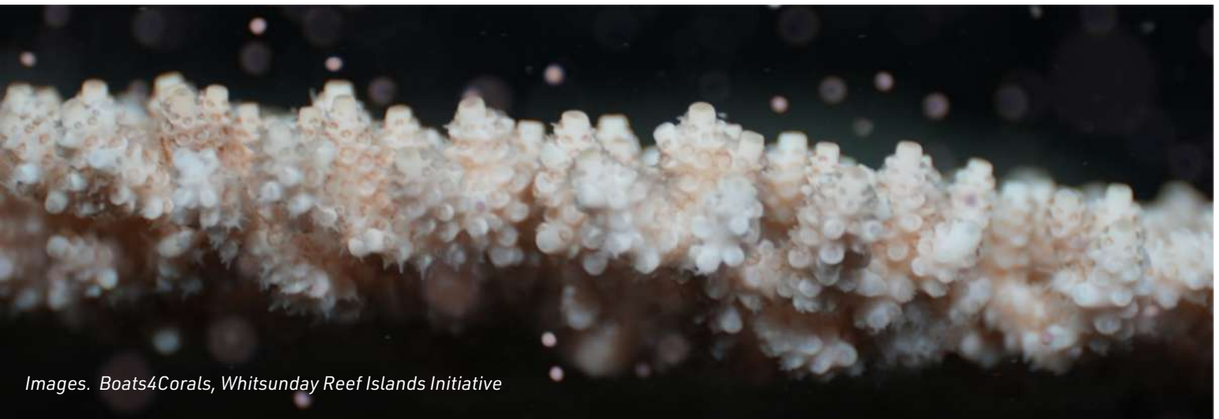
Boats 4 Corals, a program of the GBRF Reef Island Initiative, was designed to test how local tourism operators and other types of citizen science groups could safely capture, spawn and deploy a nursery pool from a tourism vessel. This technique involves a 4m$^2$ inflatable pontoon lined with a 3m$^2$ net that cultures the larvae in water and is designed to sit alongside the operator vessel. Following a pilot study in October 2020, which transferred larvae cultures to a settlement site, the team has observed that the corals have completed the reproductive process and successfully settled on the new site. They are now looking to scale the technique to different reef areas with higher volumes of people and scale the larval culture in smaller, manageable pools. In the long term, the team envisions that Coral IVF might be mainstreamed into standard operating procedures with standardised equipment that can be easily deployed by operators and citizen scientists.[28]

In its pilot stages, four local operators participated, motivated to safeguard the patches of reef that they frequently visit. Operators were self-selecting, trained in the technique, and committed to transporting academics to see sites during spawn events. In a reciprocal relationship managed through a set of standard operating procedures (SOPs), the Charter Boat Industry and Association coordinates tourism vessel participation and in turn, guides become leaders in Coral IVF and expand their knowledge to educate tourists. In its pilot stage, the program worked with tourism vessels to ensure insurance and is looking to expand to private chartered vessels in the future.

As a part of the Reef Island Initiative, project governance includes a local advisory group consisting of the Great Barrier Reef Marine Park Authority (GRMPA), National Parks, and the local council. All permitting for the project is governed by the GBRMPA since the project takes place in the jurisdiction of the marine park. Further, a local project manager, embedded in the Natural Resources Management organisation in the catchment area supports overall project management and coordination.


*Image. Boats4Corals, Whitsunday Reef Islands Initiative*


*Image. Boats4Corals, Whitsunday Reef Islands Initiative*



*Images. Boats4Corals, Whitsunday Reef Islands Initiative*

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Use of **Marine Robots, Rangerbots,** can assist with mapping water quality and bleaching levels across expansive areas and guide site selection
+ **Currents and coral spawning at each location behave differently** depending on geography in the Marine Park, so **methodologies need to be customised** by location.
+ By adapting design and collection technique based on this learning, the team **improved larval collection from 4M in year 1 to 18M in year 2**
+ A spatial analysis prepared by the University of Queensland informed **site prioritisation for the highest restoration anticipated benefit** based on current and historic parameters: geomorphic variation, wave exposure, dissolved inorganic nitrogen, suspended sediment, benthic cover, larval connectivity.
+ **Spatial mapping and data proved essential** to both coral restoration site selection as well as identification of high hard coral diversity suitable as donor colonies

**WORKING WITH TRADITIONAL OWNERS IN HEALING SEA COUNTRY**

+ Engaging Traditional Owners is creating opportunity to **integrate TO storytelling** into spawning events and tour offerings

**EMPOWERING COMMUNITY**

+ Integrating tourism with scientific research is **driving palatability of in-water restoration** practices and testing avenues for local involvement
+ The safety and support of **reef health must be demonstrated first before tourists** can be directly involved in the project, and allowability will be determined by GBRMPA

**SCALING WITH TOURISM OPERATORS**

+ Restored sites pose great potential to **support local economic opportunity** in future
+ Upskilling during COVID-19 crisis could **ultimately broaden skills in the long-term**
+ Leveraging existing local industries supports **workforce development and scaling**
+ Operators are **self-selecting** to sustain economic viability of sites and out of deep motivation to support reef health

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ **Standard Operating Procedures** for pool deployment, anchoring calculations, and discharging/re-seeding **streamline permitting and procedures** to enable scaling
+ **Embedding a project manager** in Natural Resources Management body ensures coordination of complex stakeholder groups

## LEARN MORE

*CORAL IVF PROCESS AND PROJECTS, GREAT BARRIER REEF FOUNDATION*

*WHITSUNDAYS TOURISM INDUSTRY ONBOARD TO DELIVER NEW LIFE TO DAMAGED REEDS, SOUTHERN CROSS UNIVERSITY*

*"REEF RANGERBOT BECOMES 'LARVALBOT'TO SPREAD CORAL BABIES" QUEENSLAND UNIVERSITY OF TECHNOLOGY*

*BOATS4CORALS: WHITSUNDAYS TOURISM INDUSTRY ONBOARD TO DELIVER NEW LIFE TO DAMAGED REEFS*

SCALING WITH TOURISM OPERATORS

# CORAL NURTURE PROGRAM

*Source: David Suggett, Coral Nurture Program*

| | |
|---|---|
| PARTNERS | Coral Nurture Coordinating Team, Operator Partners (Wavelength Reef Cruises, Ocean Freedom, Passions of Paradise, Quicksilver/Great Adventures, Sailaway, Down Under Cruise and Dive), INLOC, Traditional Owners, Great Barrier Reef Marine Park Authority |
| COORDINATION | Prof David Suggett (University of Technology Sydney), Mr John Edmondson (Wavelength Reef Cruises), Dr Emma Camp (University Technology Sydney) |
| GOALS | + Build ecological resilience by boosting (and maintaining) coral diversity and cover<br>+ Enable reef stakeholders through partnership with scientists<br>+ Build stewardship capacity and sustainability through innovative coral propagation approaches<br>+ Employ research to ensure the scale of propagation and survivorship reported is validated to ensure program credibility and scalability<br>+ Legacy and knowledge sharing through new approaches to target what species to plant, where and when |
| SCALE | 15 sites across 6 high value tourism reefs offshore Cairns-Port Douglas. Current out planting spans 1.7ha |
| TECHNIQUE | Low cost nurseries for coral propagation and Coralclip® technology for out planting |
| FUNDING | Initial Feasibility (2018-2019) and Proof of Concept (2019-2020) phases funded by the Australian & Queensland Government "Boosting Coral Abundance" Challenge. Current Phase (2021-2024) is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation, and with propagation and planting funded in partnership with Reeftip Drinks Co. (DIAGEO), with support in 2021 also to operators under the Queensland Government and Great Barrier Reef Marine Park Authority's "Activate" scheme. |
| TIMESCALE | Initiated in 2018, with the goal to plant a minimum of 100,000 corals by 2024. Over 60,000 corals have been planted by the end of 2021. |


## A DEEPER DIVE

The Coral Nurture Program on the Great Barrier Reef is a collaborative partnership between tourism operators and scientific researchers to support long-term stewardship of the reef. The program utilises tourism vessel infrastructure as well as the skills, experience, and knowledge of personnel to deploy interventions at tourism sites that are of high ecological and economic value. The program uses a new and innovative method, Coralclip ®, to undertake coral propagation, which can be more efficient and cost-effective than alternative options to plant coral, which is an order of magnitude more efficient and cost-effective than conventional attachment methods, and alongside low cost coral nurseries are integrated into daily tourism operations. Further, tour operators are uniquely positioned to educate visitors about management activities and reef conservation.

In developing these new techniques for coral propagation at scale and in partnership with the tourism industry, Coral Nurture Coral Nurture Program identified major limitations in how research had historically viewed tourism as merely end-users of science, as opposed to equal partners. By running training programs in coral propagation techniques, monitoring growth and survivorship of nursery stock and out plants, the program builds capacity in stewardship methods alongside those already in place (e.g., Crown of thorns removal, reef health monitoring). In doing so, Coral Nurture Program builds social resilience by equipping operators to undertake other essential activities during tourism downturns where vessel time and trained staff can be financed. They also support the economic resilience of operators, who would otherwise be wholly dependent on visitation numbers, by paying for boat operator time to transport researchers. The program is also working with local media outlets to promote restoration activities and needs while also maintaining a realistic, yet positive, perception of reef condition.

The program found that tour operators were motivated to steward and rebuild reef health in four key ways: altruistic incentive to steward the reef and maintain healthy tourism sites, opportunity to leverage federal subsidies for training and upskilling, opportunity to generate new educational and service offerings, and address media portrayal of a "dead" reef. For example, through a Government funded "Activate Tourism" COVID-19 stimulus package, operators trained in coral planting could be funded to implement planting (in lieu of operating tours) as a means to retain vessels and skilled staff during tourism downturns.

Initial activities (Phase 1: Feb 2018 - 2019) focused on designing workflows and completing ecological surveys, historical site knowledge, and development of Coralclip ® to replace chemical fixtures. Phase 2 (April 2019 - 2020), focused on propagation on new reefs with varied environmental and conditions alongside varied tour operators and business models ranging from smaller non-diving sailing based operators to large super-catamaran operators. During this phase, standardising workflows, training, site valuations, and data reporting were critical. Phase 3 now includes broader adoption across further tourism and other stakeholders (e.g., Traditional Owners), robust tracking of ecological responses to out planting at scale, and development of co-financing models to ensure sustained operations.

