

EVALUATION OF COREMAP PHASE 2 IN THE EASTERN INDONESIA BASED ON THE CHANGES IN CORAL COVERAGE

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ABSTRACT

COREMAP (Coral Reef Rehabilitation and Management Program) is a long term program initiated by the Government of Indonesia to enhance the welfare of the coastal communities by protecting, rehabilitating, and achieving sustainable use of the Indonesian coral reefs and their associated ecosystems. COREMAP is three phases planned program. The first phase was launched in 1998 and finished in 2004. Phase 2 began in 2006 and ended in 2011. The last phase has started since the end of 2014 and will finish in 2019. One of the performance indicators of COREMAP phase 2 (COREMAP 2) was a significant improvement of live coral cover in 80% of all sampling sites. The aims of this study are to find out and evaluate the trend of live coral cover during COREMAP 2. Annual monitoring of coral reefs was conducted in all sites of COREMAP 2 in the eastern Indonesia. Those sites were: Pangkep, Selayar, Buton, Wakatobi, Sikka, Biak Numfor and Raja Ampat. Permanent transects were applied at each site. Life form of benthic data including hard corals was collected using the Line Intercept Transect (LIT) method and surveyed using SCUBA diving equipment. The result indicates that all sites, except Biak Numfor, demonstrate improvement in live coral cover during COREMAP 2. In contrast, live coral cover in Biak Numfor shows a decline due primarily to storm damage, destruction by bombs, some bleaching, and predation by *Acanthaster planci*. An increase in live coral covers in six out of seven sites during COREMAP 2 indicates that the activities of COREMAP 2 (e.g. public awareness, community based MCS, alternative livelihood) has a positive impact on the management of coral reefs in the Eastern of Indonesia.

Keywords: COREMAP, coral reef, coral cover, Eastern Indonesia

INTRODUCTION

Indonesia as an archipelagic state has 2,517,858 ha of coral reefs (Giyanto *et al.*, 2017) representing 17.95% of the world's coral reefs (Spalding *et al.*, 2001). Coral reefs provide a highly structured habitat and shelter for many marine organisms. Several studies reported that Indonesia is spot of the world's greatest marine diversity (Tomascik *et al.*, 1997; Moosa, 1999; Hopley and Suharsono, 2000; Wallace *et al.*, 2003).

Coral reefs and their associated marine life have an important value for Indonesia. They

protect coastlines from the damaging effect of wave action. In addition, they provide natural resources, such as foods, drugs, and generate income through marine tourism. Unfortunately, they are vulnerable to human-induced stress. Degradation of coral reefs in Indonesia is mainly caused by sedimentation, land based pollution (such as industrialization and domestic waste disposal), coral mining, physical damage, overfishing and the use of destructive fishing practices, such as explosives and poison fishing (Ongkosongo and Sukarno, 1986; Erdmann, 1995; Cesar, 1996; Edinger *et al.*, 1998; Edinger *et al.*, 2000). Therefore, coral reefs need to be

effectively managed in an integrated manner. The management of coral reefs is often highly complex and very site specific. There are typically many different issues and stakeholders involved. In addition, there is a diverse set of interactions between coral reefs and their environment in regard to ecological, geographical, social, economic and political character (Cesar, 1996).

To protect, rehabilitate, and achieve sustainable use of the Indonesian coral reefs and their associated ecosystems which, in turn, enhance the welfare of the coastal communities, Indonesian government initiated COREMAP (Coral Reef Rehabilitation and Management Program). COREMAP is a long term program consisted of three phases. COREMAP Phase 1 was launched in 2000 and finished in 2004. COREMAP Phase 2 (COREMAP 2) started in 2006 and ended 2011. The last phase of COREMAP (COREMAP Phase 3 or COREMAP CTI) has started since the end of 2014 and it will finish in 2019.

There were several indicators used to assess the performance of COREMAP 2. One of them was the increase of coral cover in 80% of total sampling sites during COREMAP 2. This is

reasonable because corals inhabited by various marine organisms. Most of them have significant economic value. Live coral cover is traditionally used as a primary indicator of coral reef health (Coker *et al.*, 2014). Healthy coral reefs are expected to have a positive impact on coastal community welfare. Therefore, live coral cover is a key measure of reef habitat quality and quantity, analogous to the coverage of trees as a measure of tropical forest loss (Bruno and Selig, 2007).

