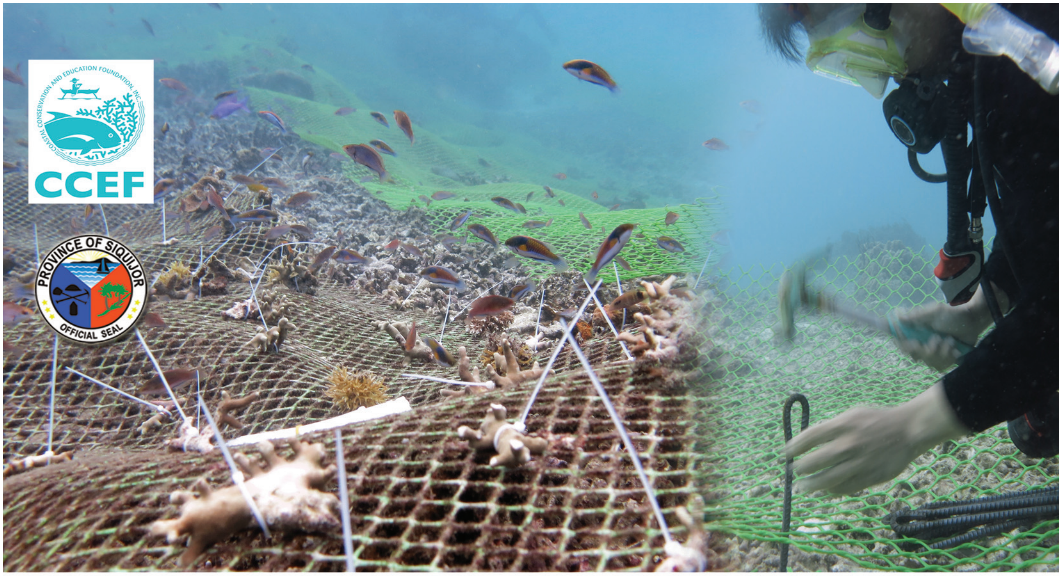
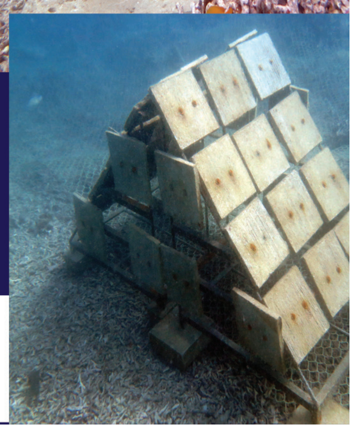


Coral Reef Rehabilitation and Reef Fish Recovery in Siquijor Province:

Lessons and Best practices



Aileen P. Maypa
Michelle R. Baird
Darrell Pasco

unico conservation foundation
giz
On behalf of Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety of the Federal Republic of Germany
ACCCoast Adaptation to Climate Change in Coastal Areas

Coral Reef Rehabilitation and Reef Fish Recovery in Siquijor Province: *Lessons and best practices*

by

Aileen P. Maypa

Michelle R. Baird and

Darrell Pasco

Printed in Cebu City, Philippines

Citation: Maypa, A.P., M.R. Baird and D. Pasco 2014. Coral Reef Rehabilitation and Reef Fish Recovery: Lessons and Best practices. Coastal Conservation and Education Foundation, Inc. (CCEF), Cebu City, Philippines, 32 p.

This publication was made possible through the support provided by the GIZ-ACCCoast under the terms and conditions of FA No. 83160091 and the UNICO Conservation Foundation in Australia. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the GIZ-ACCCoast and UNICO Conservation Foundation.

Captions:
Front cover: Installment of stabilization mats and coral transplantation (top); Fishery recovery tools (bottom right).
Photos by: Michelle R. Baird, Aileen P. Maypa and Simon Cabale
Cartography by: Dalton Dacal

Table of Contents

Title	Page
Introduction	**1**
Chapter 1: Assessing Reef Damage from Typhoon	**3**
Manta Tow	3
LIT and PIT Methods	3
Permanent Photo Quadrat Method	4
Status of Siquijor's Coral Reef after typhoons Sendong and Pablo	5
Coral Reef Recovery Study	8
Chapter 2: Planning and Training	11
Chapter 3: Designing Siquijor's Coral Reef Rehabilitation and Reef Fish Recovery	15
Chapter 4: Coral Reef Rehabilitation and Reef Fish Recovery Tools	**19**
A. Substrate Stabilization	19
B. Coral Transplantation	20
C. Fishery Recovery	25
Chapter 5: Impacts and Outcome	**27**
A. Substrate stabilization and consolidation	27
B. Coral Transplants: growth and survival	29
C. Fishery Recovery Tools	31
Helpers in Coral Rehabilitation	35
Coral Rehabilitation Team	36
References	38

Introduction

This province – wide coral reef rehabilitation and reef fish recovery initiative in Siquijor Island is part of CCEF's larger research on coral reef resilience and recovery in partnership with the Province through the Provincial Agriculturist office and the Provincial Monitoring Team (PROMOTE). Our work started in early 2013, right after typhoon Bopha (Pablo) severely damaged the nothern and eastern coast of the island. This initiative is also in line with the Coastal Resource Management (CRM) framework of the local government units (LGUs) of Siquijor Province. One major objective of our research is to develop protocols and tools that are community- and LGU – friendly to contribute to climate change adaptation and enhance resilience capacities of the aforementioned bodies from typhoon

Coral reef rehabilitation and fishery recovery designs must be well planned and must fit within the coastal resource management framework of the area. In the Philippines, designs and protocols for reef rehabilitation that are specifically targeted for typhoon damaged areas are still being developed and are on its experimental stages. By sharing our best practices and lessons learned in Siquijor Province, we hope to complement our methods with existing effective protocols

and manuals and introduce protocols and methods for large scale rehabilitation that can be implemented by LGUS and coastal communities. Further, we hope to contribute in the decision making and planning stages of coral reef and marine protected area (MPA) managers on (1) whether rehabilitation is the best direction of a damaged coral reef, (2) what factors must be considered to have effective reef rehabilitation designs and, (3) what are the limitations of reef rehabilitation. The focus of this booklet is on coral reef rehabilitation because the widespread degradation of this taxonomic group has large implications to the biodiversity conservation and food security. Because of the strong association of reef fishes to their habitats, it makes them vulnerable to the same threats that coral reefs are facing.

1 CHAPTER

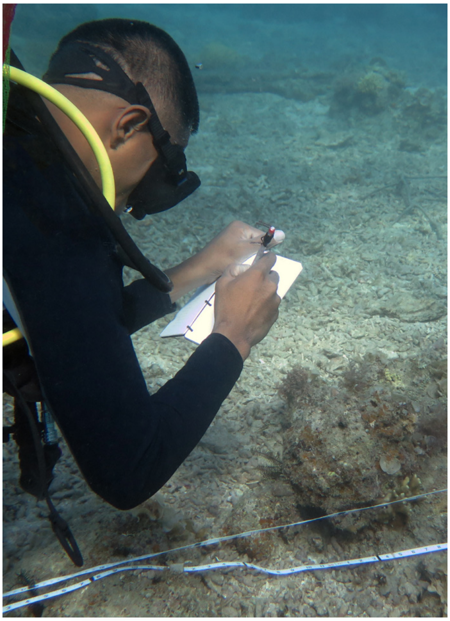
Assessing Coral Reef Damage

Manta Tow

The manta tow method is widely used for assessing broad scale changes in coral reef cover. It is an appropriate method to assess reef damage due to typhoons like Sendong (Washi) and Pablo (Bopha). This method is decribed in detail in English et al. (1997)

An LGU personnel on a manta board

Line Intercept Transect (LIT) and Point Intercept Transect (PIT)

