14. Reef Coral Restoration Program in the Bicol Region, Philippines

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1. Introduction

Numerous studies have reported that coral reefs worldwide are declining in terms of its abundance, diversity, and habitat structure mostly are anthropogenic contribution[1,2] and were further affected by compounding impacts of massive coral bleaching, diseases and typhoons[1,3]. It is estimated that around 30% were already destroyed, while almost 60% may be gone by 2030[1,4].

Similar situation was also observed in the Philippines where local reefs had declined over the last four decades[5]. Nationwide survey showed more than 90% of the same stations were in the poor (0-25% live coral cover) and fair (26%-50% live coral cover) categories. Having an average hard coral cover of around 22%[5].

In Bicol Region, living coral cover ranged from 30-60% and are continuously declining, and most of the reasons for this low coral cover were anthropogenic, such as destructive fishing methods, navigation and pollution. With this, Marine Protected Areas (MPAs) with the purpose of protecting these habitats and its fishery resources were strategically established along the coastal waters of Bicol Region, however, decades have passed but the hard coral cover in these areas have insignificant or no improvement at all and in some cases have declined (Mendoza et al., unpublished). It is therefore vital that appropriate measures must be done to rehabilitate degraded coral reefs and its associated aquatic organisms to reverse or even stop the declining reef situation. It should be noted that reef corals are critically important because they are essential habitats for fishes and other species, and provide direct energy and other nutrient inputs to the ecosystem.

With the impacts of climate change and pollution which increases coupled with high anthropogenic influences, corals can be easily affected that may also affect its fisheries, other aquatic resources, people and their livelihood and with the declining state of our coral reefs, need for conservation and rehabilitation efforts are deemed crucial for ecological, biological and economic recovery and stability of reef system. However, as of this present time, no concrete policy had been implemented to restore or even rehabilitate our reef areas aside from establishment of marine protected areas. Several methods have been utilized to improve marine and coastal ecosystem using the context of ecological approach models, such as artificial coral reefs[6-8], electric mineral growth (EMG) technology[9], and reef ball techniques[10,11] and transplantation of reared coral fragments[12-14].

In 2012-2014, the Department of Science and Technology (DOST) funded a nationwide coral restoration program named “Filipinnovation in Coral Reef Restoration Program” wherein, Bicol Region, specifically in

San Fernando, Masbate was one of the project locations, which was implemented by Bicol University Tabaco Campus (BUTC) (Mendoza et al., unpublished). With the prospect of coral restoration demonstrating the experiences in San Fernando, Masbate (Ticao Island) and combining the practices in the Filipinnovation in Coral Reef Restoration Program, a follow-up study in San Miguel Island, Tabaco City, was conducted, with the project title of "Establishment of Coral Demonstration Site in San Miguel Island" in 2016 by BU Tabaco Campus, wherein we showcased and explored the viability of low technology and low cost methodologies in coral reef restoration[15].

The main purpose of the nationwide reef restoration was to demonstrate the viability of the reef restoration technique in the Philippines to encourage local government units (LGUs) to adopt the method and implement such in their coastal areas (Mendoza et al., unpublished). While the demonstration site in San Miguel Island was done to showcase low technology coral reef restoration scheme utilizing locally available materials and reducing the possible cost of the restoration process so that we can encourage the participation of local communities and the local government units[15].

When this project was presented to LGUs and other stakeholders sometime in 2014, some of the LGUs and non-government organizations (NGO) expressed their desire to implement coral restoration in their areas like the municipality of Tiwi, Albay where the research personnel of BUTC were commissioned to undertake series of trainings, seminars and education campaign to different sectors of the communities from youth to LGU personnel. The same activities were done in Legazpi City, Sorsogon City and Tabaco City. However, there were other local agencies that initiated reef restoration activities like in Masbate City where they integrated coral silviculture using coral fragments (Figure 1) and Pioduran wherein they used iron bars with different shapes and designs (Figure 2).

