UN environment programme

ICRI
International Coral Reef Initiative

United Nations Decade on Ecosystem Restoration 2021-2030

CORAL REEF RESTORATION

AS A STRATEGY TO IMPROVE ECOSYSTEM SERVICES

A guide to coral restoration methods

Authors

Margaux Hein, Ian McLeod, Elizabeth Shaver, Tali Vardi, Sylvain Pioch, Lisa Boström-Einarsson, Mohamed Ahmed, Gabriel Grimsditch.

Suggested Citation

Hein MY[1,2], McLeod IM[2], Shaver EC[3], Vardi T[4], Pioch S[5], Boström-Einarsson L[2,6], Ahmed M[7], Grimsditch G[7](2020) Coral Reef Restoration as a strategy to improve ecosystem services – A guide to coral restoration methods. United Nations Environment Program, Nairobi, Kenya.

[1] Marine Ecosystem Restoration (MER) Research and Consulting, Monaco

[2] TropWATER, James Cook University, Australia

[3] The Nature Conservancy, USA

[4] ECS for NOAA Fisheries, USA

[5] University Montpellier 3 Paul Valery, France

[6] Lancaster Environment Centre, Lancaster University, UK

[7] United Nations Environment Programme, Kenya

Advisory Committee

Austin Bowden-Kerby (*Corals for Conservation*), Emily Corcoran (*Independent consultant*), Alasdair Edwards (*Newcastle University*), Jessica Levy (*Coral Restoration Foundation*), Jennifer Loder (*Great Barrier Reef Foundation*), Joanie Kleypas (*National Centre for Atmospheric Research-USA*), Jennifer Koss (*NOAA*), Elizabeth McLeod (*The Nature conservancy*), Phanor Montoya-Maya (*Corales de Paz*), Buki Rinkevich (*National Institute of Oceanography-Israel*), Francis Staub (*ICRI*), David Suggett (*University of Technology Sydney*), Didier Zoccola (*Centre Scientifique Monaco*).

Layout

Johanna Villani Design

Funding

This work was funded by the Swedish International Development Cooperation Agency and the Principality of Monaco.

Additional Support

This project was also supported by the Australian Government's National Environmental Science Program Tropical Water Quality Hub (NESP TWQ) funding to Ian McLeod, Margaux Hein, and Lisa Boström-Einarsson.

Acknowledgement

We would like to express our gratitude to the following experts for supporting this report through the provision of text, case studies, photos, external peer review and guidance: Amanda Brigdale, Anastazia Banaszak, Agnes LePort, Tory Chase, Tom Moore, Tadashi Kimura, members of the ICRI Ad-Hoc Committee on coral reef restoration, and the leadership team of the CRC. We thank them for providing their valuable time, knowledge and expertise, continuous trust and exemplary collaboration and professionalism.

List of Acronyms

CRC – Coral Restoration Consortium

CMP – Conservation Measures Partnership

GBR – Great Barrier Reef

IFRECOR – French Initiative for Coral Reefs

ICRI – International Coral Reef Initiative

IPCC – Intergovernmental Panel on Climate Change

NASEM – National Academies of Sciences, Engineering, and Medicine

NOAA – National Oceanic and Atmospheric Association

RRAP – Reef Restoration and Adaptation Program

RRN – Reef Resilience Network

SER – Society for Ecological Restoration

UNEA – United Nations Environment Assembly

UNEP – United Nations Environment Programme

Cover: Freedivers monitoring corals growing on tables in Pulau Hatamin, Indonesia © Martin Colognoli /Coral Guardian