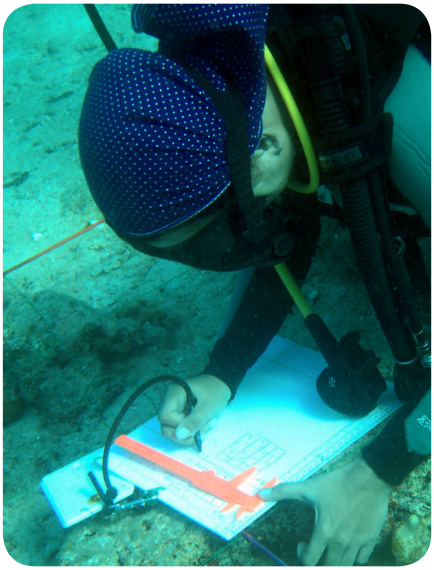


R. Catitig assessing the substrate after typhoon Pablo using PIT

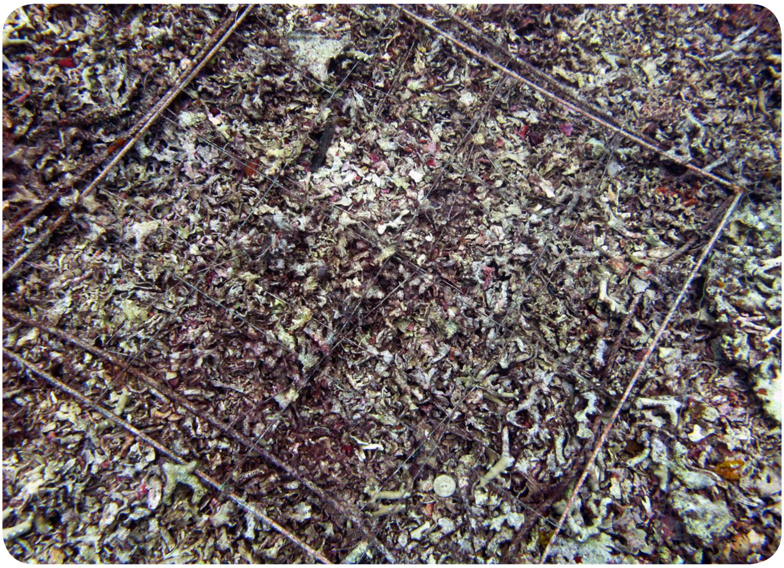
Transects methods are used to assess natural and/or human induces impacts. Transects are suited to medium-scale surveys and can answer questions like: 1. What is the cover of our reef (Beenaerts and Berghe 2005), 2. How much of our reef has damaged and, 3. How is it changing? The PIT method can be learned quickly by partner local government units (LGUs) and local community through repetitive trainings. These methods are described in English et al. (1997).

Permanent Photo Quadrat Method

Quadrats can be used for finer scale surveys with specific questions (Beernaerts and Berghe 2005). Permanent quadrats can answer questions concerning coral reef recovery and resilience (e.g. recruitment and colonization).



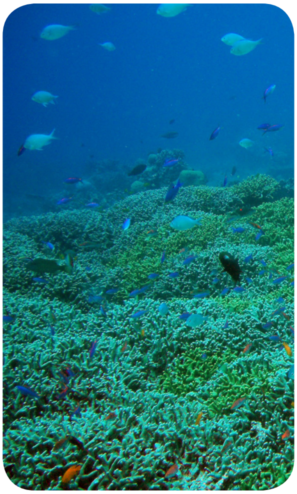
M. Baird measuring coral recruits



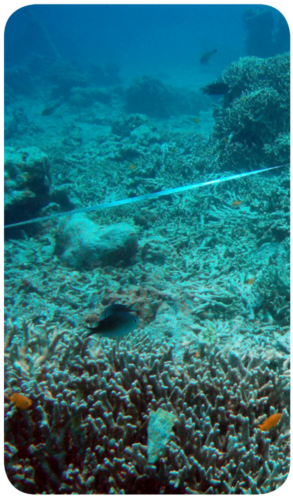
A permanent quadrat installed after typhoon Pablo in our MPA sites to monitor benthic recolonization and coral recruitment.

Status of Siquijor's Coral Reefs after typhoons Sendong (Washi) and Pablo (Bopha)

Candaping B Marine Sanctuary



before the typhoon



after Typhoon Sendong

after Typhoon Pablo

One of the major marine ecosystems that humans depend on for food, livelihood and employment is the coral reef (White and Cruz-Trinidad 1998). However, coral reefs were severely destroyed in the central Philippines along the tracks of the sequential super typhoons in the years 2011 (Sendong), 2012 (Pablo) and 2013 (Yolanda). When coral reefs are destroyed and homogenized to a flat rubble substrate the reef loses its complexity yet this is crucial habitats for reef fishes (e.g., some fish take shelter in holes and crevices between coral species or some fish prefer to hide in between coral branches). Thus, abundance and biomass of reef fish also decline.

This ve[illegible]lly leads to biodiversity loss (Graham et al. 2006, Maypa 2007). Sharp declines in commercially important fish species (target species) were documented in coral reef marine protected areas (MPAs) along the coasts of Maria and Enrique Villanueva Municipalities, with more than 80% damage after typhoon Pablo (Figure 1). As such, this reef fish declines and species loss threaten the livelihood and food security of fisherfolks and coastal communities. Reef fish catch are likely to be negatively affected when coral

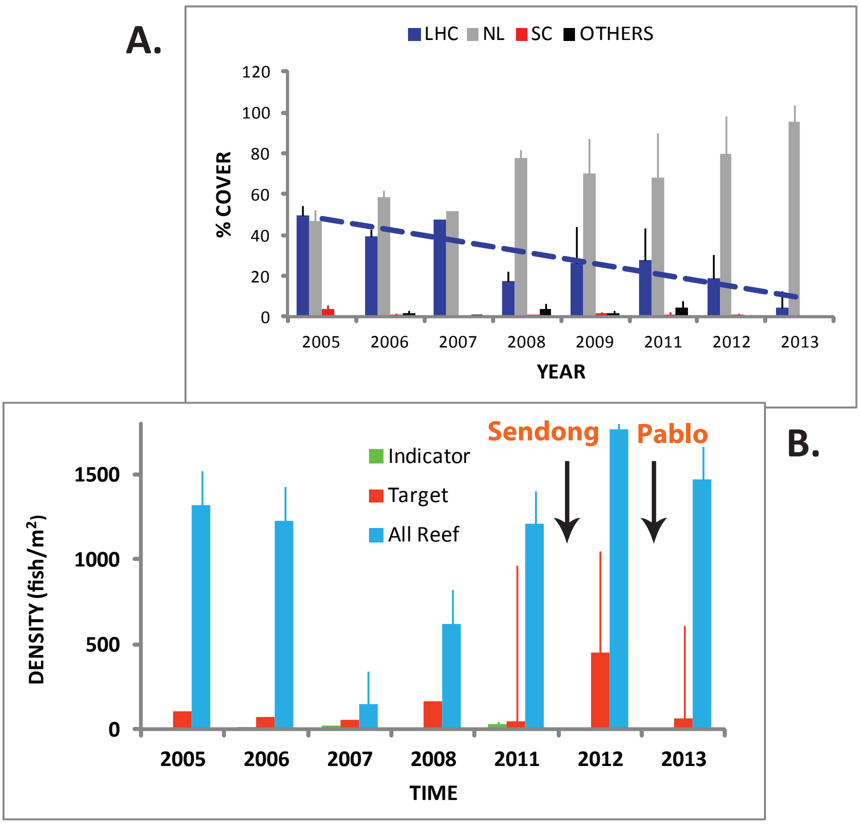


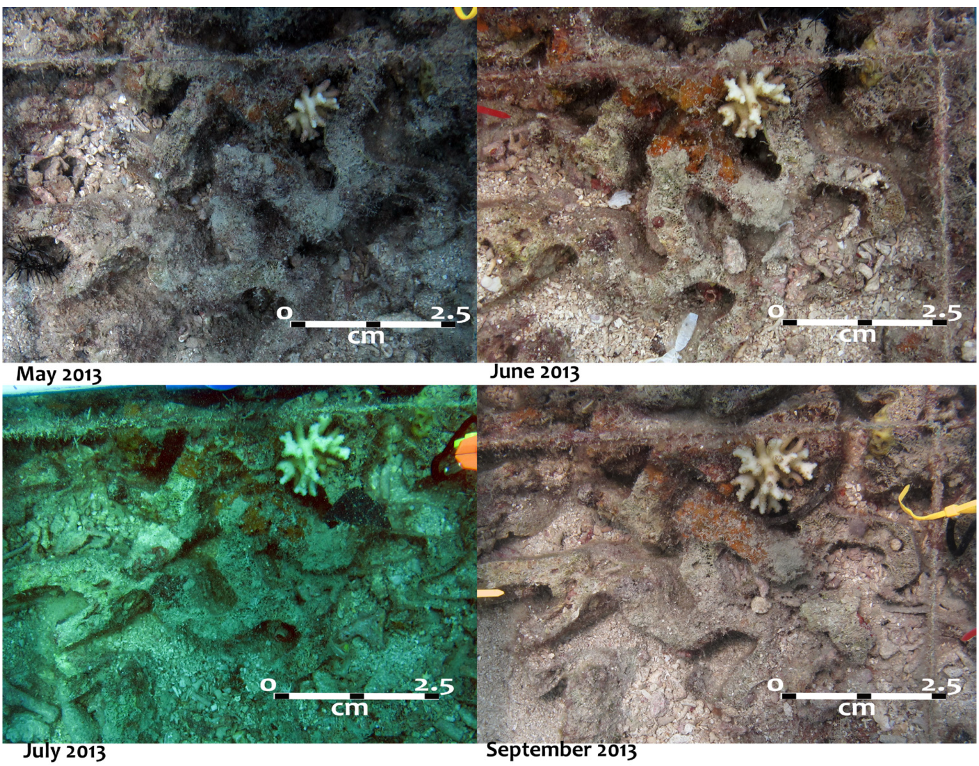
Figure 1. (A) Changes in live hard coral cover (%LHC) and (B) reef fish abundance from 2005 – 2013 in Candaping B. Red arrows indicate when typhoons Waishi (2011) and Bopha (2012) occurred. Source: Maypa et al. 2013.

reefs are gone and, it is important to note that natural coral reef recovery can take 20-50 years in severely damaged areas (Grigg and Maragos, 1974; Stoddart, 1974; Pearson, 1981; Dulvy et al. 1995). In cases of blast fishing or human disturbance where a previously healthy reef classified as moderately productive is destroyed, loss in sustainable fish yield from an area of 1 km^2 is approximately 128 t (White and Cruz-Trinidad 1998). Thus, in Siquijor Province, coral reef rehabilitation was implemented using different designs and tools that match the need of the site

Coral reef rehabilitation and fishery recovery initiatives are best implemented within marine protected areas and as part of the MPA Plan or CRM framework of the area.