Recognizing the importance of the reef restoration in Bicol Region, together with high acceptance on the viability of the coral restoration process, Coral Restoration Project was included as one of the extension or "roll-out" technology under the Institutional Development and Innovation Grants (IDIG) Program funded by Commission on Higher Education (CHED) implemented by Bicol University in 2018. This extension program was conducted region-wide in collaboration with four local State Universities and Colleges (SUC) namely in Camarines Norte, Masbate, Sorsogon and Partido. In here, series of methodology trainings and information campaigns were conducted in each SUC together with their local partners like the LGUs, private sectors and

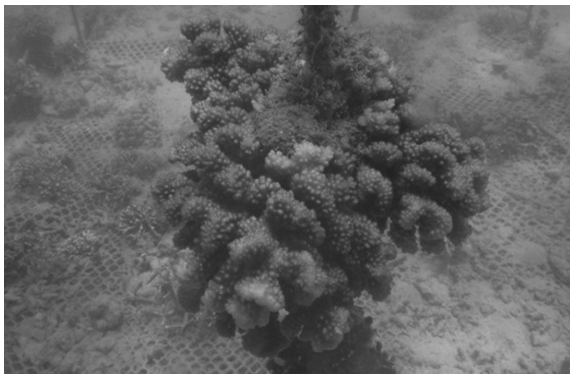

Figure 1 Artificial coral reef in Masbate City, Philippines.

Figure 2 Artificial coral reef in Pioduran, Albay, Philippines.

other sectoral groups.

With all the experiences in reef restoration activities in Bicol Region, it is evident that strong community participation and LGU initiative are crucial input in any undertaking and their participation is strongly influenced by their knowledge on the subject matter. This is the reason why Information and Education Campaign is also important; this is where BUTC will come in. On the other side, enforcement and other support systems of the LGUs are of utmost significant contribution in its success.

2. Status of Corals in Bicol

Several studies have been conducted by Bicol University Tabaco Campus to determine current status of coral reefs in the Region. Recent surveys were done from 2015 to 2019 in selected areas among the different fishing grounds of Bicol (Figure 3). Most of the stations were located in Lagonoy Gulf with 17 stations, followed by Ticao Burias Pass and Asid Gulf with 5 and 3 stations respectively and only 1 station in San Bernardino Strait (Figure 3).

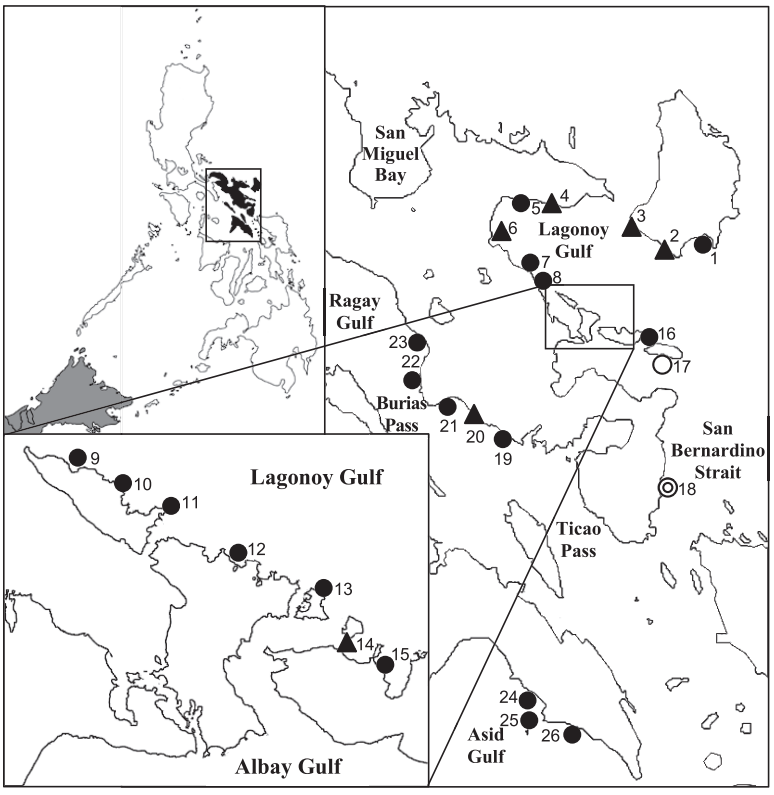

Figure 3 Map of the stations surveyed. The colors of the points indicate the live coral cover (LCC) in Bicol Region.