## OUTCOMES ON THE REEF

+ **5** operators and **2** other stakeholder partners engaged in Cairns-Port Douglas
+ **>60,000** corals planted since August 2018 until December 2021 across **15 sites**
+ **Nursery corals first spawned** in 2020 and the very first coral fragments planted in 2021 spawned, indicating that efforts are stimulating new natural regeneration
+ Long-term survivorship of planted corals using Coralclip® can range from **75-95%** but typically is **>80%** across all sites
+ Surveys have shown that planting **overcomes recruitment bottlenecks** and retained **high survivorship** during the 2020 heat wave on the northern Great Barrier Reef


*Image: Coral Nurture Program, Paige Strudwick*

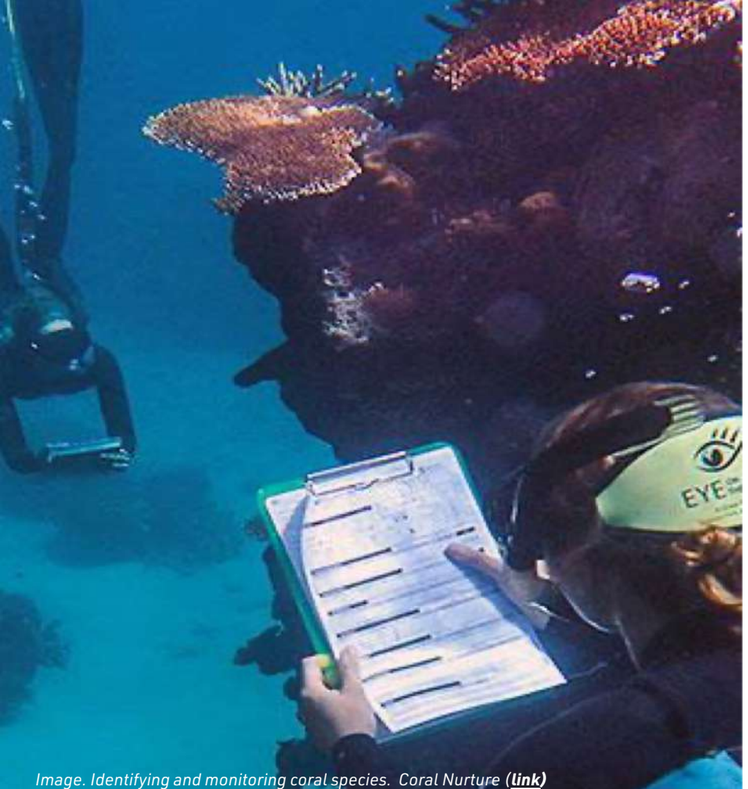


*Image. Identifying and monitoring coral species. Coral Nurture (**link**)*

*Image. Coral propagation nursery platform, Coral Nurture (**link**)*

*Image. Coral Nurture Program*

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Propagation, out planting and general ecological success can be **monitored by both academic researchers as well as tourism operators**
+ Nursery design and out planting should consider location-specific requirements. For example, floating coral nurseries need to be positioned where herbivorous fish can maximise 'natural cleaning'
+ **Heat tolerance** needs to be accounted for in future high-value implementation sites
+ **Measuring out planting success in replicate plots** alongside controls is essential to gauge effectiveness against natural recovery rates and makes visible tourist demonstrations
+ **Sourcing coral as fragments of opportunity alone may limit species diversity** available for planting, but buys time to scale up more diverse nursery stocks
+ **Risk analysis and impact landscape maps** demonstrated reef connectivity, bleaching, and stress factors on reefs and informed site selection

**SCALING WITH TOURISM OPERATORS**

+ **Training operators with new capacity for coral propagation-based reef rehabilitation** (and associated monitoring) provides economic resilience where activities can be financed
+ **Low-cost tools and standardised work flows** ensure minimal disruption to normal operator functions
+ **Operator participation required adherence to an equitable code of operation** that prioritizes reef heritage values, and should be aligned to other stewardship activities (e.g., high standard operators)
+ **During tourism downturns** (e.g.,COVID-19 border closures) operators can repurpose vessels and trained staff from tourism to intensive propagation-based stewardship where financing is available
+ **"High value" reef sites that generate the highest economic value** and are the most routinely visited were selected for stewardship activities. This reduced extra labour costs and streamlined logistics

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ Strict permitting conditions apply to out planting, including new standards that ensure the planting is done with coral species and populations that have survived prior bleaching events to **support climate adaption in reefs**
+ **New permitting processes ensure streamlined implementation** and transparency, such as GBRMPA's new Fragment of opportunity permit (now clause) developed during the initial stages of Coral nurture Program

**INNOVATING THROUGH FUNDING AND FINANCING**

+ **Grants supported initial training and seed funding for operator propagation,** necessary for proof of concept to attract larger financing
+ Every $1 AUSD of grant funding can be **matched by as much as $10 AUSD in kind** based on tourism operations
+ Every $1 spent on coral propagation r**etains $10 reef tourism value** based on how current coral propagation offsets losses
+ **Sustained financing** for operations are currently in place through a blended finance model of Government, Foundation, and Corporate support
+ **Sustained financing through small scale activities are generally not advised** where investment (and return) cannot be tracked , e.g., adopt-a-coral"
+ Cost of planting through Coral Nurture Program is typically **$1-$4 per coral**, depending on operational context

## LEARN MORE

CORAL NURTURE METHODOLOGY

CORALCLIP®: A LOW-COST SOLUTION FOR RAPID AND TARGETED OUT-PLANTING OF CORAL AT SCALE. SUGGETT ET AL. 2020.

CORAL NURTURE PROJECT ON THE GREAT BARRIER REEF WITH PASSIONS OF PARADISE

# TESTING TECHNIQUES AND STRATEGIES

## INSIGHTS AND PERSPECTIVES FOR IMPLEMENTATION PARTNERS

**Defining the rationale, evaluation of sites and techniques, consideration of future climate conditions, communications, and monitoring are key criteria for intervention selection and long-term learning.**

+ **Testing a range of pilot projects can support decision-making in anticipation of catastrophic events**

+ **Site selection should be informed by ecological connectivity, environmental conditions such as, current and future projected climate conditions, current stresses, and existing levels of resistance and resilience as well as socio-economic goals, such as tourism value**

+ **Logistics and accessibility of sites matters both for implementation and maintenance**

+ **Restoration which supports adaptation, such as the propagation of heat tolerant species or genes, may enhance resilience in the face of climate change**

+ **Policy-backing, political will, and sustainable governance and funding are necessary to ensuring long-term success of interventions and programs**

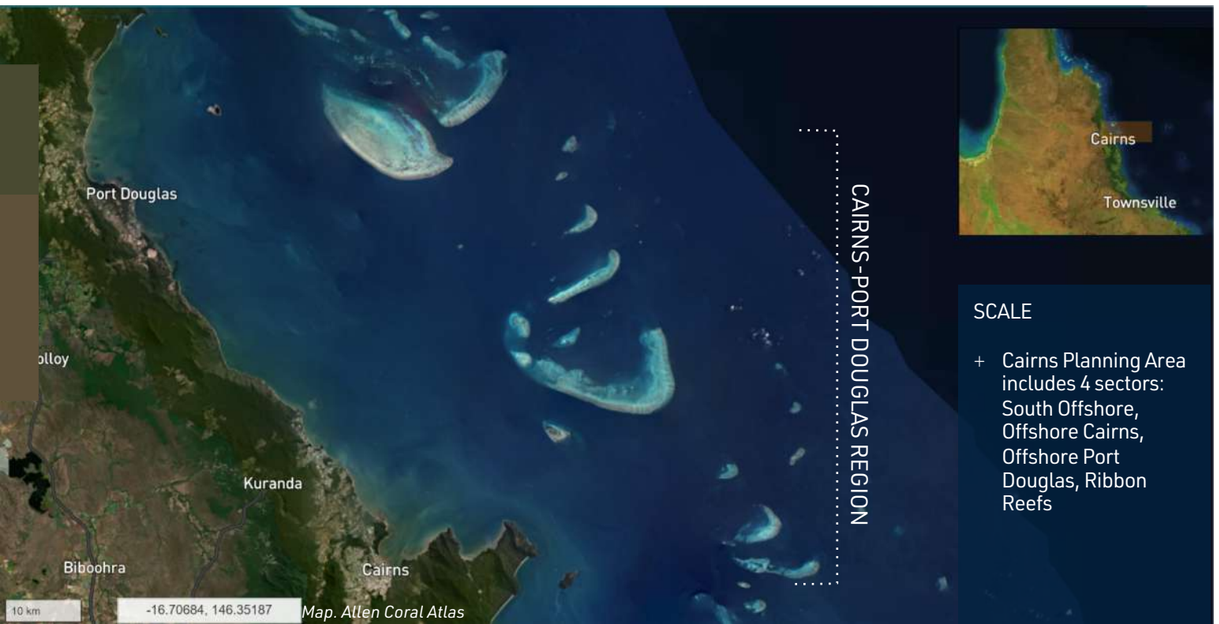
*Image. Coral Nurture Program, Paige Strudwick*

TESTING NEW TECHNIQUES AND STRATEGIES

# CAIRNS-PORT DOUGLAS REEF HUB

*Source: Jennifer Loder, Great Barrier Reef Foundation; Stewart Lockie, James Cook University The Cairns Institute; Brian Singleton, Yirrganydji of the Reef Restoration and Adaptation Science Co-Design Group; Sam Stone-Jovicich and Bruce Taylor, CSIRO*

| | |
|---|---|
| PARTNERS | The Hub is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation. The Hub is coordinated by TropWATER and enabled by the partnership's Community Reef Protection and Traditional Owner Reef Protection components, and the Reef Restoration and Adaptation Program with the Hub Steering Group and a network of local partners. |
| COORDINATION | Hub Coordination is delivered as a part-time role by James Cook University's TropWATER with guidance from the Hub Steering Group |
| GOALS | + **Coordination**: Strengthening on-ground project delivery, learning and sharing<br>+ **Communication**: Creating a forum for Traditional Owners, the tourism industry and community to share ideas, stories and lessons<br>+ **Connection**: Connecting local-scale projects with those underway in other regions as well as the larger-scale Reef Restoration and Adaptation Program<br>+ **Capacity:** Providing tools and capacity-building to strengthen the design, implementation and monitoring of restoration projects to deliver outcomes |
| SCALE | Cairns-Port Douglas region, Great Barrier Reef |
| TECHNIQUE | Network of people focusing on coordination, engagement, and capacity building amongst the multiple parties working on restoration and site stewardship |
| FUNDING | Funding towards Hub collaborative design, a locally-based part-time Coordinator and priority knowledge sharing, training, outreach and communication activities. Separate on-ground project funding for towards local-scale coral rehabilitation and stewardship projects and Traditional Owner-led projects. |
| TIMESCALE | Concept launched in mid 2020, with investment in the pilot program through June 2024 towards long-term planning |