North Broken Passage GBR
© Catlin Seaview Survey

Contents

EXECUTIVE Summary

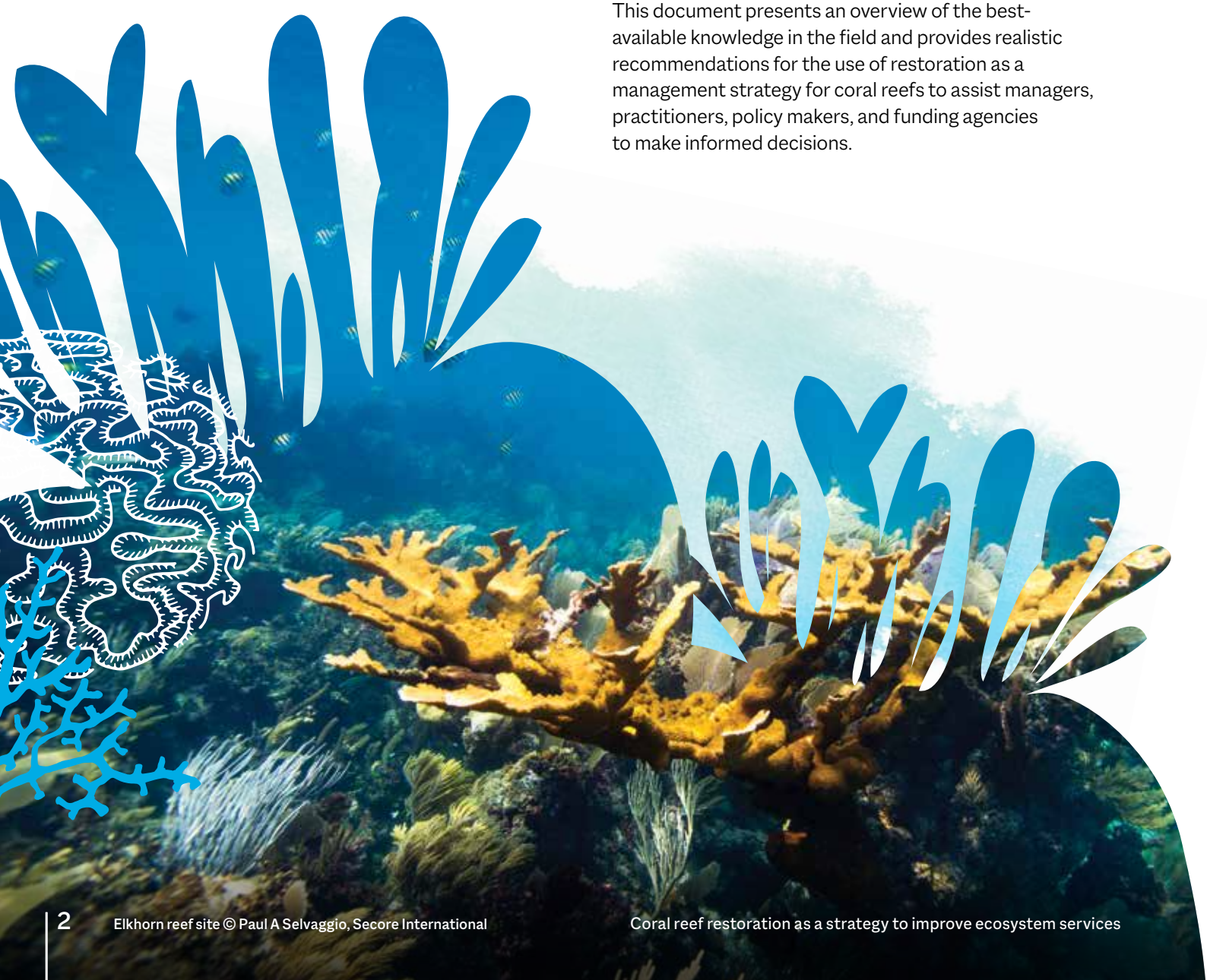
Coral reefs provide billions of dollars in ecosystem services every year globally but are in fast decline in the face of rising climate and anthropogenic disturbances. Urgent climate action is required along with bold local management to halt the declines and support coral reef resilience now and into the future.

Coral reef restoration is increasingly advocated for as a management strategy to combat dramatic declines in coral health and cover globally. It is also increasingly suggested as a mechanism to help countries deliver on national and international commitments under various multilateral environmental agreements.

Yet, there is still a limited understanding of the effectiveness of coral reef restoration efforts, particularly in supporting the maintenance of ecosystem services.