Live coral cover condition: Excellent (◎), Good (○), Fair (●), Poor (▲). Monitoring site: 1. Bato, 2. Malilima, 3. Agojo, 4. Presentacion, 5. Aguirangan, 6. Atulayan, 7. Tiwi, 8. Malinao, 9. Rawis, 10. Sagurong, 11. Dakulang Puro, 12. Uson, 13. Namanday, 14. Galicia, 15. Gaba, 16. Acal Point, 17. Rapu-rapu, 18. Bulusan, 19. Donsol, 20. Pio Duran, 21. Liago, 22. Oas, 23. Libon, 24. Recodo, 25. Naro, 26. Placer

Live coral cover (LCC) in the Region ranged from as high as 84% in Bulusan, Sorsogon (Figure 3, "18") to as low as 8% in Presentacion, Aguirangan in Camarines Sur (Figure 3, "4", "5"), while dead coral cover ranged from 64% to 2% in Atulayan, Camarines Sur (Figure 3, "6") and Agojo, Catanduanes (Figure 3, "3"), respectively. Out of the 26 stations, only 2 showed with more than 50% living coral cover or within the excellent to good coral cover condition, while 18 stations are within the 26-49% cluster which is considered fair coral cover, and 6 stations showed with poor condition (0-25% LCC). On the average, Bicol Region's LCC is around 34% or can be translated as 'fair coral cover condition", while the dead coral cover is 31%. Although this figure is not a representation of the whole Bicol Region, where majority of our sites were located in Lagonoy Gulf, this can be a good snapshot of the condition of the corals in the region.

Evidence of the worsening condition of the reef ecosystem of the region is exemplified by the relatively high percentage of stations where dead coral cover (DCC) is higher than its LCC. This may reflect the disturbances in the previous years. Several studies conducted in the area showed high impact of illegal and destructive fishing along the reef areas like presence of trawls, seine nets, blast fishing and compressor divers[16,17] (David et al. Mendoza et al. and Soliman et al., unpublished).

The relatively high number of sites with "poor" coral cover and very few stations in excellent and good condition warrants an active rehabilitation measure such as coral fragments transplantation. This is if we want to limit the effect of further destruction to our reefs. In Philippine setting, most of the areas that have been rehabilitated through coral transplantation became a protected zone/s or were done in protected zones.

3. Coral Rehabilitation Program in Bicol

With the introduction of reef rehabilitation methodology in Bicol Region, several LGUs have expressed interest in the activity. A total of 13 sites were identified to have reef rehabilitation program, with 5 sites already in the implementation phase and 8 with proposed reef rehabilitation program (Figure 4).