## A DEEPER DIVE

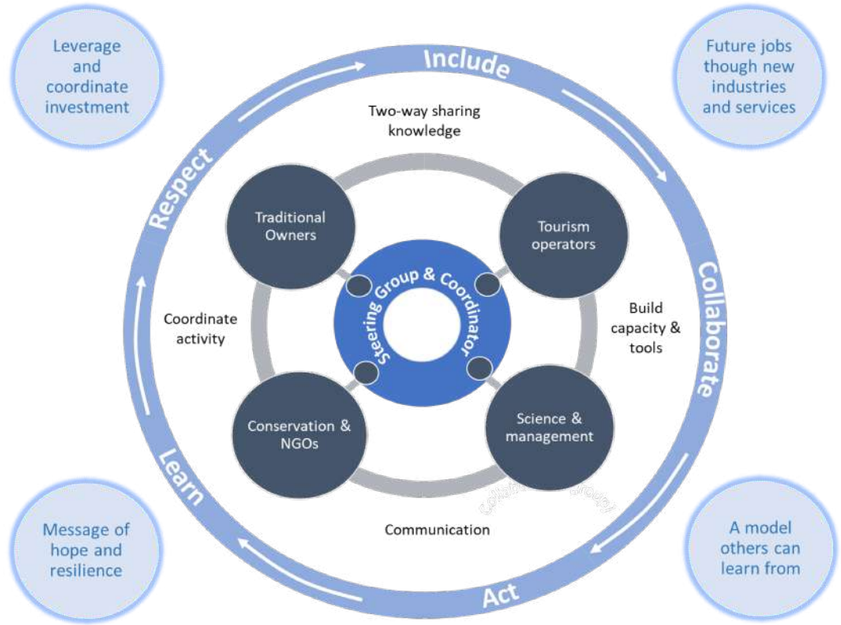
The Cairns-Port Douglas region is home to multiple coral restoration and stewardship projects supported by Traditional Owners, scientists, tourism operators and the community who are deeply committed to a healthy and resilient Reef. As the diversity and scale of active intervention projects grows to help the Great Barrier Reef adapt and recover in the face of a changing climate and other local threats, a greater need was identified for place-based formal knowledge networks, coordination and collaboration.

In late 2020, six focus groups came together to design a Cairns-Port Douglas Restoration Hub. Together, over 30 individuals from over 20 organisations contributed to the articulation of Hub goals, language, values, opportunities, and activities. Key principles and agreements around Hub activities were discussed, recognizing that stakeholders and partners from diverse backgrounds, organisations, territories, and skill sets are convening through this Hub. Some of these themes of operation include:

- **Respectful** interaction and recognition of efforts, rights, knowledge, and diverse impacts
- **Inclusive** as an open network, with different interested and ideas about restoration
- **Collaborative** and neutral space that is non-competitive and focuses on uniting many partners towards shared purpose
- **Action-focused** towards individual and collective action, accelerating what's already happening and not adding complexity or extra work
- **Supportive of learning** and open to trialling new and different approaches before scaling as well as openly communicating challenges and unexpected outcomes

In 2021, the Hub focus was on building foundational governance frameworks. A Steering Group was selected through an open process to be representative of the diversity of the Cairns-Port Douglas Reef Hub network and provide localised strategic leadership to guide the design and operations of the Hub. A local Coordinator role was collaboratively developed and filled to provide critical implementation capacity to support the Hub from early 2022. In 2022 the Hub will transition to implementation with a series of activities to implement short-term tangible opportunities and build longer-term pathways to support shared goals. Early discussions have focused around enabling holistic approaches to care for Country with Traditional Owners, strengthening relationships and pathways to connect with the Reef Restoration and Adaptation Program (RRAP), and fostering knowledge sharing and learning within and beyond the network.

A visual depiction of the Hub concept developed with input from the focus groups is below.



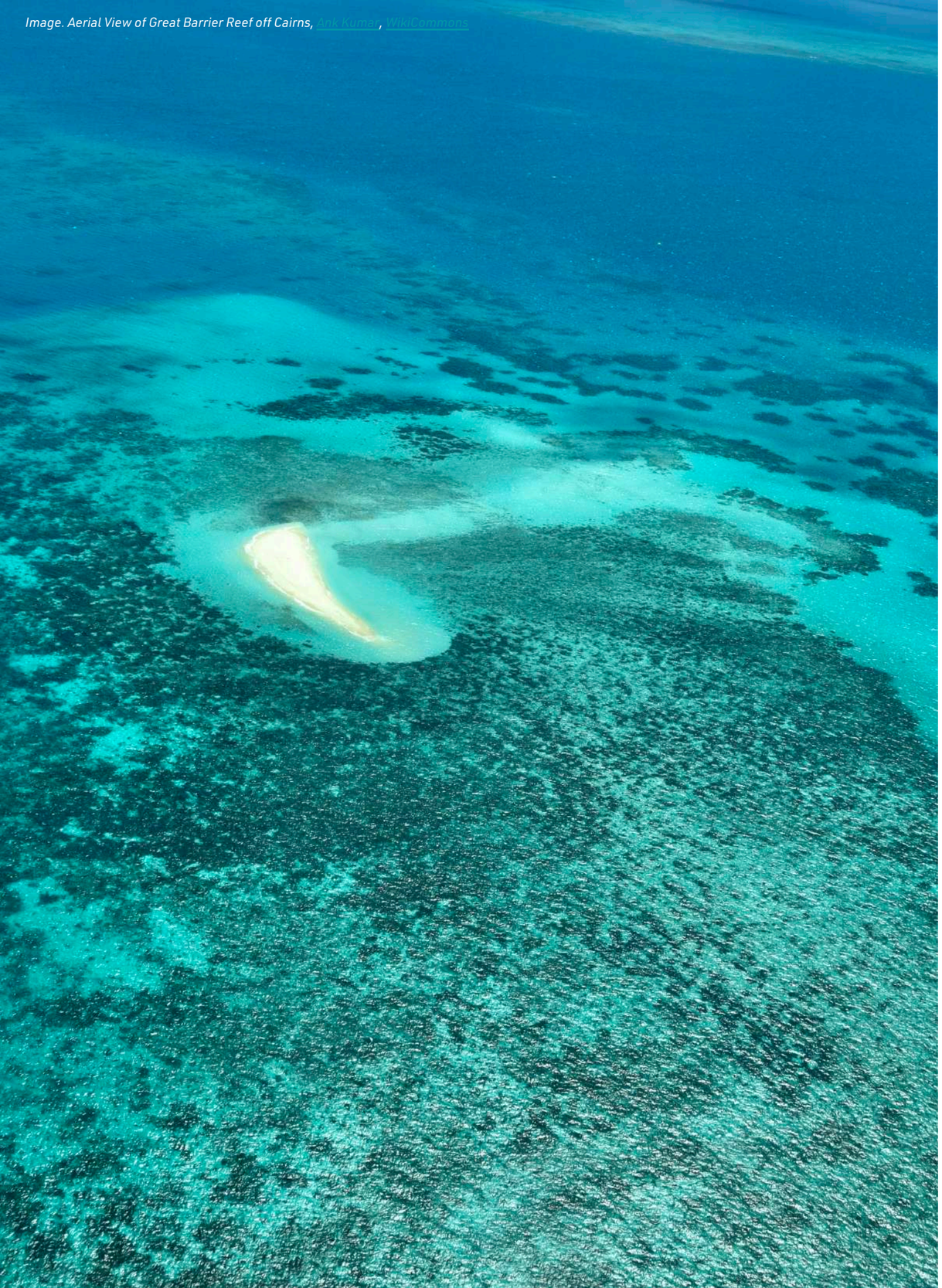


*Image. Aerial View of Great Barrier Reef off Cairns, Ank Kumar, WikiCommons*

# IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Globally, there are numerous efforts to design monitoring and evaluation frameworks, but there are greater needs to **tailor the approach** for the Great Barrier Reef
+ There is interest in strengthening channels for **sharing, piloting and scaling** proven frameworks to enable greater collective impact through a range of types and scales of reef protection and rehabilitation actions
+ Connecting a range of local-scale site stewardship activities with growing research and development building momentum through the Reef Restoration and Adaptation Program (RRAP) is important to build clear **pathways and information exchange across science and practice**

**WORKING WITH TRADITIONAL OWNERS IN HEALING SEA COUNTRY**

+ Creating space and time for **two-way learning and building of cultural competency** between Traditional Owners, community, and science researchers ensures that communication is supported and aligned
+ Language such as "reef healing" reflects a **broader scale as well as cultural and spiritual significance** for actions, not typically captured in planning and activities.
+ Traditional Owners are **"partners," not "stakeholders,"** reflecting their inherent rights and custodianship for Land and Sea Country
+ Supporting community partners with **early engagement and enablement of genuine partnerships** with Traditional Owners ensures culturally sensitive approaches and builds confidence for respectful relationships. This learning is a continual and ongoing commitment

**EMPOWERING COMMUNITY**

+ **Language is important**. Restoration can be a polarising term that some feel portrays a negative image of a damaged Reef to people outside the region or implies poor management
+ Planning and action timelines must account for **trust and the time it takes to build it** amongst partners and varied Traditional Owner communities
+ Enabling stewardship requires that actions are both scientifically based and **culturally appropriate** and reflective of a collective narrative about the reef and region

**SCALING WITH TOURISM OPERATORS**

+ Active intervention is still relatively new on the Great Barrier Reef and therefore connecting with management for program design can help identify and address potential challenge areas for policy, permits and process
+ **Tourism operators are critical partners for reef stewardship**. They bring local knowledge, operational capacity, and commitment to protecting high-value tourism sites and sharing this with their guests

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ A **dedicated Coordinator** is central to connecting across a range of partners with interests in Reef restoration and stewardship activities, helping to operationalise collaborative approaches to design and deliver impactful activities
+ The program is **committed to 'learning by doing'** and refining or adapting approaches as the project evolves through monitoring, evaluation, and learning

**SCALING AND FUNDING**

+ Identifying shared priorities may help to enable future investments in piloting and scaling work. Separate to the Hub, an open call for coral restoration and stewardship projects was called including pilot projects and scaling projects. Learnings from these projects will be shared across the Hub network
+ Future grants towards Traditional Owner Sea Country will facilitate healing of mangroves and sea grasses, in addition to corals - applying a more **holistic lens to healing Sea Country**

CAIRNS-PORT DOUGLAS REEF HUB WEBSITE

## LEARN MORE

TESTING NEW TECHNIQUES AND STRATEGIES

# REEF ISLANDS INITIATIVE WHITSUNDAYS

*Source: Mel Rodgers, Great Barrier Reef Foundation; Johnny Gaskell, Reef Catchments*

| | |
|---|---|
| PARTNERS | Great Barrier Reef Foundation, Great Barrier Reef Marine Park Authority, Queensland Parks and Wildlife, Local Council, University partners (Australian Institute of Marine Science, Southern Cross University, University of Technology Sydney), Whitsundays Charter Boat Industry Association, Ngnaro Traditional Owners, Whitsunday Regional Council, Reef Catchments, Tourism operators (Ocean Rafting, Red Cat Adventures, SV Whitehaven, Southern Cross Sailing, Daydream Island, Hayman Island, Reef Check Australia, Kiana Sail & Dive) |
| COORDINATOR | Johnny Gaskell, Project Manager, Reef Catchments |
| GOALS | + Build knowledge base by bringing together best available science, research, and mapping together with Traditional Owner knowledge<br>+ Take meaningful action on ground and in water, measuring impact through evaluation and dedicated research programs<br>+ Support local reef stewards through local community engagement, education, and stewardship<br>+ Embed carbon reduction and sustainability into local actions |
| SCALE | Whitsunday Islands |
| TECHNIQUE | Multiple techniques, depending on site conditions and rationale |
| FUNDING | $4M of $14M from Lendlease, Australian Government's Reef Trust, Queensland Government, Fitzgerald Family Foundation directed towards Whitsundays |
| TIMESCALE | Established in 2018 and will run through 2025 |

*Map. Allen Coral Atlas*

## A DEEPER DIVE

With tourism at the heart of the Great Barrier Reef and nearly 40 percent of all tourists visiting the Whitsundays, the Great Barrier Reef Foundation launch the Reef Islands Initiative in 2018 as the largest reef habitat rehabilitation project of its kind in the Southern Hemisphere – bringing together Traditional Owners, scientists, local tourism leaders, governments and the community to protect and restore critical habitats. The effort is promoting reef stewardship by piloting new restoration approaches, encouraging ecotourism, supporting upskilling of the community, and investing in climate-forward projects, technologies, and tourism behaviour change.