To find out whether the performance indicators of COREMAP 2 based on the change of coral cover could be achieved or not, annual monitoring of coral reefs was conducted in all sites of COREMAP 2 in the eastern Indonesia. The aims of this study were to find out and evaluate the trend of live coral cover during COREMAP 2.

MATERIALS AND METHODS

CRITC (Coral Reef Information and Training Centre), which is the responsibility of Research Center for Oceanography LIPI (RCO LIPI), conducted the annual coral reef monitoring in 7 sites of COREMAP 2: Pangkep, Selayar, Buton, Wakatobi, Sikka, Biak Numfor and Raja

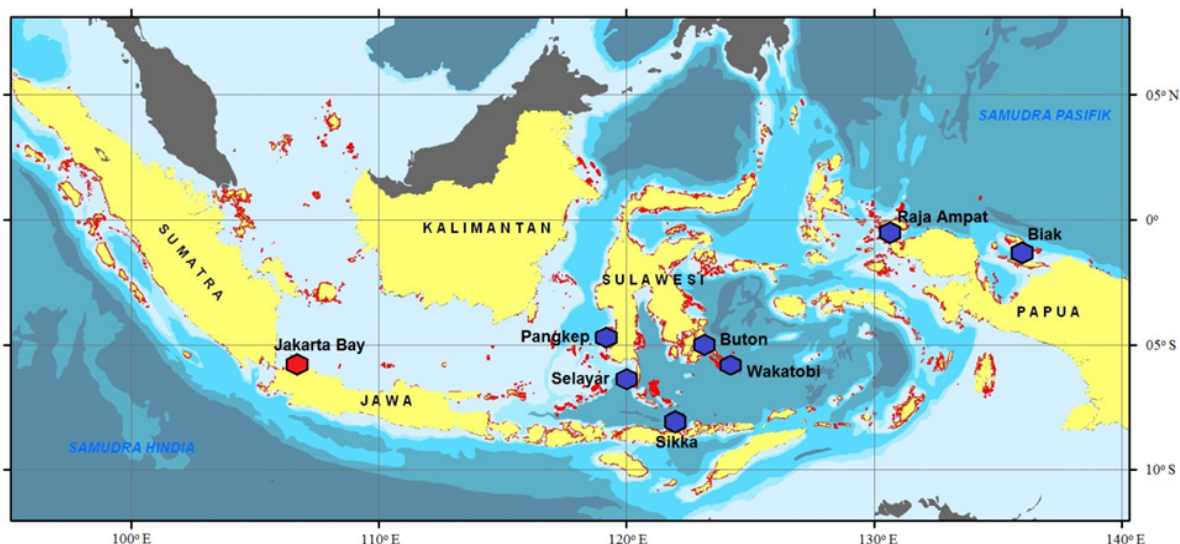


Figure 1. Map of seven sites of COREMAP2 in the eastern Indonesia (blue pentagon), and Jakarta Bay (red pentagon)

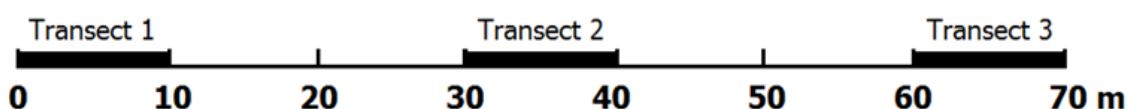


Figure 2. Line transect applied at each station in each site

Ampat (Figure 1). Several sampling stations of each site were plotted using Global Positioning System (GPS) and designed as permanent transect stations, signed by buoys, for coral reef monitoring during COREMAP 2.

The Line Intercept Transect (LIT) method (English *et al.*, 1997) was used in this study and SCUBA diving was carried out to collect the data. A measuring tape was placed across the reefs and any life form of benthic including hard corals underlying the line transects was recorded. The length of live corals and other organisms under the tape was measured to the nearest centimeter. Each station has three 10 m length transects that were lied along 70 m line (Figure 2), parallel to coastal line at 5 m depth where corals mostly grow well. The use of the three 10 m length transects, instead of one transect with 30 m, intended to increase the validity and reliability of data. The condition of coral reefs at the first 10 m transects may be different from other two 10 m transects. Replication generally yields more accurate and reliable summary statistics (Blainey *et al.*, 2014). Johnson (2002) stated that replication reduces error because an average of independent errors tends to be smaller than a single error. Replication serves to ensure against making a decision based on a single, possibly unusual, outcome of a measurement of a unit.

