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Coral recruitment before and after bleaching event 2010 in Pulau Weh, Aceh, Indonesia

Rekrutmen sebelum dan sesudah peristiwa pemutihan karang 2010 di Pulau Weh, Aceh, Indonesia

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Abstract

A monitoring study was conducted at Pulau Weh, which is located in Sabang Province Aceh, Indonesia in the northern part of Sumatera from April 2010 to April 2013. This study aims to monitor and evaluate the current status of coral reef, compotition and abundance of juvenile corals on natural substrates and recruits in the chosen sampling sites. Six sampling stations were chosen to determine the changes in coral reef after bleaching event and two stations were chosen to study coral recruitment. The survey was conducted using 5x5m permanent quadrate, placed at two different depths: 4m and 8m. Photo Quadrate method was applied to monitor the coral changes and the recovery of coral reefs in Pulau weh. Where at each sampling location within the quadrate, a series of photographs was taken with a digital camera with wide angle lens and analyzed in the laboratory. A digital probe was placed at each site, where by the temperature was recorded every 2 hours starting from April 2010 to September 2011. An increasing and extreme temperature shock was recorded in May 2010, where the highest temperature recorded was as high as 32 °C for a long duration. From the series of observation, 85% of the coral coverage in the study area in the six sampling site was found bleached and dead during the bleaching phenomena in May to July 2010. The overall number and density of juvenile corals were higher in the upper reef than the lower reef. Low coral recruitment occurred during the sampling periods interfered with disturbances (bleaching event and storm) compared to normal sampling period without disturbance.

Keyword: Coral reef; Coral bleaching; Photograph; Recruitment; Pulau weh

Abstrak

Penelitian ini dilakukan di Pulau Weh, yang terletak di Provinsi Aceh, Indonesia mulai dari bulan April 2010 sampai dengan April 2013. Penelitian ini bertujuan untuk memantau dan mengevaluasi status terumbu karang, komposisi dan kelimpahan juvenil karang pada substrat alami dan rekrutmen di lokasi yang sudah ditentukan. Enam stasiun pengambilan dipilih untuk melihat perubahan terumbu karang setelah peristiwa pemutihan berlangsung dan dua stasiun dipilih untuk melihat rekrutmen karang baru. Survei ini dilakukan dengan menggunakan kuadrat permanen yang berukuran 5x5m yang ditempatkan pada dua kedalaman yang berbeda yaitu: 4m dan 8m. MetodeFoto Kuadrat diaplikasikan untuk memantau perubahan karang dan pemulihan terumbu karang di Pulau weh setelah peristiwa pemutihan. Foto hasil pengambilan gambar dengan kamera bawah air selanjutnya dianalisis di laboratorium. Alat perekam suhu dan cahaya digital ditempatkan di setiap lokasi penelitian, dimana suhu akan direkam setiap 2 jam sekali mulai dari April 2010 sampai September 2011. Peningkatan suhu secara ekstrim telah dicatat pada bulan Mei 2010 yaitu setinggi 32 °C dalam jangka waktu yang lama. Dari serangkaian pengamatan 85% dari tutupan karang di daerah penelitian ditemukan mati disebabkan fenomena bleaching bulan Mei-Juli 2010. Jumlah keseluruhan dan kepadatan juvenile karang lebih tinggi pada terumbu bagian atas daripada karang yang lebih rendah. Rekrutmen karang yang rendah terjadi selama periode bleaching berlangsung dibandingkan dengan periode sampling normal tanpa gangguan.

Kata kunci: terumbu karang, coral bleaching, foto, perekrutan, pulau weh

1. Introduction

Indonesia lies at the centre of the coral diversity region being one of the countries having the world's richest and most diverse coral reef (Veron, 2000). Coral reefs nowadays are facing challenges from various environmental and anthropogenic disturbances and are showing signs of degradation (Richmond

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and Hunter, 1990; Edmunds and Bruno, 2008; Crabbe, 2010; Crabbe 2011).

Coral bleaching is the loss of the symbiotic *zooxanthellae* from coral polyps (leads to the loss of energy) that eventually turns the corals into bone-white in colour. The trend of bleaching has been continuously increasing since 1979 and it has been known as one of the major treats to coral reefs nowadays (McClanahan et al., 2009). Coral bleaching differentially affects coral species (Marshall and Baird 2000), coral types (finger coral having higher mortality than mounding corals) (Loya et al. 2001). The most large scale bleaching has followed the El Nino Southern Oscillation (ENSO) with observation of coral bleaching following the warm phases, which recently include the years 1988, 1992, 1995, 1998, and 2003 (Marshal and Baird, 2000).

