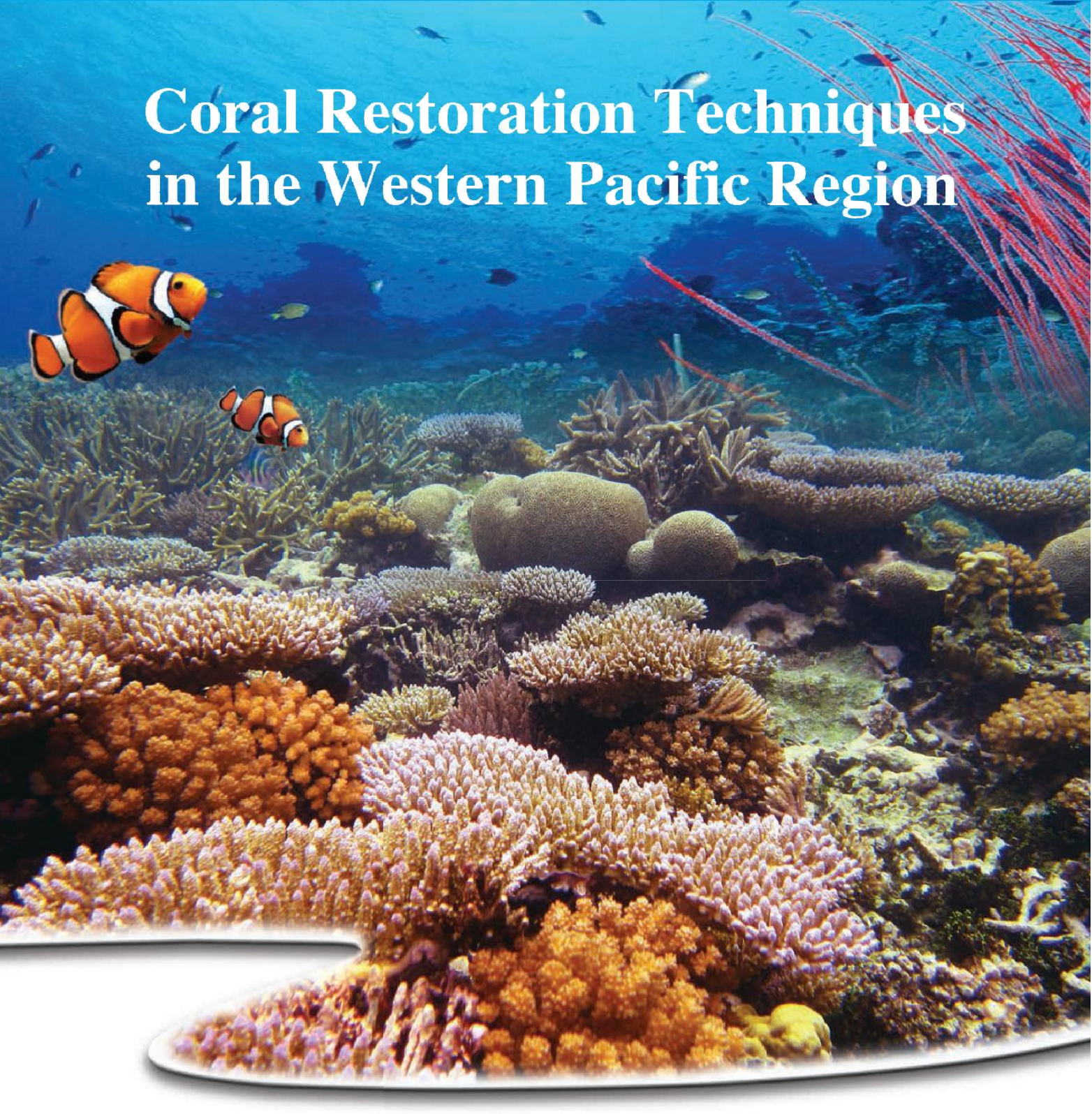
Coral Restoration Techniques in the Western Pacific Region