In 2019, the United Nations Environment Assembly (UNEA) adopted Resolution 4/13 requesting the United Nations Environment Programme (UNEP) and the International Coral Reef Initiative (ICRI) to better define best practices for coral restoration for the maintenance of ecosystem services, including for coastal defence and restoration of fish nursery areas. The coming UN Decade on Ecosystem Restoration (2021-2030) and Ocean Science for Sustainable Development (2021-2030), provide an opportunity to highlight the work already underway and set out a path for future actions.

This document presents an overview of the best-available knowledge in the field and provides realistic recommendations for the use of restoration as a management strategy for coral reefs to assist managers, practitioners, policy makers, and funding agencies to make informed decisions.



Elkhorn reef site © Paul A Selvaggio, Secore International

The report is organised in **six** parts.

1

WHAT IS CORAL REEF RESTORATION?

Part 1 defines coral reef restoration in the context of climate change and describes current coral reef restoration goals and methods.

2

CURRENT CHALLENGES AND OPPORTUNITIES

Part 2 presents opportunities and challenges, particularly around scale, standards, ecosystem integrity, and socio-cultural considerations.

3

TO RESTORE OR NOT TO RESTORE – A CALL FOR REALISM

Part 3 calls for realism and advises caution against the unplanned use of coral reef restoration, especially on reefs where local disturbances cannot be mitigated.

4

RECOMMENDATIONS

Part 4 highlights general recommendations on using coral reef restoration as a management strategy, focusing on steps to take prior to restoration in the planning and design phase, as well as in the implementation and monitoring phases. Recommendations that are specific to goals and methods are also highlighted.

5

CONCLUSIONS AND ACTION PLANS

Part 5 draws general conclusions and provides links to trusted sources of information.

6

CASE STUDIES

Part 6 presents six case studies of coral reef restoration efforts in different parts of the world.

Whilst not designed to reduce climate impacts, coral reef restoration can be a useful tool to support resilience, especially at local scales where coral recruitment is limited, and disturbances can be mitigated. Ongoing investment in coral reef restoration research and development globally will improve the scale and cost-efficiency of the methods currently applied.

However, at present, there is limited evidence of long-term, ecologically relevant success of coral reef restoration efforts. Coral reef restoration should not be considered a 'silver bullet' and should be applied appropriately, with due diligence, and in concert with other broad reef resilience management strategies. In the context of climate change, applying coral reef restoration methods effectively and efficiently requires 'climate-smart' designs that account for future uncertainties and changes.

Increased consideration of ecological engineering, beyond just planting corals, that integrate reef-wide and long-term ecological succession processes are also necessary to improve the current scale, cost and effectiveness of coral reef restoration methods.

We suggest coral reef restoration strategies follow four critical principles: 1) planning and assessing around specific goals and objectives, 2) identifying adaptive strategies to mitigate risks, 3) engaging local stakeholders and communities in all stages of the restoration efforts, and 4) developing long-term monitoring plans to allow for adaptive management and to improve the understanding of restoration effectiveness for specific goals.

RECOMMENDATIONS

MANAGEMENT RECOMMENDATIONS

- **Coral reef restoration efforts need to be integrated into broader reef management strategies.**

  Implementing bold action to reduce anthropogenic stressors as part of a broad management strategy is essential to improve the reef conditions necessary for reef restoration to be successful.

- **Future impacts of climate change should be incorporated into the planning and design phase of coral reef restoration efforts.**

  Short and long-term management decisions should be 'climate-smart', accounting for climate change projections and site-specific vulnerabilities to disturbances.

- **Socio-economic considerations need to be considered systematically in all stages of coral reef restoration processes.**

  Engaging various stakeholders in all stages of reef restoration efforts is crucial to build long-term support from the public, empower partnerships with diverse sectors and stakeholders, and link conservation actions to economic goals.

- **Coral reef restoration efforts need to integrate ecological processes beyond planting corals.**

  Meeting goals associated with securing and enhancing the provision of reef ecosystem services, and overall coral reef resilience to climate change requires broader considerations of ecosystem processes associated with reef health, physical integrity, and connectivity principles.

- **Methods' selection should account for cost-effectiveness and scalability, as appropriate for the local context.**

  This report provides an overview of these parameters for current well-established coral reef restoration methods.

