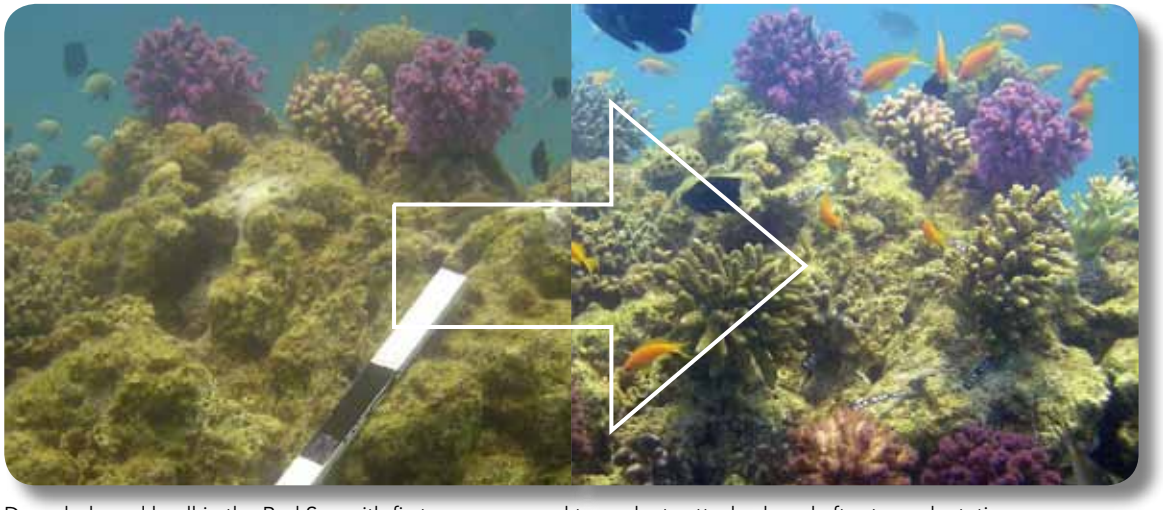
Reef Restoration & Rehabilitation

October | 2010

AdvisoryPaper

Rehabilitation of reefs is a long-term process, not a quick-fix



Denuded coral knoll in the Red Sea with first nursery reared transplants attached; and after transplantation was completed (Y. Horoszowski).

Over 400 million people in more than 100 countries rely on coral reefs for their food and livelihoods, but these reefs are under threat. There are at least 255,000 square kilometres of coral reefs worldwide. Of these, 19% are considered severely degraded, while another 15% are thought to be under imminent risk from human pressures.

This is set to get worse, with scientists predicting that global climate change will significantly degrade coral reef ecosystems within 50 years, as a result of rising sea surface temperatures and ocean acidification.

Corals are the keystone species which give structure and complexity to coral reef ecosystems. They are subject to large-scale regional incidents, such as bleaching-induced death and predation by Crown-of-thorns starfish. Corals are also very vulnerable to climate change.

Rehabilitation or restoration of damaged reefs is possible in certain circumstances; however, like marine protected area management, it is complex, requires investment, expertise and long term planning. Even then it may fail because of unforeseen and unpredictable events outside the control of managers.

Recommended actions to support reef rehabilitation:

1. **Try to prevent damage occurring in the first place. It is much less expensive to protect reefs or mitigate impacts than to attempt to restore damaged reefs.**
2. **Identify and mitigate the cause of local human damage to the reef before attempting any rehabilitation.**
3. **A rehabilitation strategy must include monitoring and allow adaptive management to cope with changing circumstances.**
4. **Where possible, use management interventions to encourage natural regeneration.**
5. **If active rehabilitation is to be undertaken, careful project planning (including risk assessment) and management, is critical.**
6. **Encourage community support for reef rehabilitation through education and participation in reef rehabilitation projects.**

The Coral Reef Targeted Research & Capacity Building for Management Program (CRTR) is a leading international coral reef research initiative that provides a coordinated approach to credible, factual and scientifically-proven knowledge for improved coral reef management.

The CRTR Program is a proactive research and capacity building partnership that aims to lay the foundation in filling crucial knowledge gaps in the core research areas of Coral Bleaching, Connectivity, Coral Diseases, Coral Restoration and Remediation, Remote Sensing and Modeling and Decision Support.

Each of these research areas are facilitated by Working Groups underpinned by the skills of many of the world's leading coral reef researchers. The CRTR also supports four Centres of Excellence in priority regions, serving as important regional centres for building confidence and skills in research, training and capacity building.