The first recorded coral rehabilitation was done in San Fernando, Masbate (Figure 4, "B1") where more than 20,000 4-6-months nursery grown fragments were transplanted in 2 hectare protected area in 2013[18]. In Legazpi City (Figure 4, "A5"), although there is no massive coral transplantation, the LGU maintains coral nurseries for tourist attraction. In here, diver-tourists during their visit can experience coral transplantation on their own. While in Masbate City and Pioduran (Figure 4, "B2", "B3"), coral nurseries were constructed for tourism and educational purposes. Pioduran constructed several nursery designs made of iron bars such as cross and dome type where coral fragments are attached (Figure 1) while in Masbate, coral nurseries were made of iron bars with plastic chicken nets where coral fragments were attached. In San Miguel Island, Tabaco City (Figure 4, "B4"), low-cost low technology methods in partnership with local residents and students (Figure 5) were demonstrated to showcase its viability as compared to the other methods that uses SCUBA and iron bars. In here, plastic ropes and bamboo poles were utilized. For the other areas, with proposed rehabilitation program, technical preparatory activities such as trainings and material preparations were already done and is only waiting for some legal, financial and logistics supports. These are in Mercedes in Camarines Norte (Figure 4, "A1"), Caramoan in Camarines Sur (Figure 4, "A2"), Bacacay and Tiwi in Albay (Figure 4, "A3", "A4") and San Jacinto, Mandaon in Masbate (Figure 4, "A7", "A8").

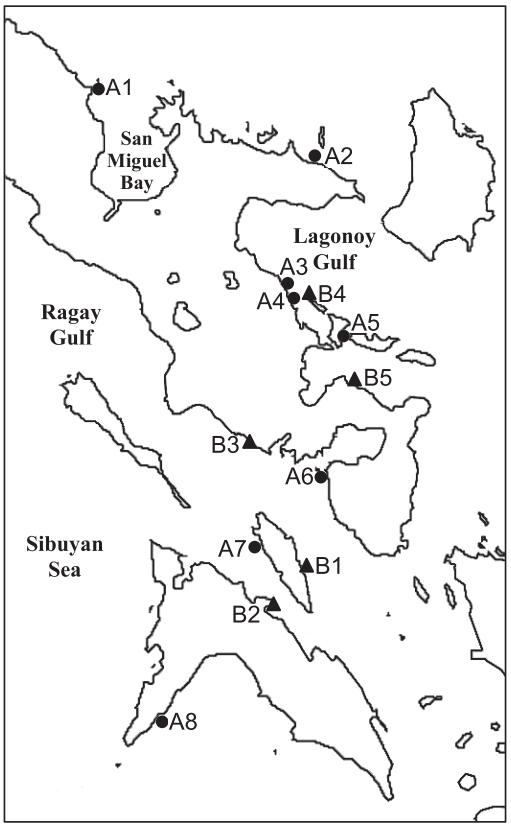

Figure 4 Locations of coral rehabilitation programs in Bicol Region.
A: Sites with proposed coral rehabilitation programs (A1: Mercedes, Camarines Norte, A2: Caramoan, Camarines Sur, A3: Tiwi, Albay, A4: Malinao, Albay, A5: Bacacay, Albay, A6: Magallanes, Sorsogon, A7: San Jacinto, Masbate, A8: Mandaon, Masbate), B: Site existing coral rehabilitation programs (B1: San Fernando, Masbate, B2: Masbate City, Masbtate, B3: Pioduran, Albay, B4: Tabaco City, Albay, B5: Legazpi City, Albay)

4. Coral Rehabilitation Method

4.1 Coral Nursery

4.1.1 Construction of Modules for the Coral Nursery

For the project in San Fernando (Figure 4, "B1"), the hanger type "T" model coral nursery unit (CNU) was used. The CNU is made of Polyvinyl chloride (PVC) material, with three (3) PVC "T" fittings, measuring 3-meter length by 1.5-meter width and 1.5-meter depth (Figure 6).

For structural support, a 12mm iron rebar was used as internal framing of the PVC "T" fittings. The CNU has 18 series of ropes (6mm) running the whole length with

Figure 5 Bed-type nursery unit

10cm gap in between rope which was fixed with plastic cable ties to maintain position (Figure 6). Additionally, a #17 G.I. wire was connected perpendicular to the ropes to minimize movement of individual rope in the event of strong current (inset photo Figure 6). While in Masbate City (Figure 4, "B2"), bed type CNU using plastic chicken mesh nets reinforced with iron bars were also used (Figure 6).

In the demonstration sites in San Miguel Island, Tabaco City (Figure 4, "B4"), low cost and low technology methods, we used the bamboo raft and the monoline technique (Figure 7).