- **The field of coral reef restoration is evolving rapidly and needs monitoring and adaptive management strategies.**

  Planning for long-term monitoring should be an integral part of any coral reef restoration efforts to allow for adaptive management and the inclusion of the latest technology and research advances.

- **Coral reef restoration is not a short-term fix for coral reef decline.**

  Ecosystem restoration efforts are interventions that need to be planned and funded as long-term (at least 10 to 20 years) strategies.

Pacific © Hannes Klostermann

POLICY RECOMMENDATIONS

- **Coral reef restoration targets should be included in commitments made to the UN Decade on Ecosystem Restoration.**

  Coral reefs are a critical, valuable and highly threatened global ecosystem, and we recommend that they should be well represented in global, regional and/or national restoration targets associated with the UN Decade on Ecosystem Restoration.

- **Policy, plans, and funding specific to coral reef restoration are needed to assist implementation at local, regional, and global scales.**

  These might include new or refined policies and plans to support on-going investment and collaborations at multiple scales towards intervention strategies for coral reefs. They should reflect the management recommendations above.

INTRODUCTION

Coral reefs are some of the most ecologically and economically valuable ecosystems on our planet. Covering less than 0.1% of the world's ocean, they support over 25% of marine biodiversity and provide a wide range of ecosystem services such as coastal protection, fisheries production, sources of medicine, recreational benefits, and tourism revenues (Burke et al. 2011).

Coral reefs occur in over 100 countries and territories with at least 500 million people directly depending on reefs for their livelihoods. Healthy coral reefs contribute substantially in benefits and services to people, in the order of billions of US dollars. For example, Mesoamerican reefs were recently estimated to provide US$2.6 billion in ecosystem goods and services annually (UNEP 2018), while the Great Barrier Reef is valued at US$56 billion with a yearly economic contribution of US$6.4 billion (Deloitte et al. 2017).

Often referred to as 'sentinel ecosystems', coral reefs are now considered the most vulnerable ecosystems to climate change and local anthropogenic pressures (Bindoff et al. 2019). Some estimates suggest that over 50% of coral cover has already been lost in the last 30 years (NASEM 2019). Disturbances such as declining water quality, destructive fishing practices, coral disease, and predator outbreaks are exacerbated by an increase in the intensity and frequency of storms and mass coral bleaching events (Hughes et al. 2018). Two recent IPCC reports (IPCC 2018; Bindoff et al. 2019) summarize the existing projections of future coral bleaching to state that coral reefs as we know them will all but disappear in a scenario of up to 2°C warming and up to 90% of coral reefs could be lost even with an increase of 1.5°C.

Urgent climate action is essential to combat 'the coral reef crisis' (*sensu*, Bellwood 2004) and ensure a future for coral

Coral reef restoration could help countries deliver on national commitments linked to Nature-Based Solutions (NBS) and Nationally Determined Contributions (NDCs) to the Paris Agreement on climate change, as well as supporting the UN Decade on Ecosystem Restoration (2021-2030). The UN Decade on Ecosystem Restoration aims to scale-up ecosystem restoration efforts globally to meet Sustainable Development Goals linked to conserving biodiversity, ending poverty, improving livelihoods, ensuring food security, and combating climate change. Coral reef restoration efforts are now implemented in at least 56 countries around the world (Boström-Einarsson et al. 2020), but there is limited guidance on the efficiency and efficacy of various methods, particularly with regards to scale, cost, and regional specificities. The Coral Restoration Consortium (CRC) was formed in 2017 to foster collaborations and technology transfer among experts, managers, and practitioners, and facilitate the adoption of coral reef restoration practices globally. Both the International Coral Reef Initiative (ICRI), a partnership of nations and organisations to preserve coral reefs, and the United Nations Environment Programme (UNEP) have adopted resolutions to better define needs, priorities, and recommendations for implementing coral reef restoration more broadly. In 2019, ICRI formed an Ad-hoc committee to advance a plan of action to promote reef restoration practices by facilitating investment and capacity-building among ICRI members. In the same year, the United