Among 7 sites of COREMAP 2 in the eastern Indonesia, a total of 78 sampling stations were surveyed and monitored, consisting of 11 stations in Pangkep, 10 stations in Selayar, 7 stations in Buton, 15 stations in Wakatobi, 15 stations in Sikka, 13 stations in Biak Numfor and 7 stations in Raja Ampat. The differences in total station of each sites are due to some considerations such as station representation related to the area of site, day of filed survey related to the cost of survey, and safety. At some locations, especially in open waters, strong waves can interfere with the observations in the field. The data of coral reefs monitoring during COREMAP 2 were stored in CRITC, RCO LIPI.

RESULTS

Live coral covers varied widely at each site. For instance, live coral covers in Wakatobi were above 40%, while in Biak Numfor were below 30%. Similar results also occurred for changes in coral cover at each site over the year of observation. For instance, live coral cover in Biak Numfor demonstrated a decline since 2009. In contrast, live coral cover in Selayar showed an increase since the baseline observation in 2006 (Figure 3).

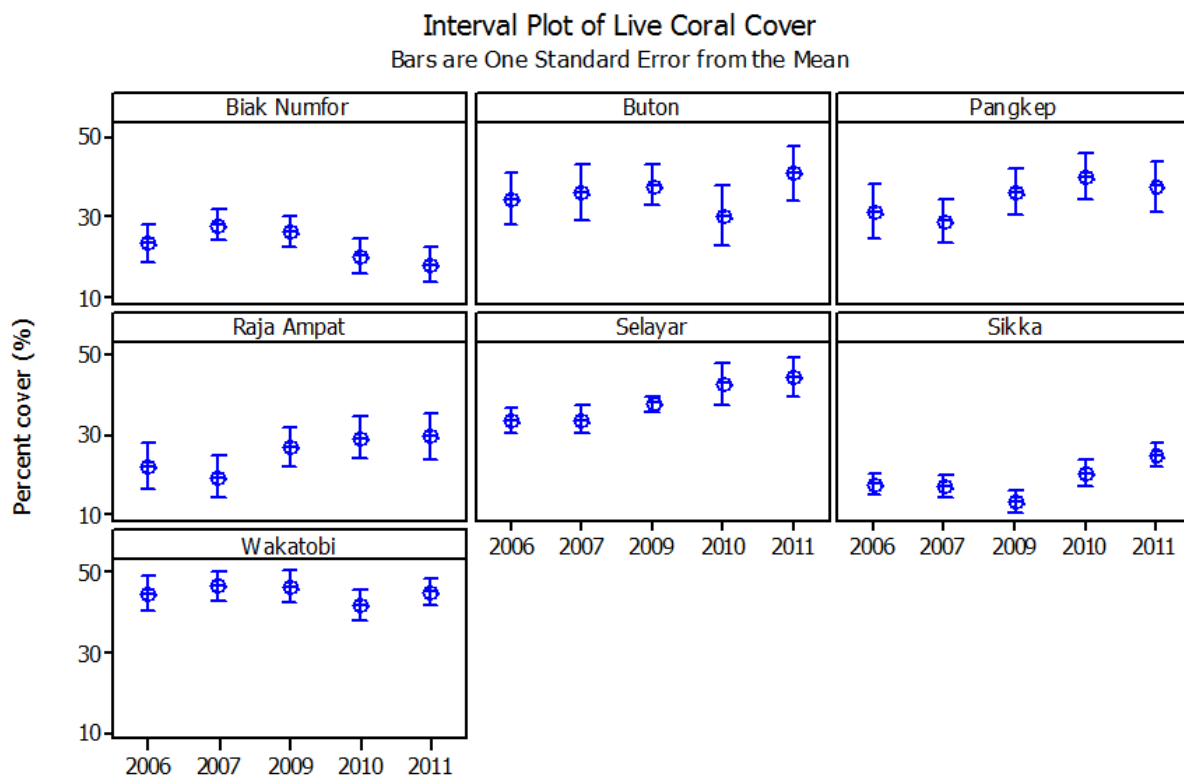


Figure 3. Live coral cover (%) in each site over the year of observation

In general, most of COREMAP 2's sites (6 out of 7 sites) showed an increase of the live coral cover during COREMAP 2 (2006-2011), except in Biak Numfor (Figure 4). During this period, live coral cover increased by 16% with an average annual rate was 3.2% (Figure 4).