Successful reproduction is only the primary step in the replenishment of the coral reefs (Mondal et al., 2011). Reproduction success may best be measured by rectruitment as the juvenile corals are susceptible to many natural and anthropogenic stressors (Richmond and Hunter, 1990; Irizarry-Soto and Weil, 2009). Coral recruitment is a process of the arrival of the newly produced planula larvae and the subsequent survival of the larvae to some later phase. The new individuals that settled and undergo post-settlement development are known as coral recruits. Coral larvae, coral recruits and juvenile corals are considered as the early life stages of coral (Edmunds and Bruno, 2008). This study investigated the impact of the 2010 mass coral bleaching event in Weh Island and coral recovery (recruitment) after mass bleaching event 2010.

2. Material and method

The study was carried out at the coral reef in Batu Dua, Gapang and Lhokweng at Pulau Weh, Indonesia. Pulau Weh is ini island located at nortwest of Sumatra, Indonesia, in the Andaman Sea (Figure 1).

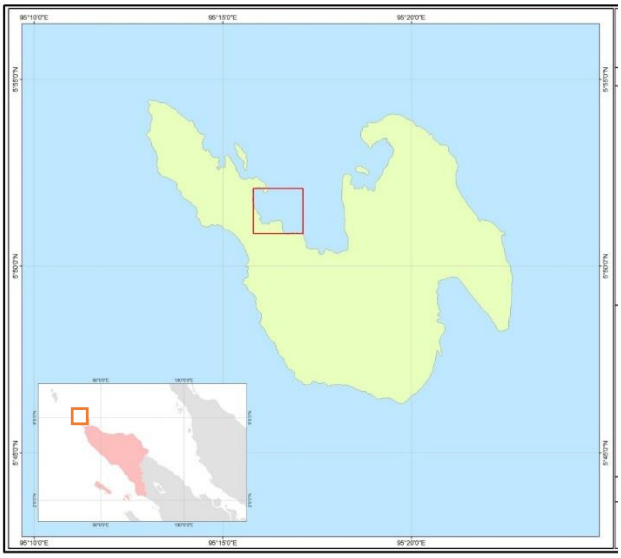

Figure 1. Site sampling.

This study aims to monitor and evaluate the current status of coral reef in the chosen sampling sites. Six sampling stations were chosen to determine the changes in coral reef before and after mass bleaching event and two stations were chosen to study coral recruitment. The survey was conducted using 5x5m permanent quadrate, placed at two different depths: 4m and 8m. Photo Quadrate method was applied to monitor the coral changes and the recovery of coral reefs in Pulau weh. Where at each sampling location within the quadrate, a series of photographs was taken with a digital camera with wide angle lens and analyzed in the laboratory. A digital probe was placed at each site, where by the temperature was recorded every 2 hours starting from April 2010 to September 2011. An increasing and extreme temperature shock was recorded in May 2010.

A 1m^2 quadrat was placed on the site marker by using the corners of the quadrat as a guide, along a 5m x 5m plot area (English *et al.*, 1994). A total of 25 quadrats were sampled within the 5m x 5m plot area (Figure 2). The photograph of each 1m^2 quadrat in the 5m x 5m plot area was taken using an underwater camera. These procedures were conducted in both upper and lower reefs.

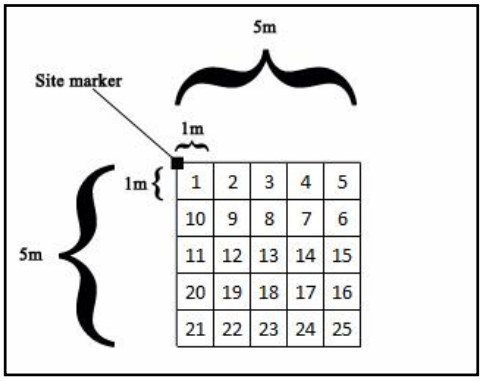

Figure 2. Photographs of the 1m^2 quadrat are taken in the 5m x 5m plot following a predetermined sequence.