The CRTR Program is a partnership between the Global Environment Facility, the World Bank, The University of Queensland (Australia), the United States National Oceanic and Atmospheric Administration (NOAA) and approximately 50 research institutes & other third parties around the world.

Coral Reef Targeted Research & Capacity Building for Management Program
c/- Global Change Institute Gerhmann Building, The University of Queensland,
St Lucia, Qld 4072, Australia
Tel: +61 7 3346 9942
Fax: +61 7 3346 3299
Email: info@gefcoral.org

Prof Alasdair Edwards
Chair, CRTR Restoration & Remediation Working Group
Tel: +44 (0)191 222 6663
Fax: +44 (0)191 222 5229
Email: a.j.edwards@newcastle.ac.uk

October 2010

Product code: CRTR 009/2010.

Reef Restoration & Rehabilitation

Reef recovery

Many coral reefs that are relatively free of human impacts have shown remarkable resilience to disturbances, such as mass-bleaching events. In contrast, those reefs already impacted by human activities often show little to no sign of recovery.

Local communities and reef managers can reduce local human impacts through enforcement of fisheries regulations, establishing effective Marine Protected Areas, pollution control and other interventions.

Alongside these management interventions, active reef rehabilitation techniques can improve ecosystem resilience, giving stressed reefs a greater chance of surviving as productive and functional systems.

These techniques have limitations which need to be considered prior to implementation of any project. Rehabilitation plans must be flexible, and include monitoring and adaptive management responses that reflect the changing needs of the reefs.

Where possible, these plans should favour preventative measures before resorting to active restoration, as active restoration tends to be more expensive, more risk prone and difficult to implement effectively at large scales.

Coral reef in the Chagos Archipelago in the central Indian Ocean about one decade after almost all corals were killed to a depth of 10m as a result of sea temperatures warming during the 1998 El Niño Southern Oscillation Event. This illustrates the remarkable resilience of reefs that are undisturbed by local human impacts (N. Graham).

Management first

Scientists recommend management actions that promote the natural recovery of reefs, such as reducing overfishing and pollution, ***before*** resorting to active restoration (e.g. coral transplantation).

Encouraging natural recovery – known as "passive" or indirect restoration – is likely to be more cost-effective than active or direct restoration methods, such as coral transplantation, seaweed removal or substrate replacement, but the latter may also be essential in some cases.

Improving the reef environment and promoting natural recovery is usually what reef managers are doing anyway. This, of course, requires very "active" and effective management as well as significant funding and may not be easy to implement for social, economic and political reasons. However, because it uses "free" ecosystem services it is typically more cost-effective, and can generate benefits over much larger areas than active restoration attempts.

At sites where there is significant human impact on the reef, some form of management control promoting passive restoration needs to be in place before active restoration occurs.

Without this, the active interventions have a high risk of failure and will be a waste of limited resources.

Education and involvement of the local community is an essential part of restoration.

Staff of the Parque Nacional Arrecifes de Cozumel teaching visiting school children about marine conservation before guiding them around the reef (C. Martinez Ceja).

Active restoration is possible, but requires careful planning

Active restoration of reefs at any significant scale requires trained experts, scientific back-up, and substantial investment. Even then, it is not yet proven to be successful at large scales. Recent research has shown how to greatly reduce costs but coral transplantation alone costs US$10,000s per hectare. Restoration of other ecosystems such as mangroves, seagrasses or saltmashes comes at a similar price.

If damage to the reef framework is so severe that physical restoration through civil engineering is required, this figure increases by 10 to 100 fold. For instance, one study of ship groundings in the Caribbean suggests costs of US$2-6.5 million per hectare to repair injured reefs.

Active restoration is also hindered by bleaching events, outbreaks of coral predators and other unexpected disturbances, which now occur relatively frequently.

At times, however, active restoration is necessary, such as when areas under effective management are not recovering from a natural disturbance or previous human impact.

Trained coral reef scientists have had variable success with experiments involving active restoration and it is unrealistic and, ultimately, counterproductive to raise expectations that coral reefs can readily be rehabilitated.

A few rehabilitation projects have been successful at scales of up to a few hectares, but others have largely failed to meet original expectations.

A key problem is that coral transplants are sensitive to a range of disturbances. Restoration will only work if the similar conditions exist at the transplant site as exist at the source site for the transplants.