Coral Reef Recovery Study

Prior to our coral reef rehabilitation initiative, we installed permanent quadrats in selected sites (Olang, Candaping, Tulapos and Binoongan). This was to study the coral recruitment, growth, survival and recolonization of the damaged MPAs. In Olang and Candaping B Marine Sanctuaries where coral reef damage was above 80%, recruitment was very low (recruitment density: 0.2 - 9.4 /25m²/month depending on the coral lifeform or species (Fig. 2). Recruit survival was also very low (Fig. 3). Mortality was very high in Candaping B and Olang Marine Sancturies and, even higher in Olang adjacent fished area.



Time series images of a coral recruit (Stylophora pistillata) in a permanent quadrat (growth = 0.08 cm/day)

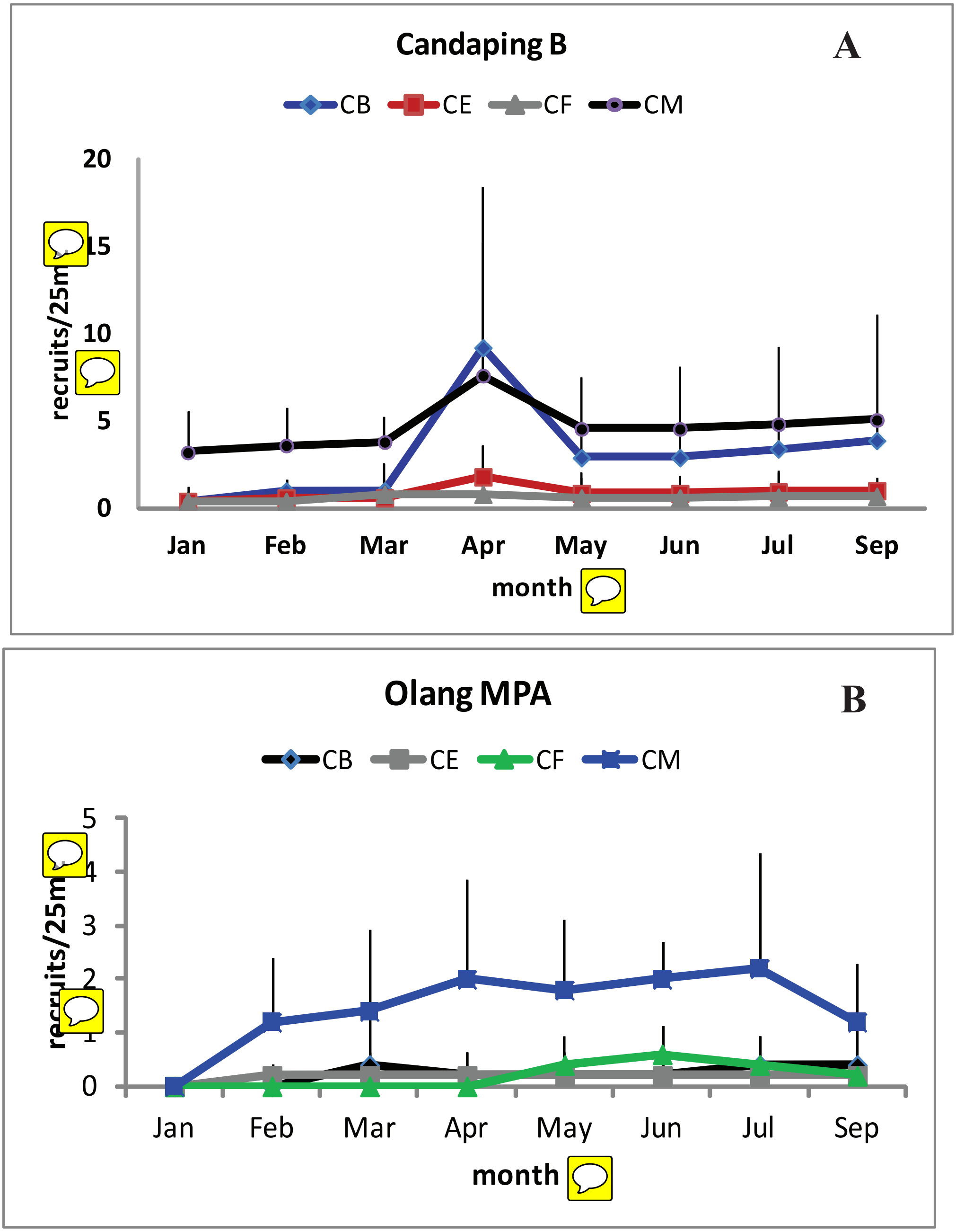


Figure 2. Patterns of coral recruitment density in (A) Candaping B and (B) Olang Marine Sanctuaries from January-September 2013 (average density ± SD)

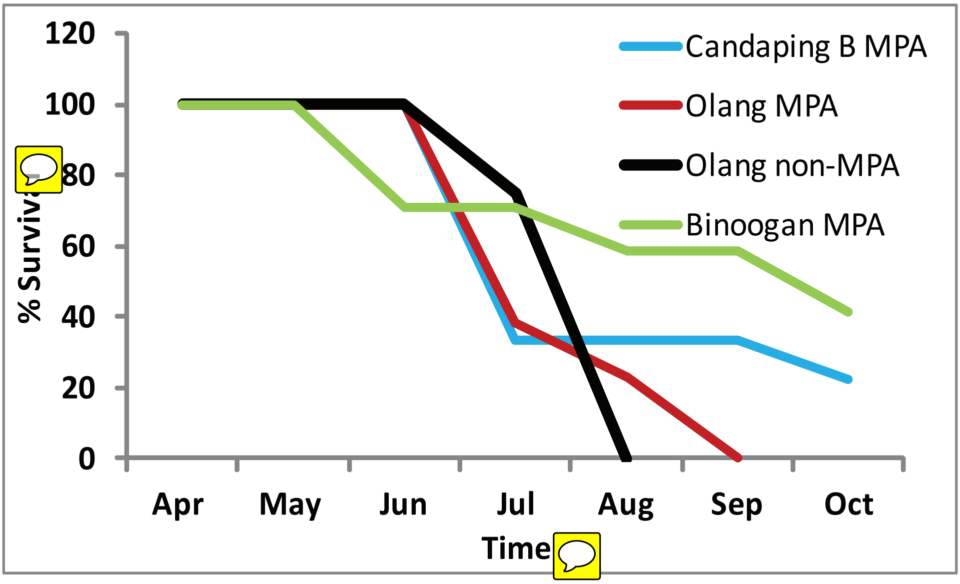


Figure 3. Survival patterns of tagged *Seriatopora hystix* recruits in four sites from April to October 2013 in Siquijor Island (n: Candaping B MPA = 9, Olang MPA = 13, Olang non-MPA =8, Binoongan MPA =17).

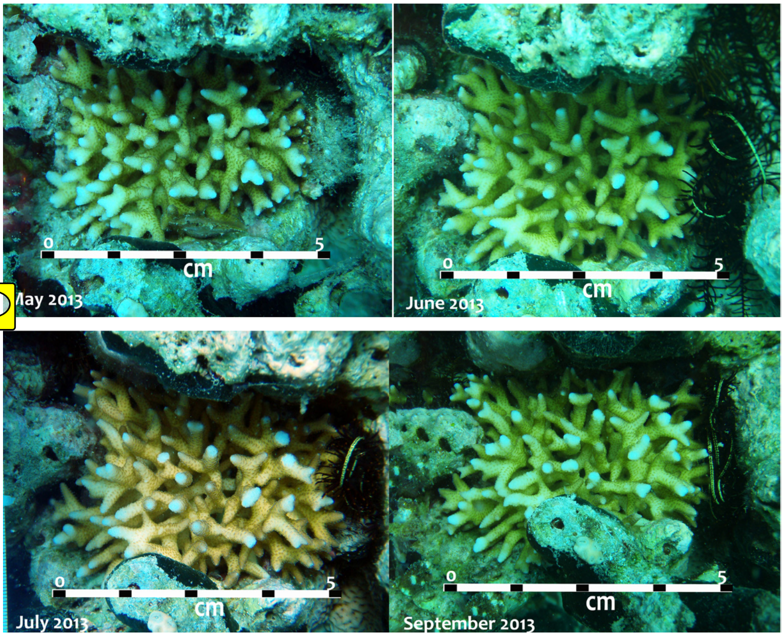


Figure 4. Timeseries images of Seriatophora hystix. from May to September 2013 in Candaping B MPA (growth rate: 0.07cm2/ day)

2 CHAPTER

Planning And Training

Coral reef rehabilitation and reef fish recovery is a costly and laborious undertaking, thus, we only implement it when necessary and with careful planning and designing. It is also important to inform and work with the stakeholders of the coral reef that will be rehabilitated. CCEF has a long-term CRM partnership with the Siquijor Province and LGUs (since 2002) and we assisted the Province in the creation and in capacity building initiatives of its Provincial Monitoring Team (PROMOTE). CCEF leads trainings, workshops and planning meetings participated by stakeholders including the LGUs, MPA mangers and local communities.