Declining live coral cover in Biak Numfor due primarily to storm damage which occurred in 2009. The strong storm followed by strong wave broke off coral branches and overturned large coral, including tabulate coral (Figure 5). Their growth become disrupted, and died after a few weeks. Furthermore, their skeleton was grown by algae. Previous studies of coral reefs provide evidence of habitat shifts from live coral dominated to dead coral and algae dominated reefs (Done, 1992). After significant stress, disturbance, or coral mortality, corals cover will decrease followed an increase of algal (Meltveld and Jadot, 2014).

Several additional damages of coral in Biak Numfor's site were caused by the use of bombs to catch fish (Figure 6), coral bleaching due to rising

sea temperatures (Figure 7), and the presence of coral predator, *Acanthaster planci* (Figure 8) (Giyanto and Hukom, 2011). Widayatun and Hidayati (2012) reported that the illegal fishing using bomb was still occur in all sites of COREMAP 2 with lower frequency compared to the beginning of COREMAP 2. As a result the coral experienced damage and turned into rubble.

Marine ecosystems, especially coral reefs, are particularly vulnerable to climate change (Hoegh-Guldberg and Bruno, 2010; Doney *et al.*, 2012). Rising ocean temperatures are leading to an increase of coral bleaching incidence and disease (Hughes *et al.*, 2003). Suharsono (2010) and Wilson *et al.*, (2012) reported that coral bleaching events occurred in early 2010 in some Indonesian waters including in Biak Numfor, Buton and Wakatobi. During bleaching events, zooxanthellae (coral symbiotic algae) are lost from coral tissues (Van Oppen *et al.*, 2009), causes the coral to turn white and undergo stress. If it continues for long period (*i.e.* lasting for one month), they are vulnerable to mortality

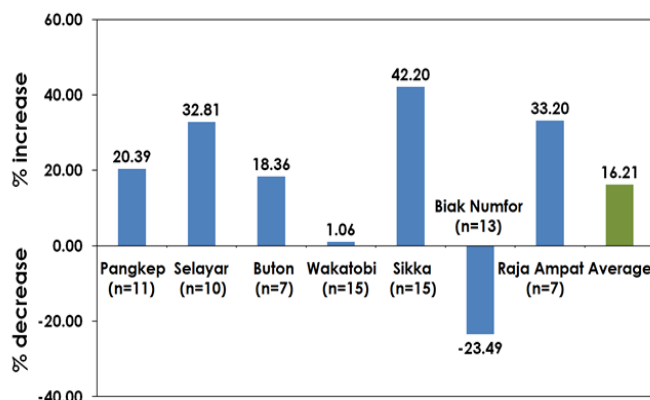


Figure 4. Change of live coral cover from 2006 to 2011 (n indicates the number of stations)

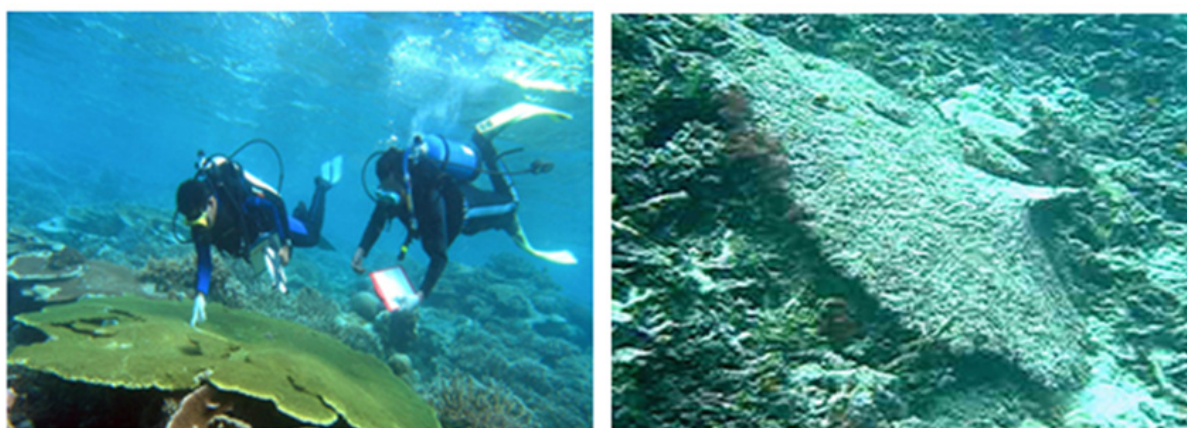


Figure 5. Coral reef in Owi Island, Biak Numfor in 2006 (left) and in 2010 (right)