In the initial stages, the Reef Islands Initiative hosted a kickoff workshop that invited community groups, National Parks, Traditional Owners, the local council, and environmental consultants to define the four pillars of the initiative and define a site stewardship model. This workshop was key to shaping a program that was integrated and collaborative in the pursuit of context-specific actions and buy-in amongst stakeholders and partners. Using a map of the Whitsundays, they identified where existing initiatives exist and how they fit within an overarching vision for the Whitsundays. The group identified in-shore fringing reefs where educational offerings could be explored as well as openings for research and restoration. They also identified a number of key test actions, including the Boats4Corals pilot *(see pp 83)* and a comprehensive mapping project that will identify sites best suited for restoration. Now, the project advisory group is beginning to consider the social and economic implications of work in these areas.

With a set of core objectives around education, community engagement, carbon reductions, the program used grant funding to incentivise partnerships for implementation. In 2020, Reef Islands Whitsundays distributed a call for proposals for organisations and Reef champions to lead activities, such as rebuilding coral reefs and crucial habitats like seagrass, upskilling tourism operators and Traditional Owners to carry out restoration, piloting innovative technology and actions for a carbon neutral Whitsundays tourism industry. The program funds a number of key projects including:

- **Boats 4 Corals** larval reseeding project *(see pp 83)*
- The **Coral Nurture Program** using CoralClip® *(see pp 87)*
- A **Coral Mapping Report** for decision support and restoration site prioritisation, including baseline mapping, stress exposure, and local connectivity
- A **Seagrass Mapping Report and Program** to collate baseline mapping, connectivity, present distribution and habitat suitability of seagrass communities and of seagrass communities and trial innovative restoration techniques for this important habitat
- The **Healthy Heart Program**, which is working with the Whitsunday Tourism Industry to reduce its carbon footprint

*Image. Whitsunday Reef Islands Initiative*

*Image. Whitsunday Reef Island Initiative, (Left: High Natural Recruitment, Right: Low Natural Recruitment)*

*Image. Whitsunday Reef Islands Initiative*


*Image. Whitsunday Reef Islands Initiative, Donor Sites (Orange)*

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Site selection and t**echniques can be based on a number of factors** - from current biophysical stresses, to economic value, to appropriateness of restoration technique, to cultural heritage
+ Extensive mapping of the Whitsundays modelled sediment thresholds, connectivities, and nitrogen to identify high-impact sites

**WORKING WITH TRADITIONAL OWNERS IN HEALING SEA COUNTRY**

+ Engaging Traditional Owners created opportunity for **cultural heritage mapping** and discussion around **biodiversity**
+ Value sites can be identified by their **sacred meaning, fishing ground, and hunting sites,** not necessarily economic value

**EMPOWERING COMMUNITY**

+ Community engagement is key to **developing trust** between such multi-stakeholder projects

**SCALING WITH TOURISM OPERATORS**

+ **Communications with the press** need be carefully managed so as not to enforce a perception of a "dead" reef

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ **Mapping of current initiatives** and filtering for alignment with community vision ensure alignment of values and unearth ideas for programs and partnerships

## LEARN MORE

*REEF ISLANDS INITIATIVE, GREAT BARRIER REEF FOUNDATION*

*$2.4M FOR REEF-SAVING PROJECTS IN THE WHITSUNDAYS*

TESTING NEW TECHNIQUES AND STRATEGIES

# REEF RESTORATION AND ADAPTATION PROGRAM

*Source: Dr. Cedric Robillot, Prof. Peter Mumby, Dr. Ian McLeod, RRAP*

**PARTNERS**

Australian Institute of Marine Science, CSIRO, the Great Barrier Reef Foundation, the University of Queensland, QUT, Southern Cross University, and James Cook University

**COORDINATOR**

Reef Restoration and Adaptation Program

**GOALS**

+ Deliver an integrated, properly governed and executed 10-year R&D program to provide a level of health insurance for the Reef by developing safe and effective new interventions before they become critically needed
+ Respond to the range of possible climate outcomes and the range of the Reef's ecological responses to this changing environment
+ Reduce critical uncertainty, improve understanding of the system, and quickly narrow a set of optimal interventions

**SCALE**

Entire Great Barrier Reef

**TECHNIQUE**

Rubble stabilisation through chemical, natural, frames, mesh, consolidation, and removal; Cooling and shading using cloud brightening, microbubbles, surface films, misting, fogging, algae; Coral seeding through larval movement, slick translocation, aquaculture, and settled devices; Field treatments and enhanced breeding stocks.

**FUNDING**

RRAP is funded through $100M allocated for reef restoration and adaptation science as part of the $443.3M partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation. This will be supplemented with $100M from philanthropy and research providers.

**TIMESCALE**

+ 10-year R&D overall program
+ 4-year of research, analysis, and testing for the stabilisation sub-program
+ 3-5 year intervention operation goal to ensure no funding, operational, or R&D hurdles
+ 5-7 year intervention operation goal for large-scale intervention implementation

*Image. Coral rubble, Peter Mumby, RRAP*

*Image. "The first cloud brightening field trial on the Great Barrier Reef in 2020. Photo courtesy of Southern Cross University." Sourced from RRAP*

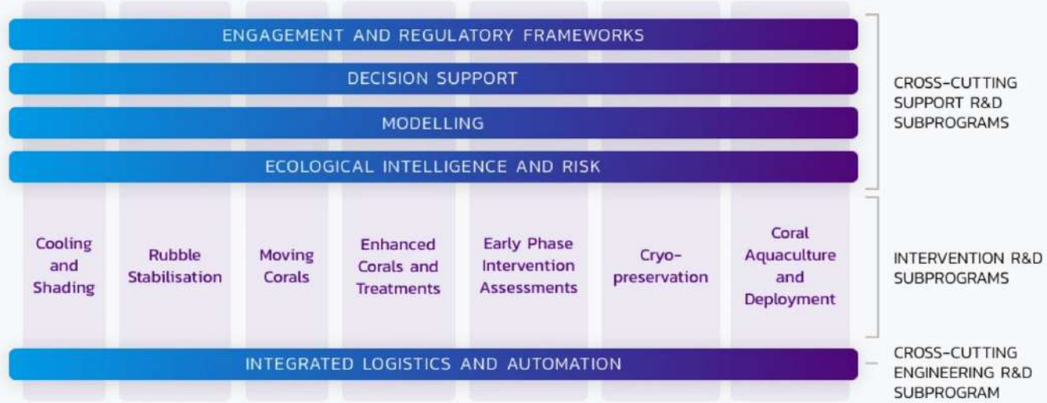
## A DEEPER DIVE

**The Reef Restoration and Adaptation Program (RRAP)** brings together Australia's leading experts to create an innovative suite of safe, acceptable interventions to help the Great Barrier Reef resist, adapt to, and recover from the impacts of climate change. The Great Barrier Reef, one of the world's largest living structures, is impacted severely by serious bleaching events arising due to increasing global temperatures. But with average global temperatures already 1°C above pre-industrial levels, emissions reduction is no longer enough to guarantee survival of the Great Barrier Reef as we know it. In addition to reducing emissions and continued best-practice reef management, the interventions resulting from this program are likely to be needed to sustain the Reef.

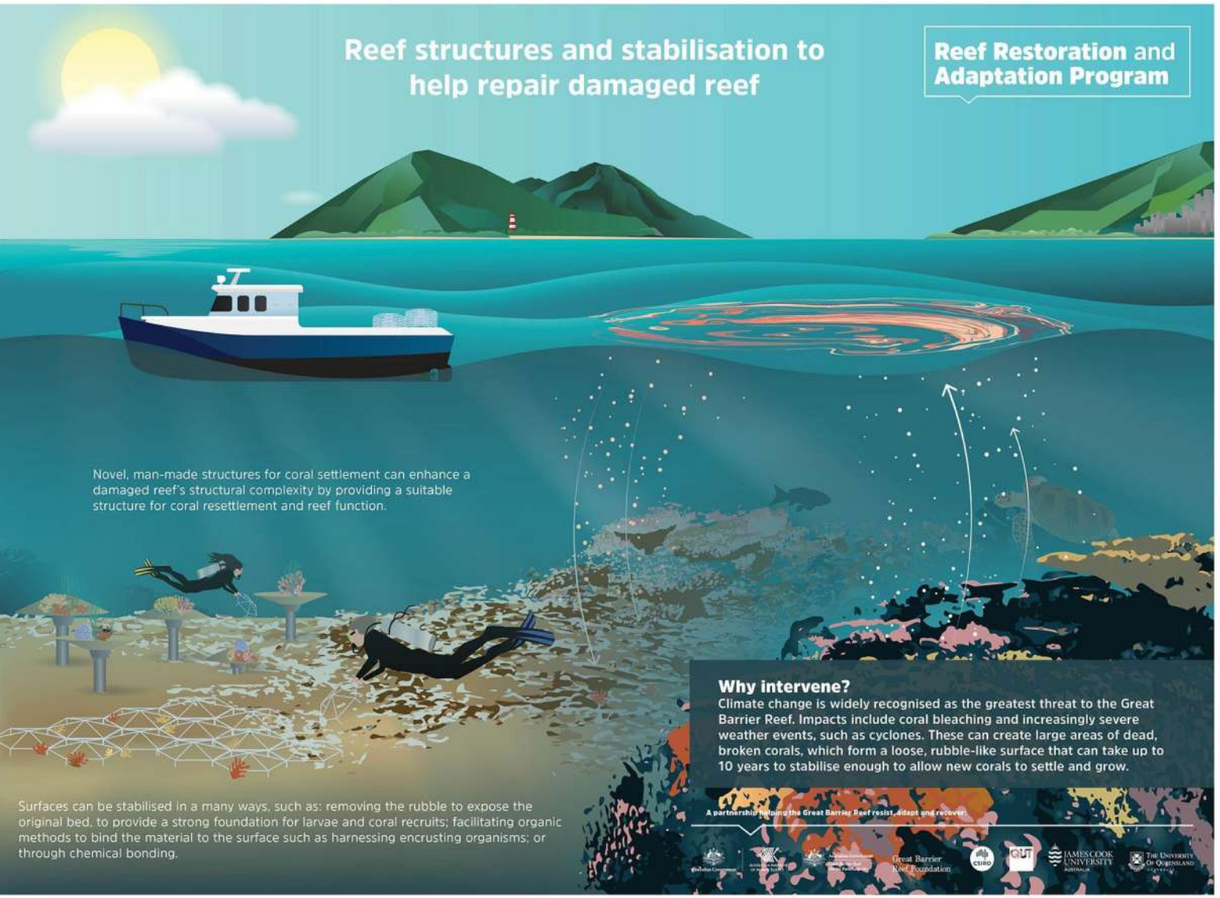
The program interventions are categorised into three main themes: Prevention, Adaptation, and Restoration. Through these themes, the mission is to create an integrated group of reef interventions which are safe, effective and scalable. Further, a core mission of this program is to understand the costs of interventions and clarify decision-making and logic around intervention decisions and scaling. Intervention typologies include: :