As an outcome, a response protocol was formulated by the participants on how to report the negative impacts of climate change on coral reefs such as typhoon damage and coral bleaching. Siquijor Province was able to create a Climate Change Response Protocol (Figure 5). Moreover, point

persons at the municipality and province levels were identified. These individuals are responsible for information dissemination and monitoring of damaged reefs due to typhoons and/or other negative impacts brought about by climate change.

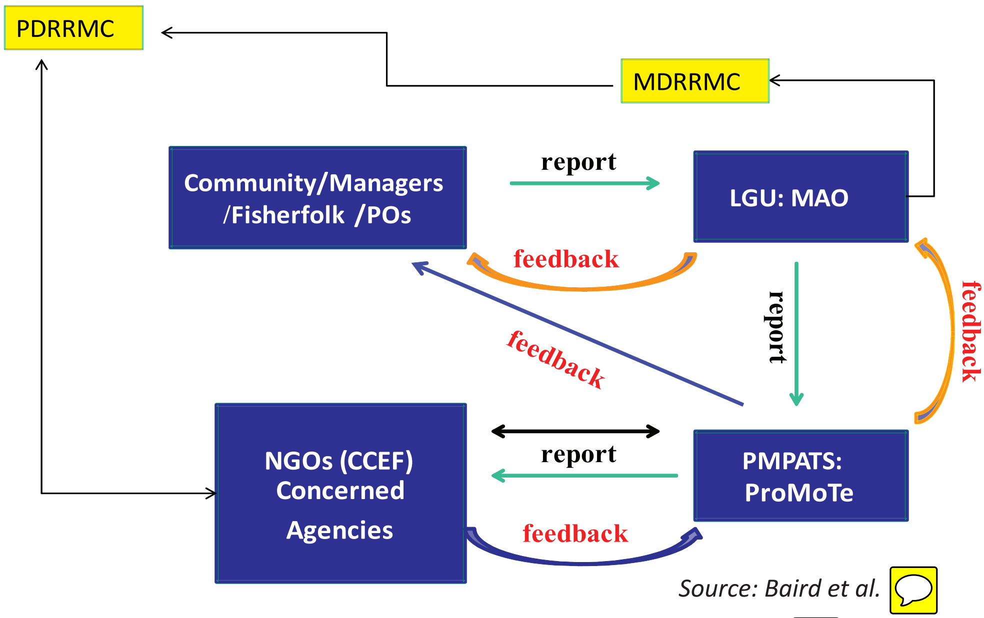


Figure 5. Climate Change Response Protocol

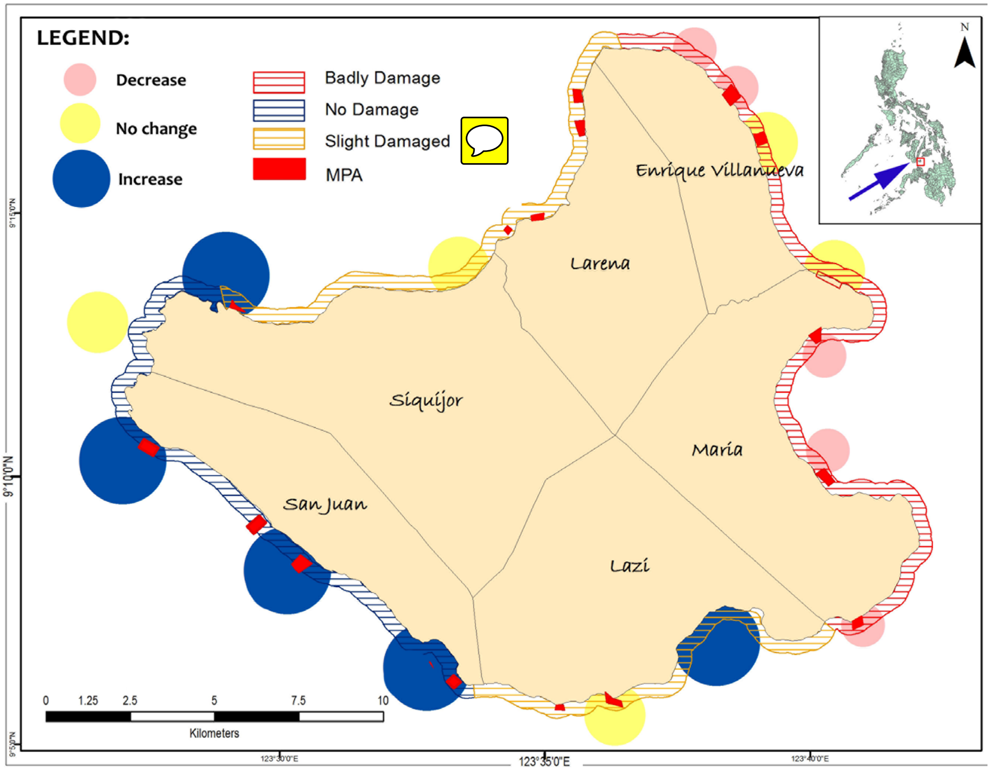


Figure 6. A map showing the status of Siquijor's coral reef and reef fish based on the perceptions of LGUs and MPA managers

In another workshop, the perceptions of Siquijor's local communities, LGUs and MPA managers on the status of their coral reefs based on measures like live hard coral cover and coral reef fish abundance were documented using a participatory mapping exercise. Results (Fig. 6) showed that all MPAs in five out of six municipalities were negatively impacted by the typhoon. It was also perceived that fish abundance declined in all MPAs where coral reefs were damaged. Only four MPAs in San Juan Municipality were reported to have no major damage, at the same time, the participants perceived that abundance of reef fish in these sites increased. The perceptions of the participants match with CCEF's Research and Monitoring Team's (REMOTE) reef damage assessments and MPA monitoring data.

Finally, prior to implementing our coral reef rehabilitation and fishery recovery plan and design, a Planning and Training/Workshop involving coral reef stakeholders in Siquijor Province was conducted. A detailed work plan with notes on activity key persons and cost sharing for each activity involved local communities, MPA managers, LGUs and the Province was made and implemented over the year. The participants were also taught on the methods and tools in coral reef rehabilitation and fishery recovery.

A large scale coral reef damage requires a multisectoral collaboration in planning, implementation and in expenditures.

3 CHAPTER

Designing Siquijor's Coral Reef Rehabilitation and Reef Fish Recovery

In designing Siquijor's coral reef rehabilitation, site prioritization was necessary. In order to prioritize, it was important to categorize the level of damage of a potential rehabilitation site. Using CCEF's coral reef monitoring data stored in our MPA database, we were able to track and quantify long-term changes including damage due to typhoons. We complement our permanent transect (PIT/LIT) data with our GIS data. Thus, a Coral Reef Damage Criteria based on the level of % live hard coral cover was created and briefly discussed below:

Coral Reef Damaged Criteria

1. High level damage, rubble dominated (75-100% rubble)

   Priority sites: Olang and Candaping B

   Marine Sanctuaries, Municipality of Maria

Sample map: Olang Marine Sanctuary, Municiplaity of Maria (Figure 7)

Major marine ecosystems: A mangrove patch a multi-species seagrass bed and a coral reef

MPA size: 138,00.00 m2 % LHC damage: 83%

Extent of reef damage: 46,942.52 m2 % LHC left after typhoon Pablo: 4.67%

% Rehabilitated area: 22[illegible].15 m[illegible] ([illegible]0.62%)

Rehabilitation tools needed: 30 (1.8 x 30 m) stabilization mats plus iron pegs; 40 high relief fish habitats; 75 low relief fish habitats

Manpower and logistics: 10 divers @ 40 dives, 2-4 supporting staff, 1 pick-up vehicle, 1 boat, scuba gear