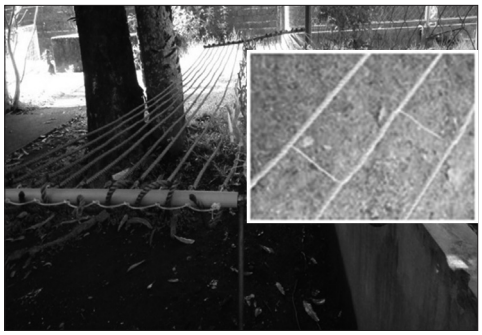

Figure 6 T - coral Nursery Unit (CNU). Inset photo: Nylon ropes embedded with #17 G.I. wire to minimize movement.

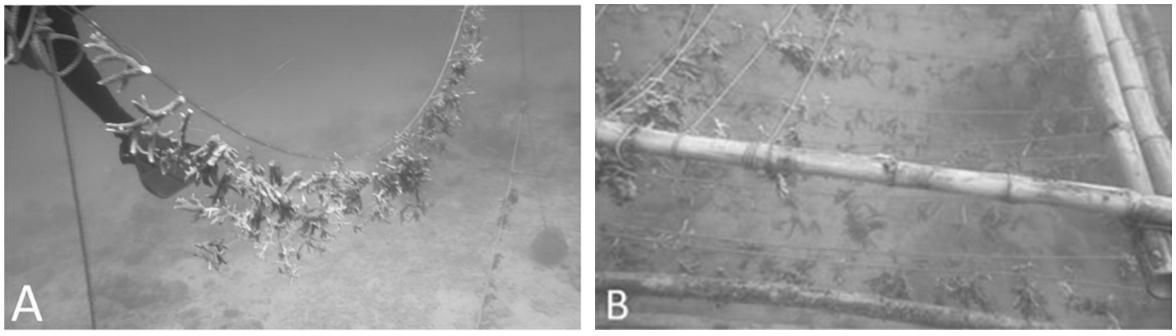

Figure 7 Low cost and low technology coral nursery units used in the demonstration sites in San Miguel Island, Tabaco City.
(A) Monoline hanging nursery unit, (B) Bamboo raft nursery unit.

4.1.2 Deploying the CNU

In deploying the CNU, a 2-diver team is required. First, the two-metal post (1.5 m × 12 mm rebar) were set-up with PVC framing at three meters apart. Once fix, the upper portion with the ropes were connected via the "T" fittings. No need to fix the fittings with solvent for ease in transferring the CNU later. For final fixation of the CNU, four pegs (12 mm rebar × 45 cm length) were used at both ends to anchor the module.

For the low-cost method, "*Bantay-Dagat*" (Coastal Ranger) helped in the deployment of CNUs. Basically, bamboo rafts and monoline CNUs were fixed at the bottom during low tide. in rocks or big stones and sometimes fixed with wooden pegs.

4.1.3 Collection of Coral Nubbins

Coral nubbins for the nursery were collected from areas with abundant "corals of opportunity" (COP). These are corals lying on the ground detached from the donor coral by natural means (storm, typhoons) or anthropogenic (boat anchoring, diver fin damage). COP were then transported to the nursery site and further fragmented into smaller nubbins at 10cm length. Donor sites for corals should be near the nursery site to minimize stress during long transport as possible.

4.1.4 Deployment, Monitoring and Maintenance of Coral Nubbins

Prior to deployment of coral nubbins to the CNU, coral nubbins were tied firmly with G.I wire (#17) as a means of anchoring. This were later attached to the CNU rope using both ends of the G.I. wire (Figure 8) with 6cm gap between coral nubbins. A twice a week dive in the nursery area were done to monitor coral nubbins from fouling organism (algae, sponges, etc), predators (starfish, snail, etc.) and other debris were removed in the CNU to increase survival rate.