+ **Cooling and shading to help protect the Reef from the impacts of climate change.** This includes testing highly uncertain geoengineering approaches, such as cloud brightening.
+ **Assisting reef coral species to evolve and adapt to the changing environment, to minimise the need for ongoing interventions.** This includes developing capacity to withstand marine heatwaves by selecting individuals and propagating them in the system using aquaculture on a large scale.
+ **Supporting natural restoration of damaged and degraded reefs.** This is the smallest part of the program and includes promoting recovery of reefs that won't recover naturally, including stabilising and providing physical settlement substrates and targeting placement of propagated larvae.


For reefs that have suffered beyond repair, restoration is a tool to support reefs which can also be used in conjunction with shading to protect these recovering reefs from heat stress down the line. This preserves rich biodiversity in source reefs and key reef areas that provide material for the rest of the ecosystem. This program underscores the linkages between cooling and shading, adaptation, and restoration. For example, restoring with species that are genetically more prone to resistance may promote adaptation to heat events, but cooling and shading may also negatively impact the capacity of other species to adapt.




*RRAP R&D Program structure. The intervention-focused subprograms will be supported by cross-cutting science and engineering subprograms.*




# Stabilisation Sub-Program

This aspect of RRAP is interested in methods to stabilise damaged reef surfaces where rubble inhibits reef recovery. Lack of a stable surface from disturbances like cyclones, crown-of-thorns starfish outbreaks, or bleaching can inhibit recruitment and recovery. While rubble stabilisation is a new approach, it is critical that restoration techniques using rubble stabilisation consider prevailing wave regimes, which can make rubble persist and hinder recovery and restoration success.

## Goals

+ **Estimate the current and future scale of rubble generation on the Great Barrier Reef to determine the extent of the problem and future threat**
+ **Create Reef-wide risk assessment maps to highlight areas most vulnerable to rubble generation, and areas where rubble is likely to become a persistent constraint on reef recovery, for use in planned management activities after disturbances**
+ **Deliver a range of guidance tools to help prioritise the range of possible rubble stabilisation interventions**
+ **Demonstrate the efficacy of an existing rubble stabilisation method and conduct experimental trials of biogeochemical bonding methods that can be more environmentally friendly and have a greater opportunity to deploy at larger scales**

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Rubble can remain **unstable for a decade or longer** after damage event, so stabilisation can restore strategic areas that might **reconnect the ecosystem**
+ **Mapping areas hit by rubble and causes of death**, such as by waves or crown-of-thorns informed intervention decisions. Rubble stabilisation may not be appropriate where crown-of-thorns starfish have not been managed, for example
+ **eReefs models** include hydrodynamic, sediment, wave, and biogeochemistry models and support approximation of intervention suitability
+ **A reef condition index** of species diversity (e.g., branching v. non branching), structural complexity, water quality, users, and coral cover can indicate future performance and link properties of the reef to users such as fishing, tourism, or cultural
+ **Tradeoffs or unintended consequences of introducing slow-growing heat tolerant or fast-growing corals i**nto today's conditions are not well understood, so the program aims to look at both using fragmentation as well as structural recreation techniques

**EMPOWERING COMMUNITY**

+ **Connecting with place-based programs,** like the Whitsunday Reef Islands Initiative *(see pp 97)* and Cairns-Port Douglas Reef Hub *(see pp 93)* provides pathways for information exchange and empowers collective participation
+ Engagement has revealed **concerns about restoration and opportunity** to investigate the perceptions of restoration activities and outcomes
+ **Personal well-being and feelings of empowerment** are seen as a benefits of participation in restoration and can galvanise support
+ **Spawning, capturing spawning slicks, concentrating, rearing and injecting** are activities that lend themselves to community involvement

**SCALING WITH TOURISM OPERATORS**

+ Restoration intervention **decisions depend on objectives**, such as supporting tourism
+ Investigation of the projected change in the reef and relationships to fisheries or aesthetic and other **economic outcomes can contextualised benefits**

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ **Decision support tools** are needed to demonstrate a portfolio of interventions, their costs, and what outcomes they might provide
+ Restoration is not typically a part of the toolbox of governance and regulatory frameworks, so **draft policies are needed to facilitate research**
+ Given their role as regulators**, GBRMPA was involved in the feasibility study of the program, then transitioned to observers** on the board and steering committee
+ GBRMPA managers engage with project teams to enable research and policy updates

**SCALING AND FUNDING**

+ Implementation of coral fragments on structure needs to be **done more cost effectively** to be scalable and a gap remains in increasing production
+ **End-to-end production** between engineers and researchers ensures rapid iteration
+ **By focusing efforts on 100-200 critical reef sites,** the program is testing the minimum effort needed to maintain reef function across the systems

## LEARN MORE

*REEF RESTORATION AND ADAPTATION PROGRAM RUBBLE STABILISATION R&D SUBPROGRAM*

*REEF RESTORATION AND ADAPTATION PROGRAM INVESTMENT CASE, OCTOBER 2019*

*REEF RESTORATION AND ADAPTATION PROGRAM FACT SHEET*

*"DIFFICULT, COMPLEX DECISIONS UNDERPIN THE FUTURE OF THE WORLD'S CORAL REEFS," RRAP, AUGUST 27, 2020.*

*"'LIFE SUPPORT' MEASURES COULD BUY GREAT BARRIER REEF ANOTHER TWO DECADES, STUDY FINDS," THE GUARDIAN, GRAHAM READFEARN, APRIL, 2021.*

*WHY DO WE NEED TO HELP THE GREAT BARRIER REEF? THE RRAP R&D PROGRAM*

*DR. LINE BAY ON HELPING CORALS ADAPT TO WARMER WATER*

# GREAT BARRIER REEF INTERVENTIONS POLICY

*Source: Dr. Leanne Fernandes, Department of Marine and Aquaculture Sciences, James Cook University*

| | |
|---|---|
| PARTNERS | Great Barrier Reef Marine Park Authority, Department of Environment and Science, Queensland Parks and Wildlife Service and Partnership |
| COORDINATION | Great Barrier Reef Marine Park Authority |
| GOALS | + Policy framework to enable permitting and risk management restoration and/or adaptation interventions<br>+ Directly support and build ecosystems resilience and provide conservation benefits at a range of scales to the Great Barrier Reef<br>+ Inform Traditional Owners, partners, proponents, stakeholders and broader community about management arrangements |
| SCALE | Great Barrier Reef Marine Park |
| TECHNIQUE | All known restoration techniques |
| TIMESCALE | Policy issued December, 2020 |

## A DEEPER DIVE

The Great Barrier Reef Marine Park Authority's Reef Interventions Policy enables decisions about appropriate restoration and adaptation activities on the reef. Given the increasing level of interest in restoration activities - from community, to philanthropy, to non-government organisations - the GBRMPA aims to ensure that restoration activities are in line with the protection and conservation of the reef and grounded in rigorous and well-design science, without compromising the attention paid to and management of local threats and pressures on the GBR ecosystem.

At its core, this policy supports the assessment, development, and implementation of intervention actions across all scales - from local to reef-wide initiatives. Further, it aims to inform uses of the Marine Park and the general public about decision-making processes related to restoration and adaptation activities. A number of management tools underpin this process and define the range of the policy and regulatory processes for implementation, including:

+ **Policy on Great Barrier Reef Interventions:** Defines reef restoration and adaptation interventions, role of the Managing Agencies and staff, role of reef intervention in the management of the Marine Parks, position of the Managing Agencies on rationale for supporting or not supporting certain types of interventions, position on Traditional Owners and interventions.
+ **Risk Assessment Permission System**: Explains the process used the assess risks primarily for staff of 'managing agencies' and applicants seeking pilot study permissions.
+ **Project Application Guidelines**: Informs project design and rubric of risk assessment and mitigation protocols for review and permit consideration purposes.
+ **The Great Barrier Reef Marine Park Zoning Plan:** Provides for a range of ecologically sustainable recreational, commercial, and research opportunities and for the continuation of traditional activities. Each zone has rules that governs uses and activities, restrictions, and permits.

Through this policy and broader management agenda, GBRMPA maintains oversight of interventions and strategies. The risk assessment also encourages consideration of other activities related to restoration interventions, like tourism and fishing.

## IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ Restoration interventions are viewed on a **spectrum of risks.** For example, control of coral-eating crown-of-thorns starfish is relatively low risk while introduction of genetically modified organisms that are heat resistant are relatively higher risk
+ **Tracking of failures** is as critical as success, despite academic research not typically publishing unsuccessful interventions
+ Interventions that may be seen as **lower risk where there is already a high amount of damage**, depending on technique type

**EMPOWERING COMMUNITY**

+ **Using existing engagement platforms** and formats can contextualise restoration efforts in terms of broader reef management and requires proponents to engage with impact with Traditional Owners and stakeholders
+ Ensuring that **expectations for restoration** are set appropriately from project outset and are messaged within the context of local stress reduction, adaptation and climate mitigation efforts

**SCALING WITH TOURISM OPERATORS**

+ The tourism industry has suffered from the COVID-19 pandemic, and operators are **eager to implement restoration** and ecotourism experiences
+ High value tourism sites make up only a small area of the Great Barrier Reef, which lend themselves to **small site-specific interventions**
+ **Setting appropriate expectations of trials** is critical to managing potential disappointment and disengagement of operators

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ Policies **written in conjunction with permitting teams** ensures that environmental assessment directly informs permit allocation
+ **Transparency of the permit application process** and sharing of monitoring and lessons is critical to ensure that managers can intervene if needed. The policy is a lever in **maintaining accountability** to project goals and risks

**SCALING AND FUNDING**

+ Policy plays a role in **setting expectations of eager non-government and funding partners** of the importance of risk management

## LEARN MORE

*POLICY ON GREAT BARRIER REEF INTERVENTIONS (No. 100513)*

*RISK ASSESSMENT PERMISSION SYSTEM , INTERNAL PROCEDURE*

*APPLICATIONS FOR RESTORATION / ADAPTATION PROJECTS TO IMPROVE RESILIENCE OF HABITATS IN THE GREAT BARRIER REEF MARINE PARK*

TESTING NEW TECHNIQUES AND STRATEGIES

# REEF REHABILITATION PROJECT AT GREEN ISLAND

*Source: Alicia McArdle, Freda Nicholson, Mars Sustainable Solutions; Neil Mattocks, Great Barrier Reef Marine Park Authority*

**PARTNERS** Commonwealth Government Great Barrier Reef Marine Park Authority (GBRMPA) and the Queensland Government Queensland Parks and Wildlife Service (QPWS) (who equally fund field management of the Great Barrier Reef Marine Park through the Reef Joint Field Management Program (RJFMP), Mars Sustainable Solutions, Quicksilver Cruises, Experience Co. (Big Cat Green Island Cruises), Coral Nurture Program and the Gunggandji Traditional Owners

**COORDINATION** Reef Joint Field Management Program and Mars Sustainable Solutions

**GOALS**

+ Understand the practical costs, training, and logistical requirements associated with specific restoration activities
+ Provide an early example of how reef rehabilitation project can be a collaboration between government and multiple stakeholders including the tourism industry, private companies, University researchers and Traditional Owners
+ Assess natural recovery processes and promote healthy coral cover to an area of impacted reef on Green Island
+ Trial multiple tools and techniques, including MARRS Reef Stars and CoralClips® as well as a trial of biodegradable coral ties
+ Provide opportunities for tourism operator partners to bring visitors to the site and educate them about ongoing reef rehabilitation efforts as well as the ongoing threats to the Great Barrier Reef

**SCALE** 375m² of unstable coral rubble and coral rock

**TECHNIQUE** Coral fragments recovered from seabed installed on 165 Reef Stars and 200 CoralClip ® devices

**TIMESCALE** 6 year monitoring and maintenance program with 1 week training and installation time periods

*Map. Allen Coral Atlas*

## A DEEPER DIVE

Green Island, traditionally known as Wunyami, is located 27 kilometres from Cairns in the Great Barrier Reef Marine Park and the associated reef habitat is showing signs of impact from crown-of-thorns starfish, cyclones, and bleaching. Its proximity to Cairns means Green Island has been a major part of the modern reef tourism industry over the past century. The site was selected for its low coral cover and loose coral rubble, a condition that makes it particularly hard for new larval coral to settle and grow.

**The Green Island Reef Rehabilitation** project is a partnership between Commonwealth and State Government management agencies, Mars Sustainable Solutions, the Coral Nurture Program, local tourism operators (Quicksilver Cruises and Big Cat Green Island) and the Gunggandji Traditional Owners. Its primary objectives are to test management and practical implementation of restoration tools, train staff and rehabilitate a small area of high value reef. Two key techniques were used in the project:

> **Mars Assisted Reef Restoration System (MARRS)** Reef Stars are hexagonal sand-coated steel frames that are placed on the sea bed to provide a stable structure on which to attach live coral fragments. Originally developed for use in Indonesia where reefs were impacted by blast-fishing, they encourage growth that eventually overtakes the structure underneath.
>
> **Coralclips®** *(see Coral Nurture Program, pp 87)* are a small spring loaded clip approximately 5.2cms long made of stainless steel that can be attached to hard coral rock using a masonry nail fitted into a coil at one end of the clip. A suitable fragment of live coral can then be held in place under the clip where it continues to grow.

Project site scoping began in July, 2019 with input from project partners. Evaluation criteria for optimal sites for reef stars and Coralclips® included presence of rubble, coral cover, presence of hard coral rock, currents, fish movement, sediment and nutrient loads and presence of algae. Permit requirements and logistical challenges were also considered. With a site selection report completed in April 2020 and travel restrictions from COVID-19 lifted, an initial baseline monitoring and fragment assessment was undertaken from July - October 2020.

In November 2020, the Mars Sustainable Solutions and Coral Nurture teams delivered training sessions for project partners from QPWS and GBRMPA in advance of the 'build days' on the reef. The training began with a 2-hour webinar, including background on the initial logistical plans. Then, in person training at the Green Island Resort included theory, followed by three days collecting coral, attaching coral fragments to the reef stars, and installing Reef Stars and Coralclips® at their final location. A final half-day was used to clean up and plan for monitoring activities. A total of 2,675 loose coral fragments using 165 MARRS Reef Stars and 200 Coralclip® devices were installed.

Monitoring and cleaning (scrubbing algae off the Reef Stars using small brushes) took place approximately every 3 weeks following the initial installation because the site is prone to algae growth. As herbivorous fish moved into the site in the months following installation, cleaning was stopped. The latest monitoring of the installation occurred in November 2021. While this data is yet to be fully analysed, increases in coral growth and fish diversity is now visually obvious. Individual corals continue to grow over the Reef Stars and in most cases, are firmly attached. Fully analysed data collected in May 2021 shows coral cover has increased from 15 percent to almost 25 percent at the rehabilitation site. This trend is expected to continue. The number of fish species per monitored transect has risen from 24 per monitoring transect prior to installation, to 33 percent per transect in May. It is likely this has further increased along with total fish numbers. Future phases of monitoring and management may also engage social scientists to explore exposure to tourists and ways in which trials might inform future perceptions of restoration as a management tool.

### OUTCOMES ON THE REEF

+ Coral cover increased from **15.6% to 24%** between November 2020 and November 2021
+ **Fish biomass and abundance** has increased
+ Cumulative mortality of fragments was **15% over the first 6 months,** higher than other sites and expected due to poorer water quality on an inshore reef
+ **Poorer water quality on an inshore reef** may be a contributing factor to slower growth rate of corals (compared with Moore Reef, see pp 67)
+ **Vast majority** of corals are cementing to their new substrate

*Images. Mars Sustainable Solutions*

# IMPLEMENTATION LEARNINGS

**TESTING AND MONITORING TECHNIQUES FOR REEF HEALTH AND RECOVERY**

+ **Green Island was chosen in part for its proximity to a ranger station** and management staff at Cairns, but the final selected reef requires a tender to access via tourism operator
+ **Coral survivorship of Reef Stars is thought to be most successful when placed near areas of healthier reef**, so the rubble areas selected were adjacent to relatively healthy coral cover
+ **Nearby areas of hard substrate with lower coral cover** were found to be suitable for deployment of CoralClips®
+ Learnings from Indonesian implementation of Reef Stars suggest that **fish movement supports reproduction and new cohorts**, so sites were evaluated for fish presence
+ Early measures of **mortality of 15 percent** for installed coral fragments were higher than expected and likely influenced by the port and river runoff, suspended sediments, and algae that inhibit survivorship. **More maintenance was conducted than originally planned** to manage algae
+ Given the **goal to test logistics and coordination**, less priority was given to coral species selection
+ **'Corals of opportunity,'** coral pieces and colonies lying loosely on a sea-bed following a physical disturbance such as rough seas, were used for the project as they were **unlikely to survive on the longer term on their own**

**WORKING WITH TRADITIONAL OWNERS IN HEALING SEA COUNTRY**

+ Challenges in engaging Traditional Owners on build-days emerged due to the lack of dive training amongst Sea Rangers, revealing opportunities for **upskilling in the future**
+ TO Sea Rangers had access to vessels, gave **input on site selection**, and participated in coral tying day
+ TO engagement revealed key priorities in **sea grass preservation and general stewardship of the reef**, less the technical aspects of the site and design
+ **Early engagement** ensured that there were no concerns with the project and priorities for continued engagement include plans to bring Sea Rangers out to snorkel the site

**EMPOWERING COMMUNITY**

+ Implementation opportunities emerged for both personnel associated with or employed by the **various project collaborators,** as well as those who don't typically work in the marine or field work spaces (e.g,. additional QPWS staff, TO community members, and GBRMPA staff)
+ **A range of skills and background knowledge necessitates** resources for more in-depth training and factoring in extra training time and supervisory roles into build-days.
+ **Community volunteers were not used to implement the project** out of health and safety concerns, revealing a need for compliance mechanisms to engage volunteers

**SCALING WITH TOURISM OPERATORS**

+ Local tourism operators consistently engaged in project maintenance and were keen to work to improve the health of a **high value site, a** popular dive and snorkel site for tourists
+ Questions around how trials might inform **future tourist perceptions of restoration** as a management tool emerged, so future phases of monitoring may engage **social scientists** to evaluate project impacts
+ Multiple partners must **coordinate timing and schedules for site visits.** Site access provided by in-kind tourism companies, for example, meant aligning with boat and staffing schedules
+ The **COVID-19 pandemic** stretched resources and ability of tourism companies to provide in-kind support, despite strong willingness to do so

**ADAPTING MANAGEMENT, GOVERNANCE, AND PROCEDURES**

+ **Given concerns around impacts of coral sands** used to construct the Reef Stars on reef health, Mars Sustainable Solutions and GBRMPA prepared a detailed risk assessment, switched to a limestone coating, and trialled biodegradable cable ties
+ MARRS are considered an **'artificial reef' under the Commonwealth Sea Dumping Act,** so a detailed assessment was required for a six year permit
+ Authorised under **Section 5.4 of the Great Barrier Reef Marine Park Zoning Plan** as a management action, no further permit under the GBR Marine Park Act 1975 was required
+ **QPWS and GBRMPA staff trained on the project expressed strong interest** in implementing more projects of a similar nature, indicating traction amongst management staff to test interventions as management strategies and pursue opportunities for future project funding

**SCALING AND FUNDING**

+ Scale and size of the build was determined, in part, by the **capacity of the team to implement stars** within a one-week training period
+ **More resources in personnel time** were needed than originally planned to support site access and maintenance of algae. **Planning for backup methods**, especially for offshore sites requiring vessel access, is critical to ensuring a resource efficient process

# 5 REFLECTING ON THE PROCESS

## CLOSING THOUGHTS AND A WAY FORWARD

*Image. Reef Islands Initiative Whitsundays*

**Coral reef restoration is a rapidly growing field of research, practice, policy, and engagement**. And as coral reefs around the world come under increasing threats from local stressors like coastal development, run-off, and overfishing, as well as the impacts of marine heatwaves, acidification, and storms related to climate change, the successful deployment of restoration will be central to effective management of reef health around the world. In developing this *Framework for Trialling Coral Restoration to Build Resilience* in partnership with Ningaloo, a number of key lessons emerged that transcend the principles, objectives, and case studies outlined above.