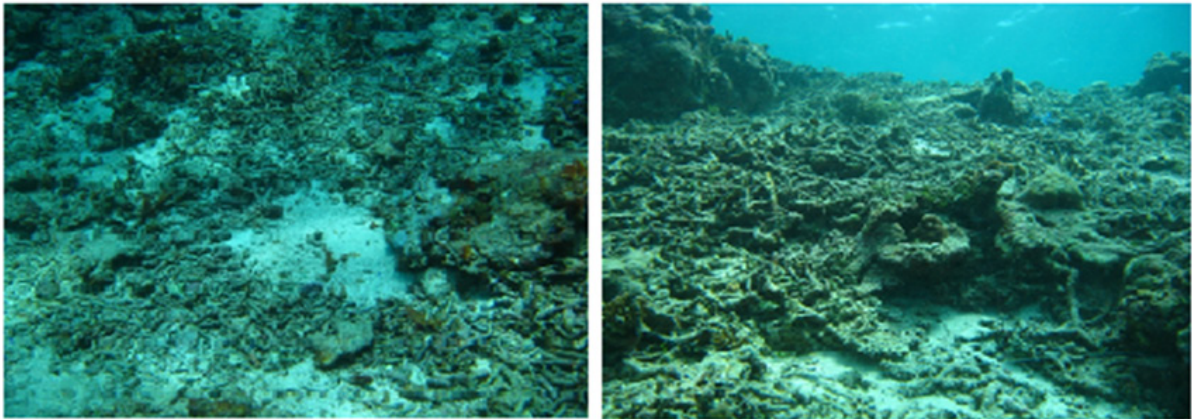


Figure 6. Coral reef in Pai Island, Biak Numfor in 2011. The damage of coral was supposed by bombs



Figure 7. Bleaching coral in Owi Island, Biak Numfor in 2011



Figure 8. *Acanthaster planci* (left) and the dead coral because of predation of *A. planci* (right)

(Grimsditch and Salm, 2006). Coral bleaching event that occurred in early 2010 was one of the reasons why the live coral cover in Biak Numfor, Buton and Wakatobi in this year demonstrated a decline (Figure 3).

The crown-of-thorns starfish, *Acanthaster planci*, is a coral predator. Widespread damage to Indo-Pacific coral reefs caused by *A. planci* has

been reported by Baird *et al.* (2013), Pratchett *et al.* (2014), Plass-Johnson *et al.* (2015). Although *A. planci* was found in Biak Numfor and caused some damage to coral reefs, but the density was still considered low. Density of *A. planci* in Biak Numfor was 0.15 individuals/140 m² in 2011 (Giyanto and Hukom 2011) or approximately 10 individuals/ha. The density of starfish from 140 individuals/ha to 1000 individuals/ha have been

considered to be an outbreak population, while density of less than 100 individuals/ha have been considered to be low (Moran, 1986).

Among 6 COREMAP 2's sites experienced an increase in live coral covers during COREMAP 2, Wakatobi showed a slight increase (Figure 4). Wakatobi was an area where the coral reef conservation had been developed before COREMAP. Wakatobi was established as National Parks in 2002, with a total area of 1,390,000 ha based on the Decree of the Minister of Forestry No. 7651/Kpts-II/2002. The Ministry of Environment and Forestry, and several NGOs have been involved in coral reef management activities in this area prior to COREMAP's involvement. This could be potentially the reason why the live coral in Wakatobi did not improve significantly. Coral reefs in Wakatobi were most likely in a stable state with optimal live coral cover that does not increase anymore.

DISCUSSION

Coral reefs are the most vulnerable ecosystem (Grimsditch and Salm, 2006), and they are also a threatened aquatic ecosystems (Hoegh-Guldberg and Bruno, 2010; Pratchett, 2013). Declining live coral cover, could be caused by disturbances that occur on the coral reefs. Disturbance could be natural disturbances or anthropogenic (human-induced) disturbances (Nyström *et al.*, 2000; Chabanet, 2005). Natural disturbances (*e.g.* storm, tsunami, coral predator outbreaks) tend to occurs in a pulsed manner, whereas human-induced disturbances often appear in a more persistent manner and slowly accumulate (*e.g.* nutrient enrichment and pollution), or occurs so frequently (*e.g.* fishing pressure, destructive fishing, uncontrolled tourism) that there is little time for recovery (Nyström *et al.*, 2000).