Estimated coast: 1.5 - 2 million

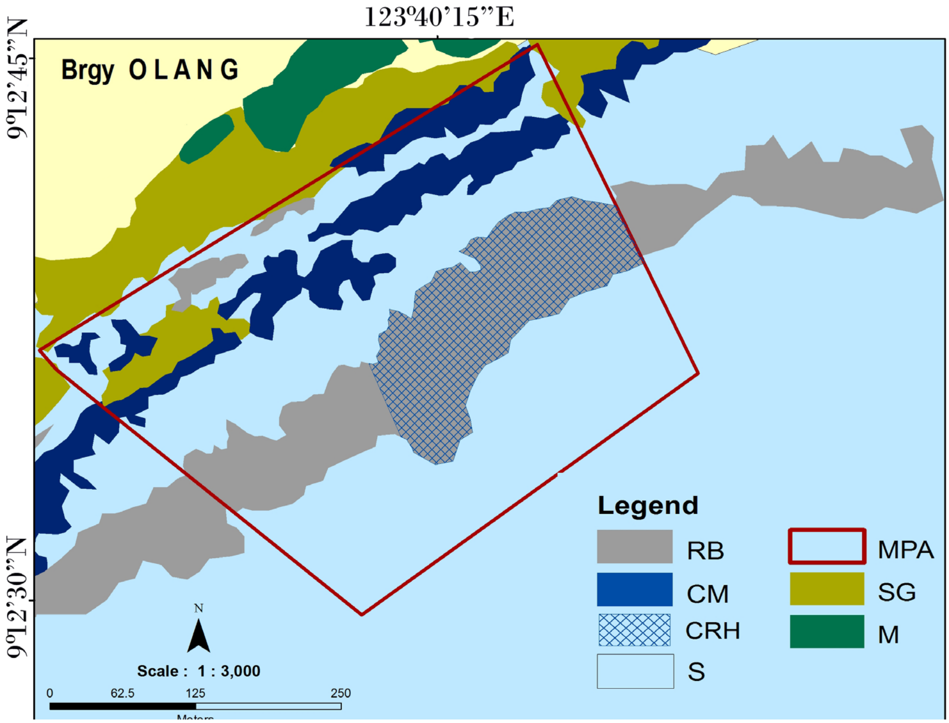


Figure 7 . A map of showing the rehabilitated site in Olang MPA. Legend: RB=Rubble; CM=Coral Massive; CRH=Rehabilitation Area, S=Sand, MPA=Marine Protected Area, SG=seagrass, M=mangrove

2. Mid-level damage, rubble dominated (50-74.9% rubble)

Priority sites: Caticugan, Binoongan and Tulapos Marine Sanctuaries of Municipality of Siquijor and Enrique Villanueva

Sample map: Caticugan Marinse Sanctuary (Figure 8)

Major Marine Ecosystems: a multi-species seagrass bed and a coral reef

MPA size: 186,000.oo m2

% LHC damage: 73%

Extent of reef damage: 110,369.08 m2

% LHC left after typhoon Pablo: 9%

% Rehabilitated area: 13.65 %

Rehabilitation tools needed: 10 (1.8 x 30 m) stabilization mats plus iron pegs

Manpower and logistics: 10 divers @ 20 dives, 2 supporting staff, 1 pick-up vehicle, 1 boat, scuba gear

Estimated coast: PhP 300,00 - 500,000.00

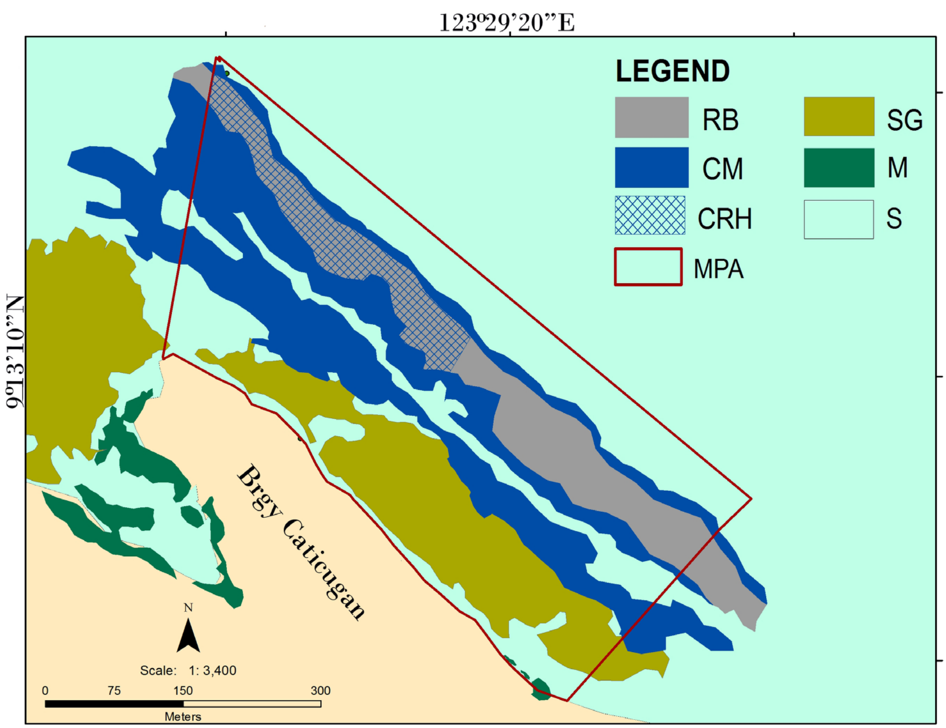


Figure 8. A map of showing the rehabilitated site in Caticugan MPA. Legend: RB=Rubble; CM=Coral Massive; CRH=Rehabilitation Area, S=Sand, MPA=Marine Protected Area, SG=seagrass, M=mangrove

3. Low level damage, mixed rubble, dead coral, rock and block and sanddominated (25-49.9% mixed non-living substrate)

Priority sites: Nonoc MPA, Municipality of Larena

Sample map: Nonoc Marine Sanctuary (Fig. 9)

Major Marine Ecosystems: A patches seagrass bed and a coral reef

MPA size: 54,802m2

% LHC damage: 44.55%

Extent of reef damage: 22,849 m2

% LHC after typhoon Pablo: 22.67%

% Rehabilitated area: 4,021m2

Rehabilitation tools needed: 20 high relief fish habitats; 40 low relief fish habitats

Manpower and logistics: 10 divers @ 20 dives, 2 supporting staff, 1 pick-up vehicle, 1 boat, scuba gear

Estimated coast: PhP 500,000.00-700,000.00

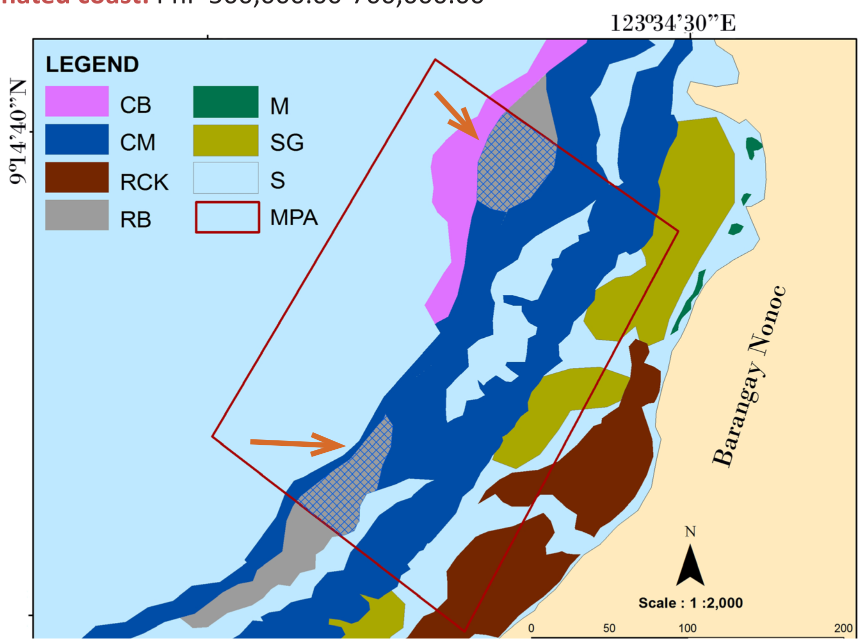


Figure 9. A map of showing the rehabilitated s[illegible]n Nonoc MPA. egend: RB=Rubble; CM=Coral Massive; CRH=Rehabilitation Area, S=Sand, MPA=Marine Protected Area, SG=seagrass, RCK=Rock, M=mangrove

4 CHAPTER

Coral Reef Rehabilitation and Fishery Recovery Tools

Tools used in coral reef rehabilitation and fishery recovery vary from protocol to protocol. However, when choosing and/or designing tools, it is important to keep in mind that the risk of failure will be minimized by using science-based effective tools. In typhoon affected reefs, the dominance of coral rubble as a substrate in areas previously dominated by branching corals is a common scenario. In cases where the coral massive lifeform dominated, upturned colonies and dead coral substrate mixed with rubble and sand were common.

A. Substrate Stabilization

Stabilization of the loose rubble substrate was achieved by laying down 30 x 2 m plastic mesh, locally called "Amazon nets" in priority sites. This material was tested and found non-toxic; corals grow on them. Raymundo et al. (2007) used this material in restoring dynamited blasted reefs in central Philippines. Iron pegs were used to anchor these mesh plots on the substrate. In addition, limestone boulders, available on-site, were deployed and placed on top of the plastic mesh to further stabilize it depending on its availability. We aim to achieve substrate stabilization through consolidation which is the process of cementing the stabilization mat and the rubble substratum by coral tissue through regeneration by partially dead corals or through growth by recruits and/or transplants (see chapter 5). Why do we need to stabilize the rubble substrate? Corals may settle on loose coral rubble. However, strong wave action likely abraid the live coral tissues of recruits and eventually results to mortality.