**Proactive planning for reef restoration trials before significant degradation occurs is an anticipatory exercise. It requires development of goals in the context of future climate scenarios and anticipation of potential future ecological, political, social, and economic impacts.** While catastrophe often generates urgent responses, deployment of resources, public attention, and policy actions, they are often reactionary and fail to capture the range of conditions and opportunities that could have curtailed losses. While planning ahead requires a dedication of resources in already stretched public agencies responsible for the day-to-day management of a marine park, it is worthwhile in the long run. These resources establish the necessary communication channels and protocols that support future decisions and responses to possible future scenarios.

**Considerations for trialling coral reef restoration are inherently about risk and negotiating varied and dynamic perspectives, drivers, and sensitivity to those risks.** There is ongoing debate in many regions about the justification of interference of any magnitude in the marine environment without certainty around the management and mitigation of possible impacts of restoration trials and ultimately interventions. At the same time, the risk of a catastrophic bleaching event combined with public expectation of a clear, coordinated, and impactful response to reef damage generates enormous political pressure on marine park management agencies. With the pace of change and level of threat so great, effective management requires agencies to embrace a culture of "learning by doing" through adaptive decision-making, while motivating buy-in and partnerships across agency departments and with a broad range of stakeholders. Finally, the "failure" of an appropriately-designed reef restoration trial to generate meaningful results is still valuable in informing future decision-making processes, technique selection, and clear expectation setting.

**While trials are experimental, they may actually produce the hypothetical restoration outcome (e.g., increase thermal tolerance), blurring the line between "trials" and "interventions" and their respective objectives.** At times in this process, the difference between a restoration trial and a restoration intervention were difficult to discern. Restoration trials are undertaken with the intention of demonstrating the ability of a technique to aid recovery. In doing so, however, they may fundamentally shift the recovery capacity and adaptation trajectory of the ecosystem. Taken together, this process underscored the importance of goal- and objective-setting as it relates to trials and assurances that trials contribute to a set of broader learnings about key factors such as scale of impact, cost-effectiveness, as well as adaptations or improvements to ecological structure and function. It also underscores the importance of coordinating across trialling efforts to ensure that measurement and results are comparable, consistently reported, transparent, and not redundant.

**Resilience-based approaches to reef restoration, and management more broadly, offer an opportunity to engage with Traditional Owners in reef communities worldwide.** Effective cross-cultural engagement takes time, is often non-linear, and requires empathy. These qualities can often run counter to a western model of working driven by norms, scientific methods, and communication that convey linear modes of analysis and highly technical research and technocratic strategies. Ultimately though, when used in isolation, these practices can limit partnership, innovation, knowledge, and progress. Resilience-based approaches to trialling can become an avenue for co-management of resources, empowered decision-making and governance, and resource availability to local and marginalized communities and organizations. The delivery of a workshop with Traditional Owners at Ningaloo around reef restoration and healing of Sea Country (Appendix I) revealed a number of lessons as they relate specifically to the process of coral reef restoration in the context of these themes. They include, but are not limited to:

- **Trials should incorporate the goals and values of Traditional Owners and partners to ensure social license, buy-in for future interventions, and funding pathways for collaboration, empowerment, and knowledge sharing.** Engaging with Traditional Owner partners early in planning processes can facilitate the effective co-design of education, implementation, and stewardship activities.

- **Free Prior Informed Consent (FPIC) should be adequately resourced to address access to benefit sharing of trials and interventions. Simply obtaining consent does not necessarily provide benefit to TOs.** Benefits of projects must be co-developed, accessible, and shared. Benefit sharing often entails resources for capacity and skill development as well as employment opportunities during implementation, maintenance, and monitoring. This might include, for example, training for lab work, in-water monitoring or collection and sampling of coral fragments, dive certifications, or other professional or technical skills development. It also means that benefits of trials are conceptualised with a broader definition beyond the biophysical health of the reef, and include the spiritual, cultural, creative expression, and aspirations defined by and of Traditional Owners. Finally, it can and should legitimately engage traditional knowledge of Sea Country and culturally significant sites, materials, and practices to inform design and stewardship of trials and, ultimately, interventions.

- **Empowerment of Traditional Owners to lead discussions and facilitate processes, for example, is one way to shift power dynamics and trust in a room.** Compensation for time and knowledge is critical. This can be achieved via structures, such as joint management governance, which give authentic and legal authority to Traditional Owners over design, policy, and management decisions and approvals. Traditional Owners must also be financially compensated for their time and engagement in decision-making and design activities. This should be accounted for and co-designed into projects, research proposals, and agency budgets.

- **Meaningful engagement is neither extractive nor a means to an end, it is a process of trust-building, co-learning, and working together.** Restoration trials offer an opportunity to build the cultural competency of western scientists and two-way learning from Traditional Owners whose knowledge has been built over millennia. So, in a workshop for example, allow for ample time for discussions and questions around open ended prompts. Further, ensure that next steps are clearly articulated and that there are plans and processes in place to iterate on ideas over time and in formats that authentically engage the issues (e.g., site visits, workshops, meetings of elders, over tea, volunteer days, cultural events etc.)

**Reef restoration trialling is a vehicle for building resilience of coral reefs as well as the communities that depend on them.** While restoration alone will not mitigate the impacts of climate change on a reef or in society, it is an increasingly powerful tool in buying time for coral reefs to adapt and managers to address the stresses that make coral reefs and communities more sensitive to their impacts. Through trialling, managers, Traditional Owners, communities, tourism operators, and researchers can co-develop the policies, practices, and decision-making pathways for future restoration interventions that build resilience, such as through:

- Re-establishing and/or maintaining genetic and species diversity of the ecosystem and preventing extinction
- Designing interventions based on current conditions, future climate projections, and vulnerability of the reef, communities, and livelihoods to complex risks
- Creating opportunities to build trust through engagement, authentic and two-way knowledge sharing, co-design, and implementation
- Supporting adaptive management and decision-making in dynamic conditions
- Empowering collective action and stewardship locally and at international scales

**An empowered, informed, coordinated, and deeply engaged approach enables a better understanding of the circumstances and local conditions under which restoration techniques may be appropriate** and how to anticipate or measure success biophysically as well as socially and economically. Coordinated trialling today, may mean a community mobilised together to respond tomorrow, empowered with lessons that grow the evidence and resources needed for reef communities around the world.



*Image. Whitsunday Reef Islands Initiative*

*Image. Joel Johnsson*

# APPENDIX I

## HEALING SEA COUNTRY AND RESTORING THE REEF: WORKSHOP WITH TRADITIONAL OWNERS AT NINGLOO

> Web Version Accessible



# HEALING SEA COUNTRY AND RESTORING THE REEF WORKSHOP WITH TRADITIONAL OWNERS

NOVEMBER 2, 2021 | CARNARVON AUSTRALIA
GWOONWARDU MIO GASCOYNE ABORIGINAL HERITAGE AND CULTURAL CENTRE

## INTRODUCTION AND BACKGROUND

The *"Healing Sea Country and Restoring the Reef"* workshop brought together Traditional Owners (TO's), the Ningaloo Department of Biodiversity, Conservation, and Attractions (DBCA), MARS Sustainable Solutions, and the Minderoo Foundation. The workshop began a process of defining aspirations for healing of Sea Country, the role of restoration in joint management of the reef between Traditional Owners and the DBCA, and opportunities for TO's to engage in restoration trialling.

This workshop served as an important starting point for ongoing conversations and efforts. It created space for Traditional Owners to talk about their perspectives and values, and discuss opportunities for meaningful Traditional Owner engagement during restoration experiment planning and implementation. Findings from this workshop are synthesized in this report and are intended to help inform future engagement around restoration activities within the broader context of Joint Management between DBCA and the TO Joint Management Body (JMB), as well as researchers and TO communities in Ningaloo.

This workshop was designed and delivered through the Resilient Reefs Initiative and the Resilience Accelerator program, a partnership with between the Great Barrier Reef Foundation and the Center for Resilient Cities and Landscapes at Columbia University.

## WORKSHOP OBJECTIVES

- Bring together Traditional Owners, the DBCA, and researchers to co-learn about restoration and opportunities to engage with it from around the world
- Listen and learn about TO's aspirations for reef health and healing, how restoration may relate to health and healing, and explore how TO's would like to engage in restoration and caring for sea country in Ningaloo
- Articulate aspirations that guide potential future restoration and early co-design of trial goals, siting, planning, design, implementation, engagement and monitoring processes
- Begin to understand the social acceptability of restoration techniques
- Scope TO partner role in MARRS Reef Star trial and build and support a working relationship between MARRS, Minderoo, DBCA, and JMB
- Begin to define role of the JMB and process for restoration planning to inform Reef Restoration Trialling Framework

# WORKSHOP LEARNINGS

## What are the core aspirations for reef healing and management?

- **Land and sea country must be managed together.** Healing the reef means management of land and sea country together, including revegetation of both land and sea.
- **We know what's coming, so let's plan now** and avoid the worst impacts of climate change. Funding and management should be proactive in order to avoid piecemeal approaches and unsustained efforts.
- **Maintaining the health and safety of the reef today** is as important as healing it from damage. Prioritize maintaining the health of the reef, and then healing the reef where necessary.
- **Reef healing means setting up the next generation** to lead the way in stewarding land, sea, and culture. Mentor the younger generation, create opportunities for skills, training, and employment, and preserve and transfer cultural knowledge for future generations
- **Cultural and biocultural landscapes need to be recognized, valued, and integrated.** Activities should ensure that care, protection, and safeguards are in place to preserve cultural values.
- **There is an aspiration to showcase traditional culture and display it with pride.** Activities should take opportunities to incorporate indigenous design (e.g. utilising the shapes of cultural totems or animals like madjun and manta rays) and Traditional Knowledge (e.g. use of indigenous materials).
- **Benefits of projects must be accessible and shared.** Meaningful engagement requires capacity and skill development and employment opportunities during implementation, maintenance, and monitoring. This might include, for example, training for lab work, in-water monitoring or collection and sampling of coral fragments, dive certifications or other professional or technical skills development.
- **Adequate resources should be made available to build sustained capacity of the TO community** to make well-informed decisions and support sea country healing. Resources made available, such as through training and education as well as adequate funding and adequate consideration of logistics involved (e.g., travel, sitting fees, accommodations), will ensure participation and value.

## How do Traditional Owners want to be involved in restoration activities?

- **Intergenerational involvement** and engagement of the younger generation in healing the reef. Young people are critical to 'leading the charge' in managing and healing country. Drawing on the knowledge of ancestors, a circle of elders can guide and mentor the younger generations involved in long-term sea country management.
- **On-country knowledge-sharing.** Traditional Owners have a deep cultural understanding of Nyinggulu and its ecosystems, which can be shared with the younger generation, management agencies and researchers when TO's apply traditional knowledge to current ecosystems on-country.
- **Training and career development** to support full-time career pathways in sea country management. TO's can be well positioned to lead or support the design, construction, and implementation of projects through a dedicated and funded Sea Ranger program, cadetships and traineeships (rangers, lab assistants etc), TAFE courses and other skills development opportunities. A key aspiration is increased full-time jobs and careers pathways for Traditional Owners working on-country.
- **Indigenous design.** TO's can guide the design aspects of reef restoration, such as through incorporating indigenous materials, totems and motifs that have cultural importance into the design of the project. These methods will provide avenues for education or cultural values and knowledge of Sea Country.
- **Traditional Owner-led projects.** TO's aspire to design, manage and maintain sea country management projects, such as coral gardens.