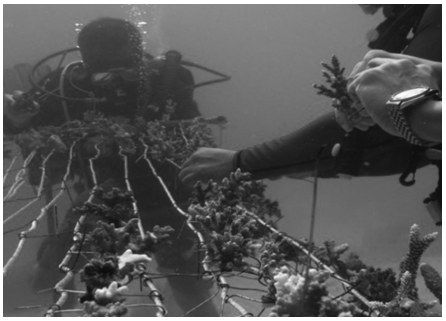

Figure 8 Coral nubbins attached to the rope of the CNU.

4.2 Coral Transplantation

After 4-6 months rearing in the CNUs, transplantation in the rehabilitation site commenced, using concrete nails, cable ties and aqua epoxy to secure the fragments (Figure 9). Prior to transplant, the rehabilitation site was assessed for the living coral cover and associated reef fishes and commercially important invertebrates. The rehabilitation site should be situated in MPAs so that the newly transplanted coral fragments are well secured and protected.

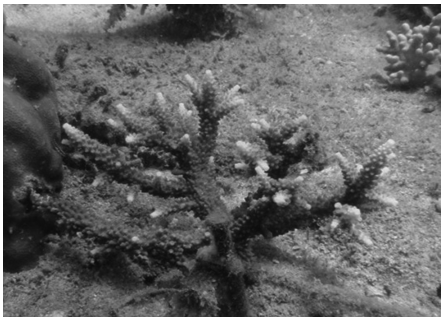

Figure 9 Coral fragments replanted using concrete nails and tie wires.

During the project implementation, Municipal Fisheries and Aquatic Resource Management Council (MFRAMC), Sea Guardians/Patrol or locally known as *Bantay Dagat* members and some of the Municipal Agriculture Office employees were requested to regularly participate in all project's activities from collection of coral fragments, preparing the CNUs, securing the coral nubbins to CNUs, rearing and transfer to the rehabilitation sites including the provision of security. In some cases, help from other community sector like women and youth were requested.

4.3 Growth and Survival Monitoring

The transplanted corals were regularly monitored every quarter both by BUTC research team (researchers and students) and the trained local personnel of the LGU (Figure 10). Percent living coral cover and survival rate of the transplanted were noted, however for more detailed analysis, transplanted fragments' growth and survival rate were also done. Other associated fishes and other invertebrates were recorded and compared with the previous condition.

Studies of BUTC on coral fragments growth (mainly *Acropora* sp.) reared in nurseries showed an average monthly increment of 1cm (Figures. 11 A and C) which is comparable to some of the studies on coral growth reared in nurseries. Survival rate is also comparable with other studies with 80%-60%survival.