IOC/WESTPAC Project on Coastal Marine Biodiversity and Conservation

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Years of Dedication to Marine Science 1989-2014

United Nations Educational, Scientific and Cultural Organization
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I) Introduction of Coral Restoration Techniques

IOC/WESTPAC Project on Coastal Marine Biodiversity and Conservation was approved unanimously by member states during the Seventh Intergovernmental Session of the IOC Sub-Commission for the Western Pacific in Malaysia in 2008 as a contribution to the High Level Objective of UNESCO/IOC in safeguarding the health of ocean ecosystems. The project focuses and covers 3 study areas

i. Biodiversity and taxonomy of marine organism
ii. Effect of disturbance and current stressors on biodiversity
iii. Restoration and rehabilitation of ecosystems

At present, many world's ecosystems including coral reefs have undergone significant degradation through natural and anthropogenic causes. Although healthy ecosystem will eventually recover naturally, reducing causes of degradation through effective management measures will help in recovery. However, direct intervention through active and passive restoration can be another option for conservation and sustainability.

Restoration and rehabilitation of coral reefs has become an important topic and major activity in many countries particular in the Southeast Asian region. This is because significant food sources for half a billion people worldwide are derived from coral reefs, and the livelihood of many people depend on these degraded coral ecosystems. Currently, several techniques of coral restoration are available and can be applied. This booklet aims to consolidate techniques used or available for coral restoration in the Western Pacific Region.

II) Glossary Related to Coral Restoration

Restoration*

The act of bringing a degraded ecosystems back into, as nearly as possible, its original condition.

Rehabilitation*

The act of partially or fully replacing structural or functional characteristics of an ecosystem that have been diminished or lost, or the substitution of alternative qualities or characteristics of those originally present with the proviso that they have more social, economic or ecological value than existed in the disturbed or degraded state.

Remediation*

The act or process of remedying or repairing damage to an ecosystem.

Mitigation*

The reduction or control of the adverse environmental effects of a project, including restitution for any damage to the environment through replacement, restoration, or creation of habitat in one area to compensate for loss in another.

Ecological restoration**

The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

Recruitment*

The successful establishment of viable individuals into a population or a habitat.

*Definitions are adopted from Edwards and Gomez (2007) and Edwards (2010)
**Definition is adopted from Society for Ecological Restoration Science and Policy Working Group (2002)

III) Assessment and Restoration Techniques

Biological restoration

Sexual propagation

Whether dealing with terrestrial or marine propagation and the reestablishment of populations, conservationists express concern about genetic diversity. This is a valid issue because of the environmental challenges of the future. There is a need for resilient species to cope with the global changes of the future. Hence, biologists are focusing some attention to the sexual propagation of corals for restoration.

An important caveat for managers to consider is the need for land-based facilities for producing larvae and their subsequent survival as attached juvenile corals that can be outplanted, whether directly to the reef substrate or to a protected rearing area in the ocean before direct deployment to the reef. Presently, unlike terrestrial plant nurseries, there are limited coral nurseries that produce juveniles for deployment to the reefs.

When considering the sexual production of coral juveniles, one consideration is the availability of sexually mature colonies. Brooding species, particularly the Pocilloporidae, usually produce larvae monthly for much of the year, although there are peak periods. The narrower fertile period of coral colonies is exhibited by the broadcast spawners, where the release of gametes is determined by the phase of the moon and only during a few months of the year.

By using broadcasting corals

A variation of this is to bring mature coral colonies to the laboratory and placing them in tanks until they release their gametes, usually at night. Once the eggs and sperm are gathered, they are thinned out to an optimum density, allowed to fertilize, and the embryos allowed to develop into planulae.