## How should managers and researchers engage with TO's in the future?

- **Meaningful co-design - TO's should be engaged in the early stages of planning.** Co-design means that TO's are involved in the early stages of planning and given meaningful opportunities to influence and be involved in the design and delivery of projects, such as through: goal setting, site selection and prioritisation, technical and aesthetic design, construction, implementation, maintenance, education & ongoing reef or project monitoring.
- **Appropriate governance.** In the near-term, projects should be brought to the JMB for initial discussion, which will then advise on further engagement.
- **Free, Prior and Informed Consent**: FPIC is a principle protected by international human rights standards that state, 'all peoples have the right to self-determination [and] the right to freely pursue their economic, social and cultural development'. Traditional Owners expect that information that is relevant and appropriate will be provided, along with meaningful opportunities for discussion, before consent is provided.

**Culturally and spiritually significant places need to be given careful consideration.** Sites like the eastern side of the gulf, Bundegi, Vlamingh Head, Yardie Creek, Winderabandi, the outer reefs between Norwegian Bay and Pt. Cloates and between Pt. Cloates and Coral Bay, the inshore area from Yalabia to Miniminiurra, and Bruboodjoo are of particular importance.

**TO observations of reef impacts can guide where restoration might be worthwhile.** Areas where there are corals washing up (for example, at Point Maud Brooboodjoo, Yalabia, Miniminimurra) might indicate impacts from tourism or erosion, and therefore inform restoration activities.


## What's next after this workshop?

Following the workshop, the DBCA and JMB will work together to ensure that TO aspirations are integrated into the review of project proposals and implementation strategies as they are proposed by researchers. This will include:

- Review and approval of this workshop report;
- Gain permission for this report, or parts of this report, to be shared internally or externally with researchers and project proponents; and,
- Continued discussion with TO's about involvement in future stages of the proposed MARRS Reef Stars/Minderoo restoration project at Bundegi.

## WORKSHOP PARTICIPANTS

### Traditional Owners and Joint Management Body

Alex Murphy
Belinda Dickerson
Charles Baron
Curtley Walgar
Dalton Dickerson
Debbie Dodd
Ethan Cooyou
Gwen Peck
Harold Dickerson
Hazel Walgar
Janet Baron
Judith Peck
Kaeden Dickerson
Laurence Cooyou
Laurie Tittum
Maree Cooyou
Nova Walgar
Paul Baron
Robert Kelly
Samuel Dickerson
Shanna Stevens

### Department of Biodiversity, Conservation, and Attractions

Joel Johnsson
Peter Barnes
Tom Nagle

### External Partners

Sarah Castine, Great Barrier Reef Foundation
Johanna Lovecchio, Center for Resilient Cities and Landscapes at Columbia University
Michaela Dommisse, Minderoo Foundation
Alicia McArdle & Freda Nicholson, MARS Sustainable Solutions


### Photographs

Front cover: Michaela Dommisse
Back cover: Michaela Dommisse, Peter Barnes, Alex Murphy


# END NOTES


1. "Reefs for Resilience: Insuring our Shared Natural Capital" The Nature Conservancy, Mark Way and Jan Kellett, April 26, 2018.
2. Ibid.
3. Mapping Ocean Wealth, The Nature Conservancy. https://www.google.com/url?q=https://oceanwealth.org/ecosystem-services/coastal-protection/&sa=D&source=editors&ust=1631214586221000&usg=AOvVaw2AAUjIRn7QnZdrEvxyiS_E
4. Quigley, Kate M et al. "The active spread of adaptive variation for reef resilience." Ecology and evolution vol. 9,19 11122-11135. 2 Sep. 2019, doi:10.1002/ece3.5616
5. Heron, S. F., Eakin, C. M., Douvere, F., Anderson, K., Day, J. C., Geiger, E., Hoegh-Guldberg, O., van Hooidonk, R., Hughes, T., Marshall, P., and Obura, D. (2017). 'Impacts of Climate Change on World Heritage Coral Reefs: A First Global Scientific Assessment.' (UNESCO World Heritage Centre: Paris, France.)
6. Matz MV, Treml EA, Aglyamova GV, Bay LK (2018) Potential and limits for rapid genetic adaptation to warming in a Great Barrier Reef coral. PLoS Genet 14(4): e1007220. https://doi.org/10.1371/journal.pgen.1007220
7. Terry P. Hughes,* Kristen D. Anderson, Sean R. Connolly, Scott F. Heron, James T. Kerry, Janice M. Lough, Andrew H. Baird, Julia K. Baum, Michael L. Berumen, Tom C. Bridge, Danielle C. Claar, C. Mark Eakin, James P. Gilmour, Nicholas A.J. Graham, Hugo Harrison, Jean-Paul A. Hobbs, Andrew S. Hoey, Mia Hoogenboom, Ryan J. Lowe, Malcolm T. McCulloch, John M. Pandolfi, Morgan Pratchett, Verena Schoepf, Gergely Torda, Shaun K. Wilson. Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science (American Association for the Advancement of Science), 1/5/2018, ISSN: 0036-8075, Volume 359, Issue 6371, p. 80. DOI: 10.1126/science.aan8048
8. Hein MY, McLeod IM, Shaver EC, Vardi T, Pioch S, Boström-Einarsson L, Ahmed M, Grimsditch G (2020) Coral Reef Restoration as a strategy to improve ecosystem services – A guide to coral restoration methods. United Nations Environment Program, Nairobi, Kenya. Available at icriforum.org/coralrestoration
9. Ibid.
10. Boström-Einarsson L., R.C. Babcock, E. Bayraktarov, D. Ceccarelli, N. Cook, S.C.A. Ferse, B. Hancock, P. Harrison, M. Hein, E. Shaver, A. Smith, D. Suggett, P.J. Stewart-Sinclair, T. Vardi, and I.M. McLeod. 2020 Coral restoration - A systematic review of successes, failures and future directions. PlosOne. 15: e0226631.
11. Policy on Great Barrier Reef interventions (Document no. 100513). Great Barrier Reef Marine Park Authority. Issued 2020. Policy under s7(4) of the GBRMP Act 1975. https://hdl.handle.net/11017/3674. Accessed, March 2022.
12. Boström-Einarsson L., et al. 2020.
13. Hein MY, et al. 2020.
14. Cooper, Wade T; Lirman, Diego; VanGroningen, Megan Porter; Parkinson, John E; Herlan, James; McManus, John W. Assessing techniques to enhance early post settlement survival of corals in situ for reef restoration. Bulletin of Marine Science, Volume 90, Number 2, April 2014, pp. 651-664(14) University of Miami - Rosenstiel School of Marine and Atmospheric Science. https://doi-org.ezproxy.cul.columbia.edu/10.5343/bms.2013.1020
15. Nur Fadli, Stuart J.Campbell, Kathryn Ferguson, Jude Keyse, Edi Rudi, Arthur Riedeland, Andrew H.Baird (2012). The role of habitat creation in coral reef conservation: A case study from Aceh, Indonesia. Oryx, 46, pp501507 doi:10.1017/S0030605312000142
16. Boström-Einarsson L., et al. 2020.
17. Elisa Bayraktarov, Phoebe J. Stewart-Sinclair, Shantala Brisbane, Lisa Boström-Einarsson, Megan I. Saunders, Catherine E. Lovelock, Hugh P. Possingham, Peter J. Mumby, Kerrie A. Wilson. 14 May 2019. Motivations, success, and cost of coral reef restoration. Restoration Ecology. Volume 27, Issue 5. P 981 - 991. https://doi-org.ezproxy.cul.columbia.edu/10.1111/rec.12977
18. Hein MY, et al. 2020
19. Condie, Scott A. Large-scale interventions may delay decline of the Great Barrier Reef. Royal Society open science. ISSN: 2054-5703. April 2021 Volume: 8, Issue: 4. DOI: 10.1098/rsos.201296
20. Elisa Bayraktarov, Megan I. Saunders, Sabah Abdullah, Morena Mills, Jutta Beher, Hugh P. Possingham, Peter J. Mumby, Catherine E. Lovelock. The cost and feasibility of marine coastal restoration. Ecological Applications, Volume 26, Issue 4 p. 1055-1074. 04 November 2015. https://doi.org/10.1890/15-1077
21. Standards Reference Group SERA (2017) National Standards for the Practice of Ecological Restoration in Australia. Second Edition. Society for Ecological Restoration Australasia. Available from URL: www.seraustralasia.com
22. Heron, et al. 2017.
23. Amber L. Carter, A. Meriwether W. Wilson, Maximiliano Bello, E. Mauricio Hoyos-Padilla, Mark E. Inall, James T. Ketchum, Andrew Schurer, Alexander W. Tudhope. Assessing opportunities to support coral reef climate change refugia in MPAs: A case study at the Revillagigedo Archipelago, Marine Policy, Volume 112, 2020, 103769, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2019.103769. (https://www.sciencedirect.com/science/article/pii/S0308597X19301654)
24. Australian Government, Great Barrier Reef Marine Park Authority. Queensland Government. Applications for restoration/adaptation projects to improve resilience of habitats in the Great Barrier Reef Marine Park (Document No. 100472). 2018. Policy under s7(4) of the GBRMP Act 1975. No, Permit Application. http://hdl.handle.net/11017/3420. Accessed through https://elibrary.gbrmpa.gov.au/jspui/handle/11017/3420
25. Bayraktarov, E., et al. 2015.
26. D. Hesley, D. Burdeno, C. Drury, S. Schopmeyer, D. Lirman. Citizen science benefits coral reef restoration activities. Journal for Nature Conservation, Volume 40, 2017, Pages 94-99. ISSN 1617-1381. https://doi.org/10.1016/j.jnc.2017.09.001. (https://www.sciencedirect.com/science/article/pii/S1617138117301504)
27. Joseph D. Unsworth, Dalton Hesley, Martine D'Alessandro, Diego Lirman. Outplanting optimized: developing a more efficient coral attachment technique using Portland cement. Restoration Ecology, Volume 29, Issue 1. E13299. 09 October 2020. https://doi-org.ezproxy.cul.columbia.edu/10.1111/rec.13299
28. "Whitsundays tourism industry onboard to deliver new life to damaged reefs." Southern Cross University. 17 November 2020. https://www.scu.edu.au/engage/news/latest-news/2020/whitsundays-tourism-industry-onboard-to-deliver-new-life-to-damaged-reefs.php