B. Coral Transplantation

Coral transplantation (CT) is misunderstood by many. Some equate CT to coral reef rehabilitation and some use it as a tool though unnecessary. When do we employ coral transplantation? Here we consider coral transplantation as one of the few tools used in coral reef rehabilitation, thus, we have an option to utilize it or not. In the next chapter, we provide suggestions when to use coral transplantation.

In Siquijor Province, we had two major objectives for using coral transplantation: (1) to stabilize coral fragments and encourage regeneration/growth and, (2) to increase the micro complexity of the area, thus, providing micro habitats for fish and other marine organisms. After typhoon Pablo, many broken fragments were observed in highly damaged areas such as Olang and Candaping B MPAs. Stabilization of loose fragments included tying with cable ties on the mat. Loose coral recruits were also stabilized using cable ties or marine epoxy. If fragments and recruits are left unstable, it is likely that coral tissue regeneration/growth will be none-slow and, coral mortality will be high especially in areas where wave energy is also high.

P. Schwab (top) and D. Delizo and W. Porpetcho planting coral fragments

Our transplantation method is opportunistic - typhoon damaged reef broken coral fragments are everywhere these will likely benefits from stabilization.

1. Fragment selection

Select fragments that have healthy tissues for transplantation.

2. Handling

Minimize touching the live coral tissue. Handle the part of the fragment with no live tissue when possible.

3. Stabilization of coral fragments

Cable ties are cheap, convenient and non-toxic tools for coral transplantation. A broken fragment can be saved and stabilized by attaching it to the stabilization mat using a cable tie. Consolidation will be facilitated if corals are attached securely to the mat and in contact with rubble substrate underneath the mat.

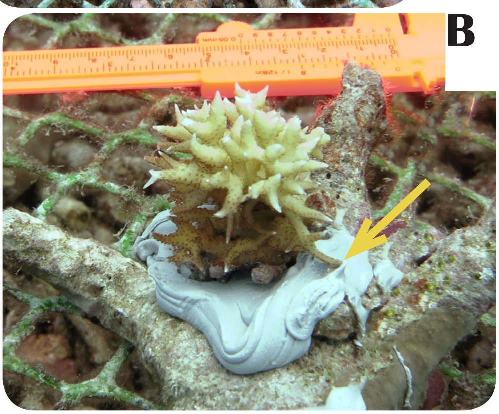
4. Interval between transplants

We used a 10 to 20 cm planting interval, but may vary with fragment size and morphology. We stabilize whatever fragement/species are available on site that are healthy.

5. Housekeeping

The remaining cable ties are cut to avoid brushing movements that may damage the regenerating coral tissue.

A



B

We used two successful fast and easy ways of attaching loose coral recruits on the stabilization mats.

(a) ***using cable tie*** and

(b) ***using marine epoxy***

C. Fishery Recovery

Coral reefs are fish habitats and the diversity of coral lifeforms create a complexity suitable not only for fish but to a diversity of marine organisms. After typhoon Pablo, majority of the reefs in the north and eastern sides of Siquijor Province were degraded to rubble. To prevent further declines in reef fish, we designed two fish habitats that can improve the habitat complexity of the area.

A high relief fish habitat module (1 m high Fig. 10) that can provide colonization space, improve habitat complexity, and provide fish habitats was designed specifically for Olang and Candaping B MPAs. Each settlement block was titled to an angle of 45° to optimize coral settlement (Sammarco 1983).

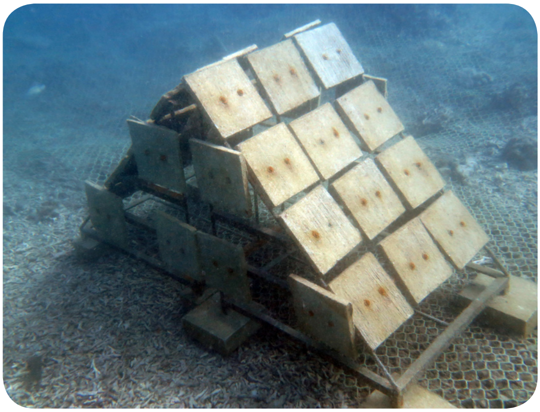


Figure 9. Photos of the high relief fish habitat modules Siquijor-PNP assiting in the deployment (top)

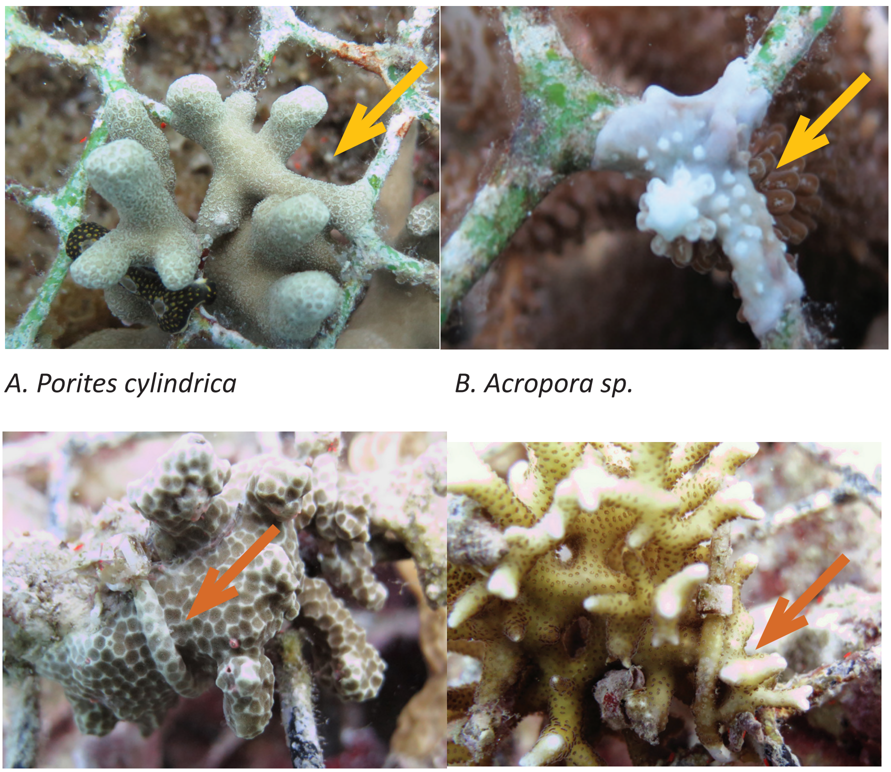
Low relief modules (0.61 x 0.61 m) were also designed. These were fabricated by local communities and MPA managers with CCEF's guidance. These were made up of limestone available on site, cemented together. These low relief fish habitat modules are shown in Figure 11.

Figure 11. Sample Photo of low relief habitat modules.

5 CHAPTER

Impacts and Outcome

1. Substrate stabilization and consolidation



A. Porites cylindrica *B. Acropora sp.*

C. Porites rus *D. Seriatopora hystrix*

Figure 12. Photos of consolidation:

Three types of consolidation were observed on our stabilization mats and on the rubble substrate:

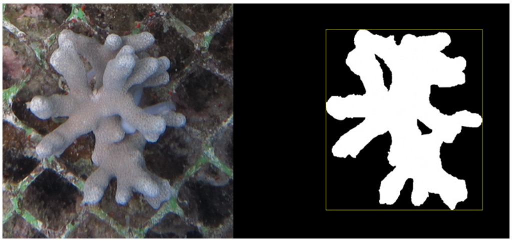
(1) **Bottom to top** coral fragment tissue regeneration/growth of broken fragments under the mat were observed to incorporate parts of the mat into its tissue after 2-6 months depending on the species after installation. Acroporids are known for their high growth rates. Both branching Porites spp. and Acropora spp. are among the dominant coral fragments in the area (Fig. 12A-B).

(2) **Top to bottom** coral fragment tissue regeneration/growth - the earliest consolidation of a transplanted fragment (*Porites rus*) was after 2 months (Fig. 12C).

(3) **Top to bottom coral recruit growth** - a *Seriatopora hystrix* recruit attached to the stabilization mat using cable ties, started to grow over the tie in 2-4 months (Fig.9D).

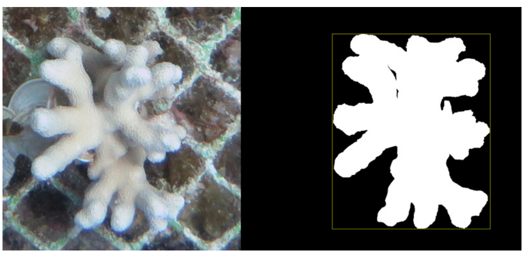
Coral transplants on a stablization mats with fish grazers

2. Coral transplants: growth and survival



January 2014

March 2014



April 2014

Figure 13. Frames of a transplanted coral fragment subjected to image analysis for growth

Growth and survival of stabilized and transplanted coral fragments must be monitored to evaluate protocol effectiveness. We used permanent photoquadrats and image analysis to monitor transplants' survival and growth.