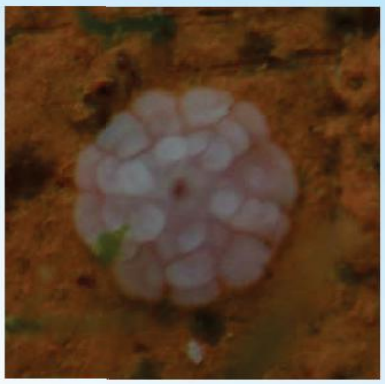
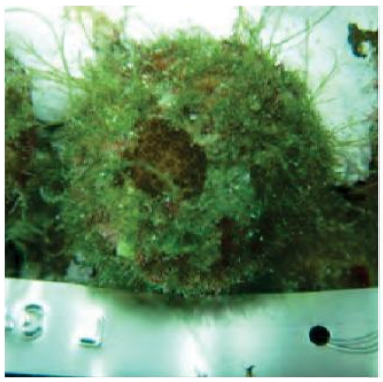
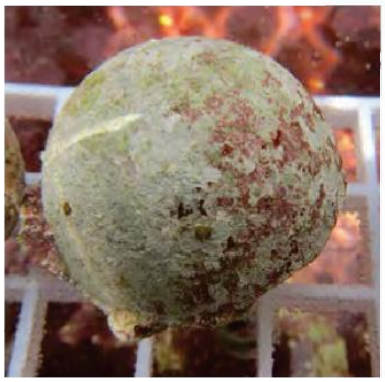
An appropriate concentration is then provided with suitable substrates so that the planulae can settle on them. Substrates have typically been pieces of terracotta or cement tiles, but more recently, various researchers have devised coral settlement devices, pins or "plug-ins" that can be handled easily and transferred to a field nursery or directly onto the reef to be reseeded. An intermediate field nursery in a protected area has been shown to enhance survival to adult size when the propagules are finally deployed to the reef.

By using brooding corals

A similar process can be followed for brooding species (e.g., *Pocillopora damicornis, Heliopora coerulea*), except that collection is more difficult in the field. Hence, brooding colonies may better be brought to the laboratory for the collection of the planulae.

The juvenile coral colonies produced in the laboratory are deployed to the reef when competent. The challenge is how to transfer the young corals to the substrate so that they are firmly attached to the reef. An important condition for the long term survival of the juveniles is their ability to overgrow their initial attachment substrate and overgrow onto the calcium carbonate reef surface.




Asexual propagation

Using fragments and nubbins:

Asexual propagation involves the creation of new individuals cloned from a large coral parent by means of fragmentation. Fragments comprise coral pieces of variable sizes. Fragments less than 5 mm comprising a few coral polyps are considered nubbins.

In a restoration exercise, preferably not more than 10% of a parent colony may be broken into numerous fragments using simple tools like wire cutters or hammer and chisel. The parent colony should be left to recover naturally. Fragments may then be directly transplanted onto a suitable substrate or attached onto plugs/pegs/pins and left to grow out in a nursery prior to transplantation.

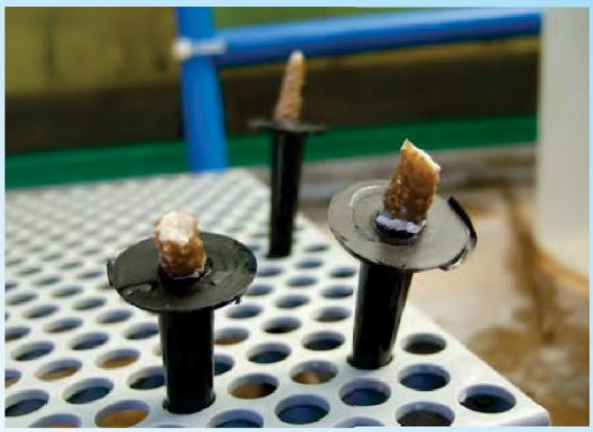
One practice that may be employed in the sourcing of transplanting material is the search for and gathering off "corals of opportunity", i.e., living fragments that may be occasionally found on the reef floor after they have been naturally (e.g., by strong wave action or storms) broken off or detached from the parent colony accidentally. If parts of the fragment have died, these portions might first be removed so that only the living portion is reattached to the reef.