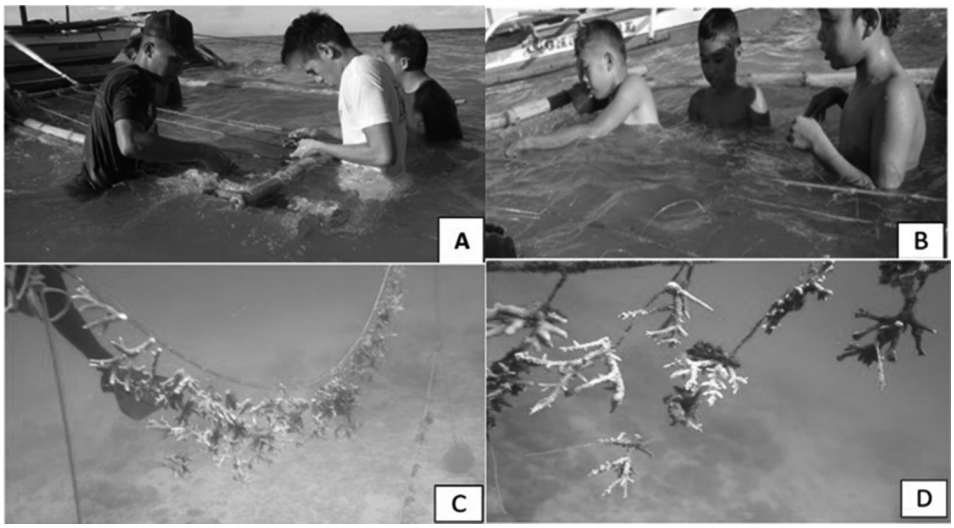

Figure 10 Two types of Coral Nursery Units used in the coral rehabilitation in San Miguel Island, Tabaco City, Philippines. (A-B – Bamboo Raft Method, C-D – Monoline Hanging Method)

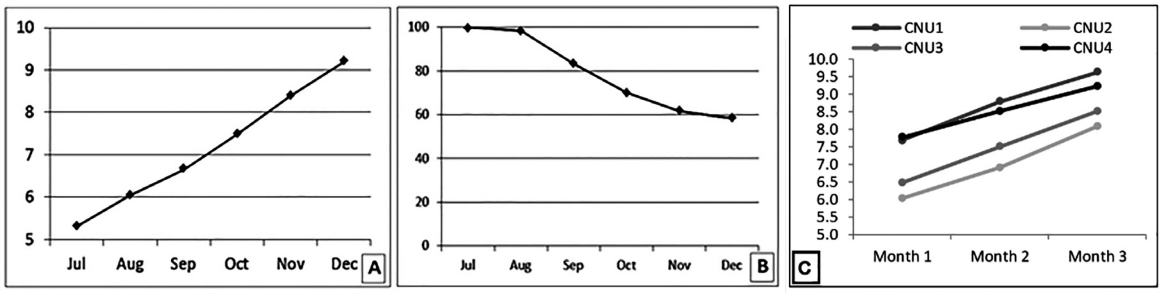

Figure 11 Monthly growth increment and survival of coral fragments reared in CNUs. (A) – Bamboo Raft CNUs, (C) – T-hanger type CNUs. (B) – survival rate of fragments reared in Bamboo raft method.

5. Cost of Coral Transplantation in Bicol

The question of cost of whether coral transplantation the best way to go about restoring damaged marine ecosystems maybe difficult to answer since there is no method that fits all. But at the moment LGUs have to do something otherwise they may lose everything given the existing knowledge inadequacies and logistics they have. For this reason, coral transplantation experiences done in San Fernando, Ticao Island (Figure 4, "B2"), Masbate and San Miguel Island, Tabaco, Albay (Figure 4, "B4") can be a model in this part of the Region. Presented herewith is the costing of two methods of coral transplantation on a per hectare basis as shown in Table 1.

The transplantation is done via LGU-Community-Academe partnership whereby the LGU provides the logistics and institutional support, the community performing the actual planting, management and protection and the academe the technical support. As such local material can be used such as bamboo poles. Labor can be in the form of "food for work scheme", thus creating impact on the fishers/people involved plus the premium of owning the project.

Table 1 Simple cost analysis of coral reef rehabilitation method in San Miguel Island, Tabaco City, Philippines.

Assumptions	Methods	
	Bamboo Raft CNU	Monoline CNU
Number of fragments per CNU	150	200
Number of blocks (5 fragments/block)	18	24
Fragments survival Rate @ 60%	90	120
Average density/hectare	200,000	200,000
Material Cost		
Cost per CNU (rope, bamboo poles, nylon etc.) (PhP)	870.00	620.00
Cost per fragment (PhP)	5.80	3.10
Cost using coral garden racks (1unit coral garden rack = 30 blocks (PhP)	1000.00	1000.00
Total Material Cost (PhP)	1174.00	1093.00
Cost per hectare (PhP)	116,000.00	62,000.00

Note: 1 USD = 45.00 PhP

6. Additional Economic Opportunity

Apart from helping coral adapt to the alarming environmental changes and to hasten recovery, coral restoration program offers other economic opportunities aside from the fisheries it supports. Restoring coral reef habitats to its former natural beauty does not only trickle down to increasing fisheries but likewise provide opportunities for sustainable ecotourism development. With ecotourism in place, a shift in the fishers' unsustainable fishing methods gradually changes to ecologically-friendly alternatives.