The softwares GIMP (GNU Image Manipulation Program) and Image J were utilized (Fig. 13).

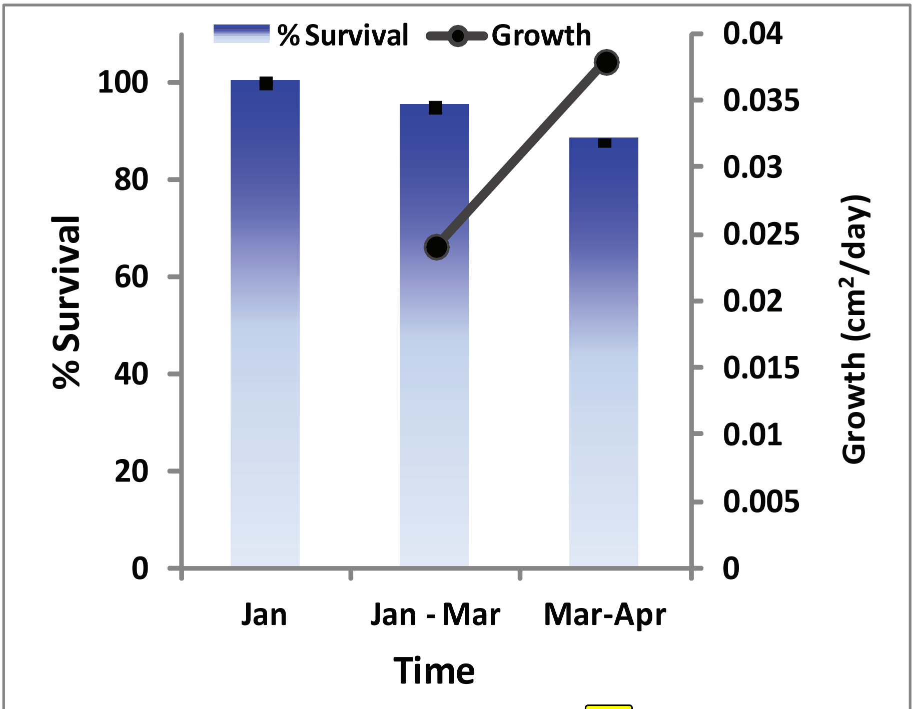


Figure 14. Survival and growth pattern of *P. cylindrica* after transplant

Figure 14 shows the survival and growth patterns of *Porites cylindrica* transplants in Olang Marine Sanctuary from January to April 2014. Survival for four months was high (88%). We measured growth rate in two time periods and it was significantly higher (paired T-test: $p = 0.020$, T-value $= -2.35$, $n = 121$) in March to April (0.024 ± 0.038 cm2) compared to January to March (0.037 ± 0.031 cm2). Many *P. cylindrica* fragments were available on site, thus, we used this species for our growth and survival though there were other species study included in our transplants. Monitoring of these parameters in our rehabilitation sites using different species is in progress and to continue for at least two

3. Fish Recovery Tools

A. Fish Habitat Effectiveness

Fish recovery can take can take some time, however, the recruitment and aggregation of small fishes in our modules occured immediately after deployment. Fairly basslets (Pseudanthias spp.), damsels (Pomacentrus spp.), small scarids, labrids and pufferfishes were observed in the modules and vicinity within two weeks to a month after deployment. A similar observation was documented in a coral reef rehabilitation initiative Komodo National Park (Fox and Haisfield in Edwards et al. 2010) and in the central Philippines (Raymundo et al. 2007). Fish aggregated immediately after installation of rock piles.

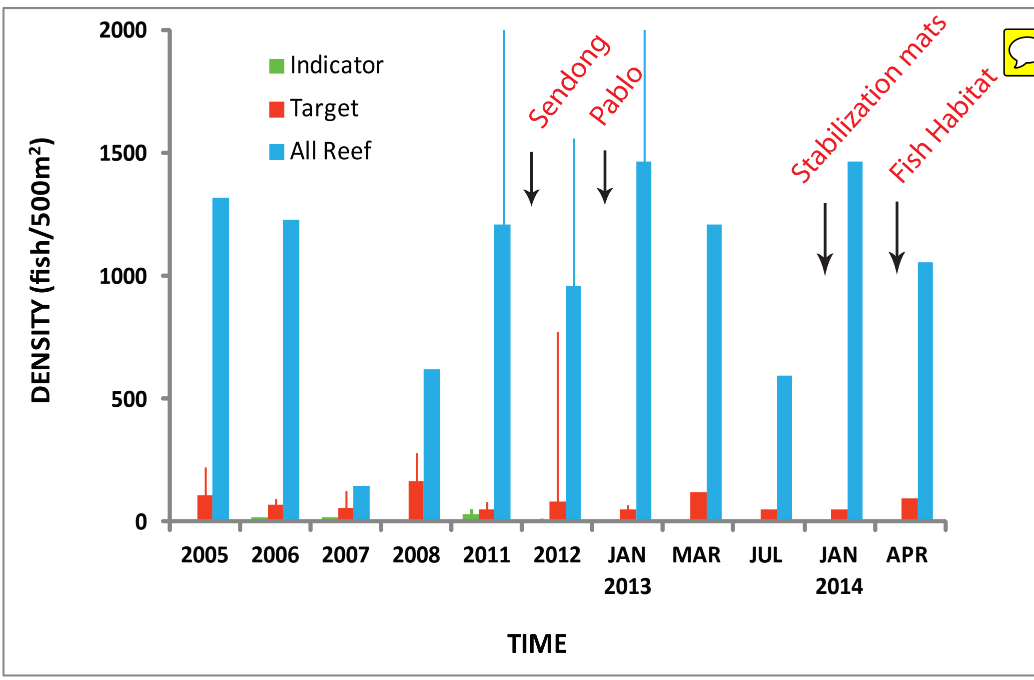
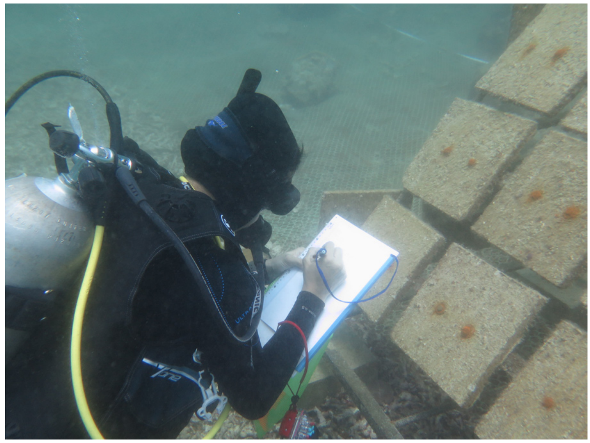


Figure 15. Changes in fish densities (mean±SD) in Olang Marine Sanctuary, a coral rehabilitation site (September 2013 to April 2014). The application of rehabilitation tools are indicated by arrows.



A. Maypa censusing settlement plates attached to fish habitats.

Figure 15. shows the preliminary results of our long-term monitoring and the fishery recovery patterns in Olang Marine Sanctuary. Our rehabilitation timeline is also shown. After the landfall of typhoon Pablo in December 2012, CCEF immediately carried out a reef damage assessment in Olang and other MPAs in Siquijor Island. Live hard coral damage was 83% in this MPA and the first to decline significantly is the indicator species group composed of butterflyfishes (Chaetodon spp.) from the year 2011 (30.2 ± 7.59 fish/500 m2) to none by the January 2013 ($p = 0.001$, $F = 7.33$, $DF = 6$). We first installed our stabilization mats in September 2013 and continued until February 2014. Further, we deployed both the low and high relief fish habitats from February to April 2014. Both target species (primarily sought by fishers) and all reef species continued to decline from January to July 2013. By April 2014, a significant increase in the density of butterflyfishes was recorded (5.0 ± 3.6 fish/500m2; $p = 0.05$, $F = 5.77$, $DF = 2$). All reef species density also increased significantly from July 2013 to January 2014 (593.67 ± 155.85 fish/500 m2; $p = 0.006$; $F = 13.7$, $DF = 2$) but appeared to decline again by April. For target fishes, a gradual increase in density is suggested, however, this is not significant. Similarly, biomass improvement was not observed in our rehabilitation areas after 5-8 month. Raymundo et al. (2007) recorded significant increases in fish abundance only after 3 years in rehabilitated dynamite blasted reefs.

