Methodology CoralGardening - Koh Tao Thailand

Introduction

Coral reef restoration includes building 3-dimensional artificial reef structures, salvaging coral species and transplanting corals on the artificial reef.

In the last decades, many coral reef restoration initiatives have been started at a global scale, using a wide range of techniques to build artificial reefs and to salvage corals. The three main techniques are:

- habitat creation + natural recruitment, using structures such as reef balls
- habitat creation + asexual reproduction, also known as coral gardening
- habitat creation + sexual reproduction

Additional techniques to enhance coral growth are:

1) electrolysis process, known as biorock method

Natural recruitment is the natural process of coral larval settlement on newly created substratum. Well-known are the so-called reef balls, open or massive concrete balls with holes to provide shelter for fish and to mimic natural reefs.

Asexual reproduction is the natural process through collection of fragments of broken-off pieces of healthy corals from the seafloor or fragmentation of (healthy) wild donor coral colonies that are cut into smaller parts.
The fragments provide new coral clones that are attached in-situ to artificial substrate in an underwater nursery. Fragments have the ability to re-attach to new substratum, and grow into new colonies. Fragments in nurseries can be cloned multiple times during further growth. This results in population growth.

Sexual reproduction of sexual derived propagules is the process of collection of gametes (eggs and sperm) during spawning from (broadcast) spawning corals and ex-situ fertilization in a tank under controlled conditions. Artificial substrate is provided for settlement of the larvae and metamorphosis into coral polyps. After reaching a certain size the coral is transplanted to the reef.
Most corals breed sexually by broadcast spawning, and colonies of the same species release gametes simultaneously over a period of one to several nights following a full moon. The timing of broadcast spawning is generally known, but limited to once or a few times per year. Brooding species have multiple periods of larval release.

CoralGardening carries out their project using the second technique of **habitat creation** and **asexual reproduction** through **collection of fragments.**

Habitat creation

The aim of CoralGardening is to educate, protect and restore. By creating attractive, artistic 3-dimensional structures CoralGardening not only provides new habitat for coral growth, with the design of the structures CoralGardening also creates new habitat for marine life to allow the artificial reef to develop into a natural reef as quickly as possible. In addition, CoralGardening attracts divers and takes diving pressure off natural reefs by providing structures in the shape of hands to use as dive site and swim-through. This is a means to educate divers on the importance of buoyancy control and to educate divers and the diving industry on responsible dive tourism to protect coral reefs.

Asexual Reproduction

The aim of CoralGardening is to protect and restore, not damage coral reefs. Therefor it explicitly does not use the method of fragmentation of wild donor coral colonies by cutting small parts from healthy corals. To restore damaged reef and to enhance coral growth CoralGardening collects 5-20 cm sized fragments lying on the seafloor in the vicinity of the new habitat structure. The fragments are pieces of corals broken off by storms or human disturbance. Fragments are collected only if they appear alive and healthy, without signs of disease, and if they are not yet overgrown by algal turf or sponges.

CoralGardening aims to restore biodiversity and genetic diversity. Collection of coral fragments supports genetic and species diversity, in contrary to asexual reproduction of new coral clones through fragmentation from one donor coral.
Corals are a colony of polyps created through asexual reproduction, meaning that each individual polyp in the colony is a clone of the original polyp that was produced through sexual reproduction. The asexual reproduction allows corals to increase in size and repair lost or damaged tissue. Corals with branching, bushy or plate-like growth forms can break easily, creating daughter colonies through natural fragmentation. Massive corals are less likely to break off and reproduce asexually. Branching species are most frequently used in asexual coral reef restoration, because of easy fragmentation and cloning, fast growth rates and quick results. However, this technique is just increasing coral abundance, creating reefs with very little species and little genetic diversity. Another problem of monoculture is that it results in a sterile population, as gametes from a single coral colony cannot self-fertilize. CoralGardening collects natural broken-off fragments of as many species as possible and has proven to be successful with survival and growth of coral fragments from many growth forms. This method preserves species and genetic diversity, which is crucial to the functional and structural diversity and long-term survival and resilience of reefs. The greater the diversity of corals on a reef, the better prepared that reef is to

survive and adapt to disturbances such as disease, ocean acidification and rising seawater temperatures.

The following methods are used to attach loose coral fragments to the artificial reef structure, depending on the construction material of the artificial reef:

2) Rope: un-tighten rope, stick fragment in between threads, tighten rope
3) Iron wire: use thin iron wire to attach the fragment
4) Bottles: use wooden wedge to fixate fragment in bottleneck
5) Bio-plastic: biodegradable ty-rips are used in an experimental set-up

Collection of fragments

Summarizing, CoralGardening uses the technique of collection of fragments, which has the following benefits:

- No damage to healthy coral colonies by using natural coral fragments that would otherwise get buried or overgrown
- No introduction of exogenous material by using local coral fragments
- Maintain coral species diversity and genetic diversity within species, to ensure long-term survival and resilience of reefs
- High survival of 5-20 cm sized fragments compared to low chances of natural larval recruitment and high mortality in sexual reproduction
- Low-cost material and low-tech method
- Complementary to local MPA management, use artificial reef restoration in ecotourism, research and education activities for public outreach and involvement of local stakeholders, divers and volunteers.
- Complementary to local MPA management, mitigate the impacts from human and natural damage by salvaging broken-off coral fragments.

Do's and don'ts by CoralGardening

Do:

- Utilize naturally created fragments from a variety of species found on the reef, to preserve species and genetic diversity
- Include long-term monitoring to measure survival, regeneration and growth
- Develop sexual reproduction techniques through coral spawning and larval culturing to increase genetic diversity and reef resilience
- Complement coral gardening with coral predator removal, clean-ups, waste water management, stakeholder involvement, education and other actions to preserve the coral reef ecosystem.

Don’t:
Break-off fragments from wild donor coral colonies
Use fragments for cloning and monoculture, to avoid a vulnerable and sterile population susceptible to disease and reproductive failure
Judge project success on the number of fragments created and short-term monitoring as this does not guarantee reef resilience and survival

References

Barton JA, Willis BL, Hutson KS (2017) Coral propagation: a review of techniques for ornamental trade and reef restoration. *Reviews in Aquaculture* **9**: 238-256

Lirman D, Schopmeyer SA (2016) Ecological solutions to reef degradation: optimizing coral reef restoration in the Caribbean and Western Atlantic. *PeerJ* **4:e2597;** DOI 10.7717/peerj.2597

Meesters HWG, Smith SR, Becking LE (2015) A review of coral reef restoration techniques. Report **C028/14** *Wageningen Marine Research*

Yeemin T, Sutthacheep M, Pettongma R (2006) Coral reef restoration projects in Thailand. *Ocean & Coastal Management* **49(9)**: 562-575

Young CN, Schopmeyer SA, Lirman D (2012) A review of reef restoration and coral propagation using the threatened genus Acropora in the Caribbean and Western Atlantic. *Bulletin of marine science* **88(4)**: 1075-1098