Six photographs of six different time interval for the same quadrat were studied simultaneously to identify the presence of coral recruitment. Juvenile coral was defined as living coral with the diameter of colony equal or less than 5cm. New coral recruits were corals that were present in the second, third or fourth observation and were not presented in the first or previous observation of photographs (Irizarry-Soto and Weil, 2009). Juvenile corals which were growing were those juveniles that were previously present in the first observation and were still detected in the following observation of photographs. The coral recruits were identified and classified into family level of Poritidae, Acroporidae, Pocilloporidae and others. The number of colonies of coral recruit in each photoquadrat was counted and recorded. Every new recruit was given an identification code (recruit ID) for the purpose of recognition. Table 1, showed the examples of recruit ID and their interpretation.

Table 1
Interpretation of recruit ID.

Recruit ID	Interpretation
S or D	S indicates upper reef; D indicates lower reef
Qx_1	Quadrat number
Rx_2	Recruitment number
Examples: SQ03R6, DQ19R1	

Any distortion caused by lens or field of view was rectified using the computer during analysis.

3. Result and discussion

The coverage of live percent cover component among the three stations (upper reef and lower reef) and among the two sampling before and after bleaching event (April 2010 and October 2010) (Figure 3). The coverage of live adult coral had decreased from April 2010 to October 2010 in both the upper and lower reefs. High sea water temperature range was recorded

for both stations in between April 2010 to May 2010. In between April to May 2010, the maximum temperature ranged from 30.46°C to 33.43°C and the average temperature ranged from 30.19 ± 0.12°C to 32.16 ± 0.54°C in the upper reef. Meanwhile in the lower reef, the maximum temperature ranged from 30.15°C to 32.50°C and the average temperature ranged from 29.90 ± 0.12°C to 31.68 ± 0.45°C (Figure 4). Khokiattiwong and Yu (2012) stated that coral bleaching occurs when the temperature exceeds the threshold of about 30.1°C at Phuket area, Thailand. The occurrence of severe mass bleaching in the Andaman Sea was due to the extreme high sea surface temperature exceeding 32°C in 2010 (Khokiattiwong and Yu, 2012). Vivekanandan et al. (2008) studies showed that the coral reef region of Andaman Sea has a thermal threshold of 31.4°C, while the maximum sea surface temperature that exceeded 31°C and remained high for more than 30 days triggered the coral bleaching in the Indian Sea. Meanwhile, Guest et al. (2012) studies also showed that severe mass bleaching occurred in Pulau Weh, Indonesia between May 2010 to July 2010 where the sea surface temperature had exceeded the maximum monthly mean temperature. The 2010 bleaching event had caused the mortality of live coral in April 2010 and contributed to the increase of dead coral cover in October 2010 in both stations.

As compared to the lower reef, the adult corals in the upper reef had a higher reduction in coverage. It showed that the corals in the upper reef received more severe impact from the bleaching event because the upper reef experienced a higher thermal stress (more prolonged periods of maximum sea water temperature above 32°C) in between April 2010 to May 2010 (Figure 4). The decreases in adult coral cover in the upper and lower reefs had lead to the reduction in the reproductive output in both of the stations. This reduction of reproductive output eventually reduced the successful coral recruitment (Baird and Marshall, 2002; Irizarry-Soto and Weil, 2009; McClanahan et al., 2009) in both stations due to the low availability of mature adult corals that are capable in producing coral larvae for future recruitment. The results in this study corresponded with the previously mentioned studies where the total numbers of new coral recruit had decreased in both stations from April 2010 to April 2013 (Figure 5) due to the decrease coverage of adult coral in both stations. This suggested that the bleaching event in May 2010 not only decreased the adult coral cover but also the coral recruitment in both the upper and lower reefs in Lhok Weng, Pulau Weh, Indonesia.

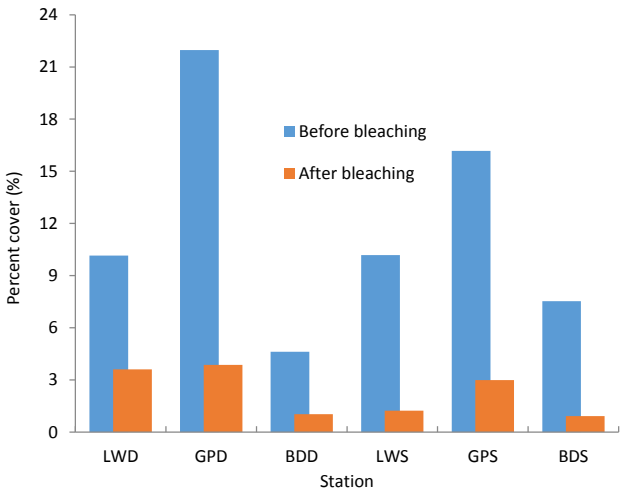

Figure 3. Percentage live coral cover before and after bleaching events at lower reef at Pulau Weh, Indonesia.