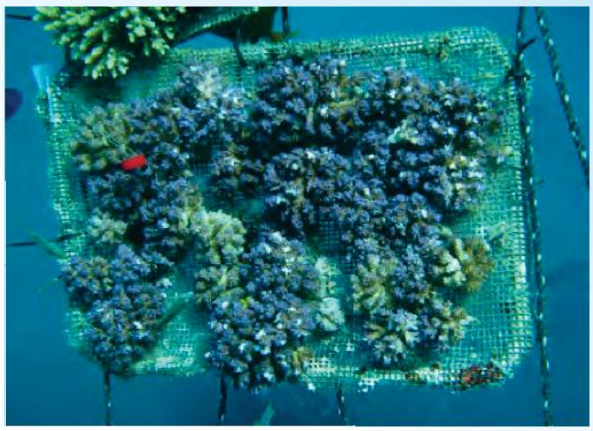
Fragments may be attached to the substrate using suitable attachment media, e.g. underwater epoxy or cement. Nubbins that are grown out on plugs may be attached directly by inserting the plugs into holes drilled into the substrate and further secured using cement. The base of the fragments should be attached as closely as possible to the substrate as the coral will eventually grow over and naturally attach themselves to the substrate. Fragments should be spaced out to allow for growth of individual corals.

Asexual propagation is a quick and simple technique for rapid restoration of degraded reefs with limited impact to the parent coral. It is a suitable technique when donor sources are readily available and when resources are limited and higher level techniques are unavailable.

Nurseries, whether land-based or ocean-based, may be used to increase the amount of transplanting material. This is the adaptation of the concept of plant nurseries on land. For this purpose, either benthic or floating platforms and rope nurseries may be considered. While genetic diversity is limited, the collateral damage to donor colonies is minimized and the number of fragments needed for transplantation can be greatly increased. Various techniques and modifications have been tried with good success, as described in published scientific papers and in coral rehabilitation manuals.

It should be noted that the use of "nubbins" requires more husbandry and time for the growth of the pieces before a competent size for outplanting is reached, usually months. Once the appropriate size is reached, the small colonies may be attached using suitable methods.





Transplanting whole corals only for rescue:

As general rule, whole coral colonies should not be harvested and transplanted for restoration purposes, because such action results in some mortalities of colonies, resulting in a net loss. However, whole coral transplantation may be considered in situations where the reef may be completely lost, e.g. due to development and habitat conversion. In these situations, this would be considered as a rescue operation.

Physical restoration

Physical restoration is defined as the repair of reef environment from an engineering approach as opposed to the restoration of biological processes. Artificial reef creation is a common technique used for physical restoration which can be used for reef aggregation. Various artificial structures, including rock, concrete (e.g. ReefBalls™), ceramic (e.g. EcoReefs™), and carbon steel structures (e.g. BioRock™), have been used in physical restoration. Once these structures have been established, either within existing reef or nearby reef systems, coral fragments can then be transplanted and secured onto these structures. Alternatively, these structures could be platforms for potential recruitment of coral larvae.

The deployment and use of physical restoration techniques have to be considered carefully due to their high costs. In spite of the significant costs, these techniques have been used widely in the Western Pacific region. For instance, the carbon steel structures have been deployed in Indonesian waters as artificial reef structures. Ceramic and concrete structures have also been used in Thailand as well as the Philippines. Reef Enhancement Units (REU) made up of concrete, fiberglass, and/or metal are used in Singapore waters. Depending on the size of these REUs, they can be relocated to other areas.

The benefits of an established artificial reef include increased reef area as well as potential new sites for recreational diving. The creation of these new artificial reef dive sites will result in reduced pressure or disturbance to existing natural reef systems by divers.

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