Coral Reef Rehabilitation and Restoration: Experience of Malaysia

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Abstract
After the event of mass coral bleaching in 2010 and the ever vulnerability on the marine environment due to climate change, the Department of Marine Park Malaysia starts to look at ways to address the future of coral reefs through coral reef restoration. Approaches such as mitigation, adaptation and resilience need to be enhanced in Malaysia marine protected areas (MPAs). A coral restoration project was initiated in 2011 in collaboration with stakeholders such as Reef Check Malaysia. It takes about three years to reach maturity and two pilot sites had been established with encouraging result. The design of the coral frame structures goes through three different stages of which the present Cores 3 frame hopefully will enhance the spatial coverage for the project. The first two frame’s design can hold about 24 coral fragments (nubbins) whereas the present Cores 3 can holds up to 70 coral fragments. A breakthrough of improved survival rates after the transplanted coral sources had been substitute using the “coral of opportunity” as a “seed” and increasing the size of each of the coral seed fragments to more than 10 cm length. Suitable site selection is an important factor in determining the success of the project. At the moment the genus from Acropora spp. and Pocillopora spp. are used for the coral transplant.

Keywords: climate change, coral reef restoration, marine protected areas, coral transplant.

Introduction
Malaysian coral reefs are mostly fringing type, and the country has more than 540 species of hard corals (Reef Revisited, 2012). Sipadan Island is an oceanic island of Malaysia encircled by corals. Although Malaysian sea waters could be about 566,285 km², at the moment only 9% of the country’s coral reefs (Fig. 1) are protected through the establishment of marine protected areas of MPAs (CT Atlas, WorldFish, 2012).

Moreover, considerable portion of Malaysia’s live coral cover had been reported to be beaching. In an effort to address such concern, Malaysia had implemented since 1998 coral rehabilitation program (Table 1) in many locations shown in Fig. 2. There had been many cases of coral bleaching starting in 2010, such as in Renggis Island off west central Tioman in Pahang where coral bleaching was reported at depth of 12 m and temperature of 31°C (Fig. 3), and in Lima Island east of Redang, Terengganu at depth of 10 m and temperature of 30-32°C (Fig. 4).
Table 1. Malaysia’s Coral Reef Rehabilitation Program (1998-2014)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sites</th>
<th>Activities</th>
<th>Stakeholders</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>Sarawak</td>
<td>Installation of Reef Ball ARs</td>
<td>Sarawak Forestry Corporation</td>
<td>Conservation</td>
</tr>
<tr>
<td>2003</td>
<td>Semporna Island, Sabah</td>
<td>Coral transplantation</td>
<td>Islamic Financial Services Board</td>
<td>Commercial</td>
</tr>
<tr>
<td>2005</td>
<td>Sabah</td>
<td>Coral transplantation</td>
<td>Tropical Research and Conservation Centre</td>
<td>Semi-conservation</td>
</tr>
<tr>
<td>2006</td>
<td>Layang-Layang, Sabah</td>
<td>Coral transplantation</td>
<td>Department of Fisheries Malaysia (DOFM)</td>
<td>Conservation</td>
</tr>
<tr>
<td>2009</td>
<td>Gaya (off Kota Kinabalu)</td>
<td>Electrophoresis for DNA/RNA analysis</td>
<td>Gayana Eco Resort</td>
<td>Conservation</td>
</tr>
<tr>
<td>2011</td>
<td>Buhay Dulang, Sabah</td>
<td>Coral transplantation</td>
<td>DOFM/Sabah Park</td>
<td>Conservation</td>
</tr>
<tr>
<td>2011</td>
<td>Tioman, Pahang</td>
<td>Coral transplantation</td>
<td>Department of Marine Parks Malaysia (DMPM)</td>
<td>Conservation</td>
</tr>
<tr>
<td>2012</td>
<td>Perhentian, Terengganu</td>
<td>Coral transplantation</td>
<td>DMPM</td>
<td>Conservation</td>
</tr>
<tr>
<td>2014</td>
<td>Bidong, Terengganu</td>
<td>Coral transplantation</td>
<td>DOFM</td>
<td>Commercial</td>
</tr>
</tbody>
</table>

Also in 2010, coral bleaching was reported in Teluk Bakau, Redang Island (Fig. 5), and in Batu Malang, Tulai Island, Tioman, Pahang (Fig. 6 and Fig. 7). In 2014, coral bleaching was observed in Pinang Island off Redang, Terengganu at 3-5 m deep waters and temperature of 31-32°C (Fig. 8).

![Fig. 3. Coral bleaching in Renggis Island, off west central Tioman, Pahang, Malaysia](image3)

![Fig. 4. Coral bleaching in Lima Island, east of Redang, Terengganu, Malaysia](image4)

![Fig. 5. Percentage of coral bleaching in Teluk Bakau, Redang Island, Terengganu, Malaysia](image5)

![Fig. 6. Coral bleaching in Batu Malang, Tulai Island, northwest of Tioman, Pahang, Malaysia](image6)
Many factors threaten the health of coral reefs. These include climate change, pollution, habitat loss, invasive species, coral disease, and illegal fishing. It is therefore necessary to develop mitigation and adaptation measures as well as resilience. Efforts have been made by various agencies in Malaysia to restore its corals, such as coral transplantation carried out by DMPM (Fig. 9) in Tioman Island, Pahang (Fig. 10) which had achieved positive results (Fig. 11), and in Perhentian Island, Terengganu (Fig. 12).
Lessons Learnt

Although the coral transplantation carried out by DMPM, there are lessons that should be shared for the benefit of countries that might embark on a similar activity. Firstly, the sites should have moderate current and unobtrusive sunlight. The fragments of corals to be transplanted must be more than 10 cm. In addition, sites should not be too close and adjacent to natural reefs. Finally, maintenance of the installations is necessary immediately after the transplantation.

Benefits of Coral Restoration

Many benefits could be gained from coral restoration through transplantation. These could include increased live coral cover, hastened recovery of target coral reefs, increased biodiversity, re-established ecological balance, stabilized surrounding environment.

Risks of Coral Restoration

While there are benefits from coral restoration, there could also be risks that come with it. As experienced by DMPM, the transplantation sites could be destroyed by freak weather, while infestation of predators could occur, e.g. oysters. High man-hour is needed for the maintenance of the installations. There could also be inadequate coral fragments that are available in nearby donor reefs. High mortality could also be encountered during the transplantation.

Concerns on Coral Restoration

Some concerns had been raised regarding coral restoration, which should be taken into account if countries intend to carry out such activity. These are: possible alteration of donor reef ecosystem especially is collection of fragments to be transplanted is unsustainable; could create false sense of hope among the stakeholders; transplanted corals could compete with local recruits; low diversity due to selective coral species transplanted; and could create unintentional species dominance with mono-species mix distribution.

Further Studies Needed

In order to demonstrate the viability of coral restoration, it is necessary that relevant studies should be conducted. These could include: fish population at restored coral reefs; other marine biotic populations on site; biodiversity abundance and species richness (for conservation purposes); choice of massive coral or non-branching species (for resilience purposes), among others. Moreover, it is also necessary to conduct capacity building of stakeholders on new handling methods of transplantation.