Sustainability of coral reefs will not be reached without a serious effort. Based on the results of this study, the live coral covers increased in 86% of COREMAP 2's sample sites. This achievement has exceeded the given indicator for measuring the performance of COREMAP 2: a significant improvement in live coral covers in 80% of sample sites.

For comparison study, we use data of live coral cover in the Jakarta Bay. The Jakarta Bay is

an area outside of COREMAP 2. It is an extreme example to describe the most severe impact of human activity to coral reef. The Jakarta Bay is located in the north of Jakarta city, capital of Indonesia, near the mainland of Java. There is a big harbor and some river in the mainland that flow into the Jakarta Bay. Consequently, many activities in the mainland will affect the water quality of the Jakarta Bay, including coral reef ecosystem in its surrounding.

Moll and Suharsono (1987) reported that coral cover declined on Bidadari Island and other islands in Jakarta Bay with coverage about 15% in 1985. While De Vantier *et al.* (1998) found that the percentages of live coral cover in Jakarta Bay was only below 5% in 1995. Similar results were also obtained in studies that were conducted at the same sites in 2005 and 2009 (Giyanto *et al.*, 2006 ; Hermanlimianto, 2010). It means that there was a degradation of coral reefs at Jakarta Bay since 1985. This result also indicates that live coral cover in Jakarta Bay is unchanged since 1995 at 5%. Once the coral reefs condition is at the minimum level (*i.e.* live coral cover not more than 5%), it is difficult to recover, especially if the surrounding environment is not supportive for corals to grow.

An increase in live coral covers in most sites of COREMAP 2 indicates that the activities of COREMAP had positive impacts on management of coral reefs. There were several activities of COREMAP including public awareness about the importance of coral reefs, Pokmaswas (Kelompok Masyarakat Pengawas) or community based Monitoring, Control and Surveillance Committee (Community based MCS) and alternative livelihood for community based-groups. All these activities were expected to reduce the pressure on coral reef.

Public awareness campaigns offered directed messages to promote behavior changes such as prevention of destructive fishing, habitat protection, sustainable fisheries, community programs and regulations. These activities were conducted through various ways, including campaigns through electronic media (TV, Radio), films, leaflets, posters, symposium, and workshops.

The increasing public awareness that healthy coral reefs are key to the life of community members, results in lower incidence of illegal

and destructive fishing. Widayatun and Hidayati (2012) reported that the frequency of destructive fishing using bomb, cyanide and trawl (*pukat harimau*) declined, although it still occurred in all site of COREMAP 2.

Public awareness activities were also conducted through formal education in schools from elementary school to high school. COREMAP developed, produced and distributed education materials, including local coral reef and marine education material, called *mulok = muatan lokal*, in Indonesian (Hidayati and Asih, 2012). *Mulok* materials were officially accepted by the Curriculum Center of the Ministry of National Education. Therefore, all the books have already fulfilled the National Education Standard.

Increased public awareness encourages the desire of community to volunteer in protecting their coral reefs. So, the activities of MCS (Monitoring, Control and Surveillance) in marine conservation area were not only carried out by Pokmaswas (Community based MCS) formed by COREMAP, but also carried out voluntarily by fisherman societies.

The impact of MCS activities generated economic and social benefits to community. Economic benefits were derived from increasing abundance of fish followed by increasing income from fishing activities. The increase of fish abundance usually indicates that the condition of coral reefs is getting better. Social benefits were obtained from the closer togetherness among communities when they conducted activities of MCS (Widayatun and Hidayati, 2012).

To reduce the pressure on coral reefs, COREMAP 2 also provided alternative livelihood. The community based groups were supported to do productive economic activities by giving them seed fund. Thus, it was expected that the community would no longer do destructive fishing, so that the pressure on coral reefs decreased (Widayatun and Hidayati, 2012).

The types of productive economic activities were adapted to the skills of community and the potential of local natural resources. The development of productive economic activities was diverse including the cultivation of fisheries

(e.g. seaweed, catfish, and grouper), processing of marine products (e.g. making fish crackers and salted fish processing), trading and agricultural activities. Widayatun and Hidayati (2012) reported that communities were benefited from their alternative livelihood activity.

CONCLUSION

Six out of seven sites (86%) had improvement in live coral cover during COREMAP 2. This improvement indicates that the activities of COREMAP 2 (e.g. public awareness, community based MCS, alternative livelihood) demonstrate positive impacts on management of coral reefs in the eastern of Indonesia.

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