The demonstration site in San Miguel Island, Tabaco City (Figure 4, "B4"), developed coral racks where fragments grown in CUNs were transferred for education and tourism purposes (Figure 12). These racks can be established in shallow areas where tourists can swim and observe corals. This can be another livelihood opportunity for the communities. Another case in point is the whale shark ecotourism in Donsol, Sorsogon (Figure 4, "B3") where fishers shifted from whale shark hunters to whale sharks' protectors and conservationists to sustain the tourism industry. Because of ecotourism other associated economic opportunities and businesses opened, providing livelihood and income not only to fishers but also to community members, tourist guides, resort owner, transport group, hotel & restaurants, including food & souvenirs vendors. This development scenario also emerges in coral reef restoration initiatives. One example is the MPA's of Legazpi City and Ligao City which highlights coral reef ecosystem; tourism is now promising throughout the year especially during summer vacation and Holidays where resorts are jam-packed with local and foreign tourism because of the Marine Protected Area where coral and other marine species are protected. Where tourists are present, business are flourishing in many aspects whether in terms of goods and services. As an impact, goods and services are translated into economic benefits that create jobs and income for the people.

7. Problems and Challenges

Although there is high acceptability both from LGUs and communities of any of the coral transplantation methodologies, lack of long-term monitoring of the transplanted fragments and natural phenomena were observed to be the main challenges of this project. This is because LGUs don't have permanent personnel to look after the transplanted corals especially when there were changes in the local officials after election, and in some cases, lower budget is allocated for this project. With this, monitoring and surveillance of the project were affected. Furthermore, corals are threatened by illegal fishing practices, natural calamities, where Bicol Region experiences almost 20 typhoons per annum with at least 1 major typhoon every 5-10 years and coral bleaching due to warming oceans.

Also, dissenting opinions about coral transplantation among scientists - there is no single coral technology that can be rolled out for the entire Philippines. One technology can be successful in an area but it cannot work in another area according to a well-known marine scientist in the Philippines (personal communication with W. Licuanan).

8. LGU Initiatives and Community Partnerships Relative to Coral Restoration

The management and protection of municipal water is specifically provided in R.A.7160 or Local Government Code, R.A. 8550 or the Fisheries Code of the Philippines and R.A. 10654, the amended R.A. 8550. The protection, management and conservation effort or initiatives of the government is likewise support be various environmental laws such as Solid Waste Management Act, the Clean Water Act, Clean Air Act and the EIS system in the country. On this note, LGU's are mandated to protect and manage municipal water including the critical habitats therein.

Among the LGU initiatives in place are in the form of institutional arrangements by way of local legislations/ordinances, creation of regulatory and law enforcement bodies (i.e. FARMCs, *Bantay Dagat*, MPAs Management Councils, etc), and implementation of programs, project and activities (i.e. establishment of MPAs, Coastal Resource Management Projects, Reforestation Projects, etc.).

At the moment, almost all of the coastal municipalities have established MPA's and CRM Projects. As a matter of fact, there are about 50 MPA's strategically located around Bicol Region. In the 1st District of

Figure 12 Coral racks deployed inside the MPA with concrete cement with attached coral fragments.

Albay, for instance, a great majority (90%) of the municipalities have established MPAs and CRM projects. These general cover management, protection and conservation of critical habitats such mangrove, coral & coral reef as well as sea grass & seaweed beds. In Masbate City efforts to protect coral reef in Buntod reef have resulted to a promising tourist destination. The mangrove reforestation in Cabusao, Camarines Sur is now a bird watching destination. These are examples of LGU-Community-Fishers partnership where unity in purpose and common vision results to a success outcome.

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