B. Coral transplantation and improving micro habitat complexity

Coral transplantation is a fishery recovery tool can significantly improve the micro habitat complexity of the damaged site. While stabilizing broken fragments on mats, our team noticed that small wrasses and damsels aggregate immediately in our transplants after divers leave the site for few minutes. A similar observation was noted by Fox and Haisfield in Edwards et al. (2010) where fish were observed to aggregate immediately in newly installed rock piles. We compared fish abundance in mats with transplants versus mats without transplants using a paired design. Fish abundance was significantly higher in transplanted mats compared to adjacent non-transplanted mats in Olang (with transplants = 189.1 fish/3m2; without transplants = 30.9 fish/3m2; paired T-test, p = < 0.001, T-value = 7.22, n = 10) and Candaping B (with transplants = 81.4 fish/3m2; without transplants = 7.0 fish/3m2; paired T-test, p = < 0.001, T-value = 4.65, n = 10) but no significant difference was found in Nonoc and Caticugan MPAs (Fig. 16). Further, we tested factors associated with fish abundance in transplanted sites using a multiple linear regression and the significant factors are, rugosity index, %LHC damage from PIT/LIT and overall area of reef damage from GIS surveys (R [illegible] 59; p = < 0.001). Our results indicate that increase in micro rugosity in highly damaged areas will likely increase the fish abundance of smaller sized fish species but may not be necessarily true in areas with mid-low damage.

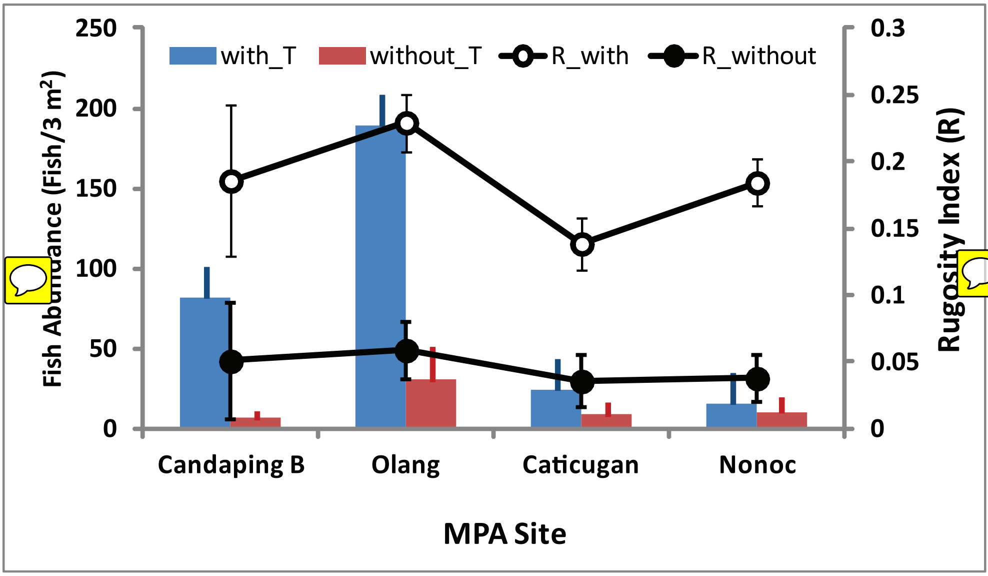


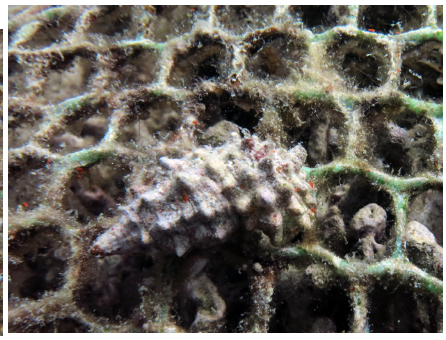
Figure 16. Comparison of fish densities (per 3m2) in mats with coral transplants and without, in four MPA rehabilitation sites with varying levels of coral damage. The respective habitat complexities of each site, expressed as the index of rugosity are also presented in this graph.

Our experience in Siquijor suggests that coral transplantation can be used as a tool for micro fishery recovery. However, It is an option and not a necessity. Areas severely damaged by typhoons may likely benefit from it, but low to mid damaged areas may able to recover using other rehabilitation tools and/or protection.

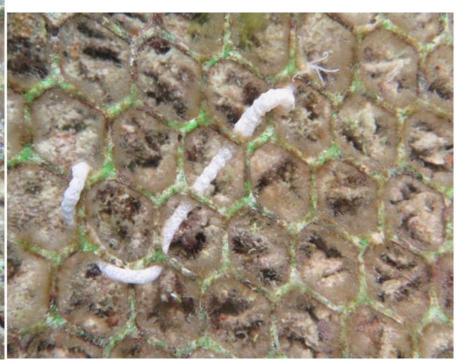
HELPERS IN CORAL REHABILITATION

a. Fish herbivore (rabbit fisher and juvenile parrot fish

b. Gastropods



c. Sea cucumber and other synaptids



Natural coral reef rehabilitation helpers like grazers serve as algae control of the stabilization mat thus, aiding in coral recruitment and growth.

CORAL REHABILITATION TEAM

LGUs and coastal communities assisting in fish habitat deployment and stabilization mat installation (top). The PROMOTE-Philippine National Police (PNP) members (middle). MPA managers and PROMOTE-members (R. Romano) and (D. Pasco) from the Provincial Agriculturist Office.

CORAL REHABILITATION TEAM

CCEF-REMOTE (top) and PROMOTE (middle); M. Steinel assisting in the installation of fish habitat modules

Special Thanks to:

The Province of Siquijor

Office of the Provincial Agriculturis through

Dr. Ramon A. Taroc

Siquijor Provincial Monitoring Team (PROMOTE)

All the LGUs and each respective Barangay Captains and officials

Office of the Mayor, Municipal Agriculture Office (MAO) and fisheries technicians of each municipality

Larena's Sunporch and staff

CCEF-REMOTE supported by UNICO Conservation Foundation in Australia (D. Apistar, D. Delizo)

CCEF-GIZ ACCCoast staff (M. Baird, R. Catitig, W. Porpetcho)

CCEF GIS Coordinator and cartographer, D. Dacal

CCEF image analyst, AJ Lozada

Project Hydrography and Bathymetry specialist, J. Maypa

REFERENCES:

Baird, M., A.P. Maypa, D. Apistar, R. Catitig, D. Delizo Jr., D. Dacal and D. Pasco. 2013. Consolidating MPA Network Planning for Resilience in Siquijor Project. Terminal Report to GIZ-ACCCoast. CCEF Technical Report 2013-06. Cebu City, Philippines 66p.

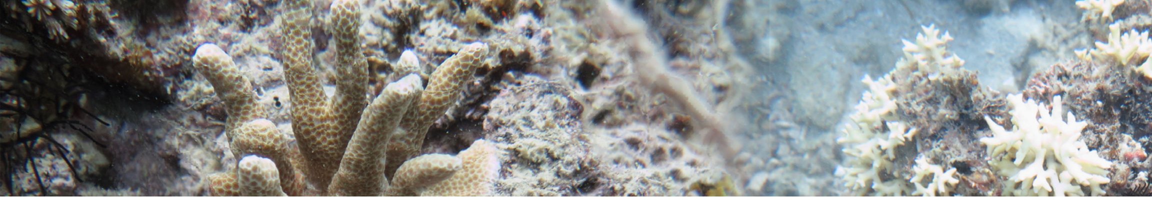
Carleton, J.H. and P.W. Sammarco. 1987. Effects of substratum irregularity on success of coral settlement: quantification by geomorphological techniques. Bulletin of Marine Science 40: 95-98.

Dulvy, N.K., Stanwell-Smith, D., Darwall, W.R.T. and Horill, C.J. 1995. Coral mining at Mafia Island, Tanzania: a management dilemma. Ambio 24:358-365.

Fox, H and K. Haisfield in Edwards, JE (ed). 2010

Graham, N.A., S.K. Wilson, S. Jennings, N.V.C. Polunin, J. Bijoux and J. Robinson. 200[illegible]NAS 103 (22): 8425-8429

Grigg, R.W. and Maragos, J.E. 1974. Recolonization of hermatypic corals on suibmerged lava flows in Hawaii. Ecology 55: 387-395.



Maypa, A.P., M. Baird, D. Apistar, D. Pasco, A. Laping and R. Catitig.2013. Marine protected areas typhoon damage assessments and recommendations for coral reef rehabilitation and fisheries recovery in Siquijor Province. The Coastal Conservation and Education Foundation, Inc., The UNICO Foundation and GIZ Technical Report 2013 – 02. Cebu City, Philippines. 18p.

Maypa, A.P. 2007. Effects of coral reef degradation on reef fish communities: Can marine protected areas contribute to resiliency? Siliman journal 48(2): 149-152.

Pearson, R.G. 1981. Recovery and colonization of coral reefs. Mar. Ecol. Prog. Ser. 4: 105-122.

Raymundo, LJ, AP Maypa, ED Gomez and P Cadiz. 2007. Can dynamite-blasted reef s recover? A novel, low-tech approach to stimulating natural recovery in fish and coral populations. Marine Pollution Bulletin 54: 1009 -1019.

Stoddart, D.R. 1974. Post-hurricane changes on British Honduras reefs: survey of 1972. Proc. 2nd Int. Coral Reef Symp. 2:473-483.

White, AT and A. Cruz-Trinidad. 1998 The Values of Philippine Coastal Resources: Why Protection and Management are Critical. Coastal Resource Management Project, Cebu City