To date, much active reef restoration has centred on ship groundings. These events typically generate funds to repair damaged reefs and are on a scale small enough for rehabilitation attempts to make an impact.

Key issues for active restoration

Scale So far, proven effective at small scales only.

Risk Activity has significant risk, with limited success or even failure not uncommon outcomes.

Skills A good understanding of reef ecology is required to design and adaptively manage projects.

Management Reefs targeted for restoration need to be effectively managed to ensure that local human activities which cause damage to the reefs do not reoccur.

Decision-making Outcomes of active restoration are still too uncertain for it to be used as an excuse for continued destruction of reefs for coastal development.

A CRTR research diver carrying corals that were reared from eggs from a nursery site to a transplant site in Bolinao, Philippines.

Coral camping in Palau! CRTR scholar Vanessa Baria checks on the progress of an experiment to artificially enhance coral larval supply to degraded reefs.

Focusing restoration resources

Given the sheer scale of coral reef degradation worldwide, there is no shortage of stable coral reef areas in need of restoration.

Previously, there has been much attention paid to restoring or introducing coral cover to unstable rubble and sand patches, which often need expensive artificial structures to which coral transplants can be attached.

This is akin to carrying out the first reforestation experiments in areas without top soil.

Instead, careful site selection, better project planning and management, and explicit recognition of the risks inherent in active restoration approaches and ways of reducing these, are essential to ensure reef rehabilitation programs do not waste limited resources.

Reef Restoration & Rehabilitation AdvisoryPaper

Restoration and remediation research

Despite considerable advances in reef restoration science over the past 35 years, the discipline is still in its infancy. However, scientists have now developed more cost-effective techniques for rearing and transplanting large numbers of corals to degraded reef areas. Nonetheless much research is still needed to establish how these techniques can be applied at large spatial scales; whether benefits will cascade to wider areas; and whether there is scope for rearing bleaching-resistant strains.

Nursery rearing of corals from fragments or larvae has allowed a marked reduction in collateral damage to reefs. There have been big improvements in transplant survival, the scale of nurseries (which can now rear 10,000s of transplants per year) and cost-effectiveness of methods.

The Coral Reef Targeted Research & Capacity Building for Management (CRTR) Program has examined both natural recovery processes and and a wide range of promising restoration interventions. It has focused on the knowledge gaps which hinder restoration.

A key aim is to advise the management community so that restoration projects can be undertaken in a more informed way and with a better chance of success.

Highlights of the efforts of the CRTR Restoration & Remediation Working Group include:

- Improving the protocols for asexual rearing of coral fragments in sea-based nurseries for restoration and showing that, with careful training, coral nurseries can flourish in a range of developing country environments using locally available materials

CRTR scholar Lee Shaish (right) assists Thai scientist Nalinee Thongtham in transferring nursery-grown colonies, ready for transplantation (G. Levy)

- Explaining how reef restoration should be undertaken within a wider coastal management context with proper planning and mitigation of risks – refer *Reef Rehabilitation Manual (2010)*
- Increasing our knowledge of how to rear corals from eggs or larvae to adult colonies; minimising post-settlement mortality; and developing methods for transplanting large numbers of reared corals to degraded reefs in a cost-effective way
- Disseminating the science underpinning reef rehabilitation to the management community via the *Reef Restoration Concepts and Guidelines: Making Sensible Management Choices in the Face of Uncertainty (2007)* and the *Reef Rehabilitation Manual (2010).*

Case study: Rehabilitation in the Red Sea

Coral reefs in the Red Sea at Eilat, Israel have been degraded by human activities including coastal development, port activities, pollution and recreational SCUBA diving. A pilot project commenced in 2005 to rehabilitate the reefs using nursery-grown corals.

Over 1700 small colonies of locally common corals were transplanted from nurseries to denuded knolls near Dekel Beach, a popular beach just south of the Eilat town centre. These transplants had a low initial mortality rate, showing good adaptation to the new environmental conditions. Some transplants were attacked by fish, but most survived and regenerated.

Since the transplantation, the knolls have been colonized by crabs, shrimps and other invertebrates. Fish abundance at the knolls has also increased. Transplanted corals have been spawning in each subsequent reproductive season.

The rehabilitation project was led by Yael Horoszowski from the Israel Oceanographic and Limnological Research, and supervised by CRTR Restoration & Remediation Working Group member, Dr Buki Rinkevich, from the National Institute of Oceanography, Israel.

One of the denuded coral knolls, 1.5 years after transplantation (Y. Horoszowski).