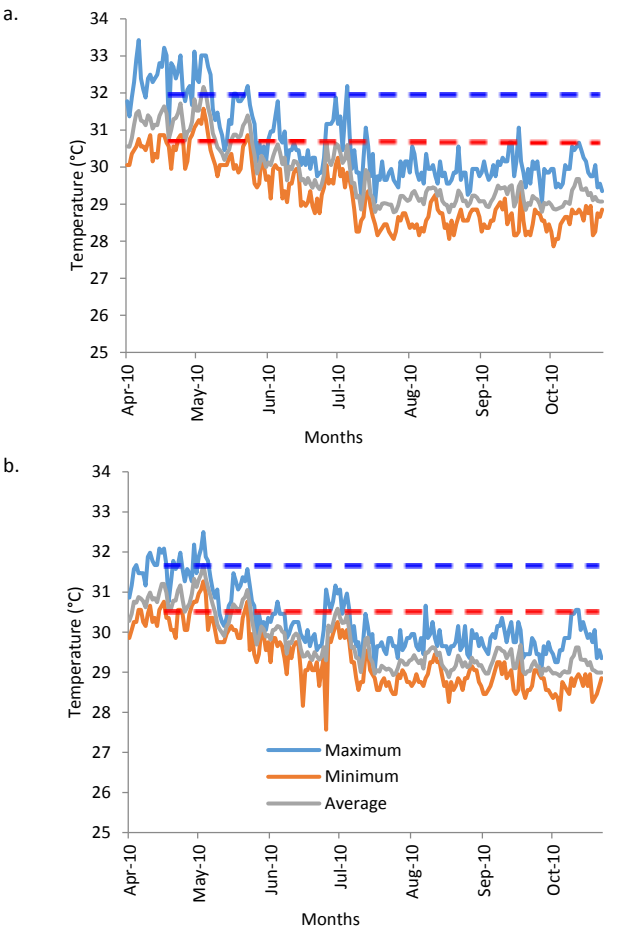

Figure 4. Sea water temperature in upper and lower reefs of Lhok Weng, Pulau Weh, Indonesia from April 2010 to October 2010. The red dotted line (- - -) indicates the thermal threshold of 30.1°C for Phuket area in the Andaman (Khokiattiwong and Yu, 2012); the blue dotted line (- - -) indicates the thermal threshold of 31.4°C in the Andaman Sea region (Vivekanandan et al., 2008).
a. Upper reef
b. Lower reef

The development branching coral for 17 months from April 2010 to April 2013 continues to increased (Figure 5 and Figure 6). Same density of overall juvenile coral (34 colonies/25m^2) was recorded in April 2010 for both stations. The overall juvenile coral density had increased to 39 colonies/25m^2 in upper reef but decreased (25 colonies/25m^2) in lower reef from April 2010 to October 2010.

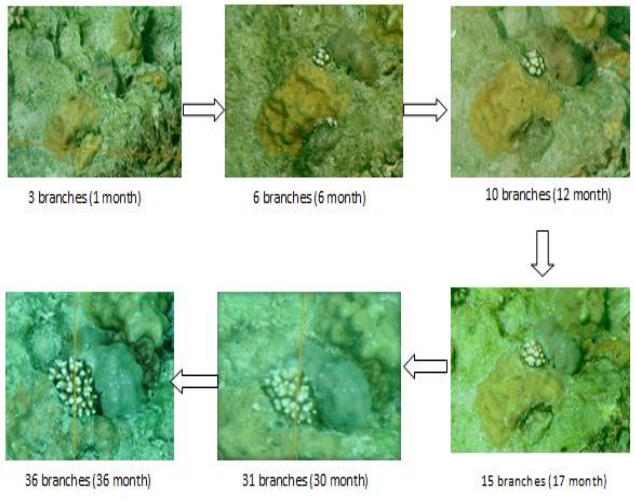

Figure 5. Changes branches juvenile coral *Pocillopora sp* of Lhok Weng, Pulau Weh, Indonesia from April 2010 to April 2013.

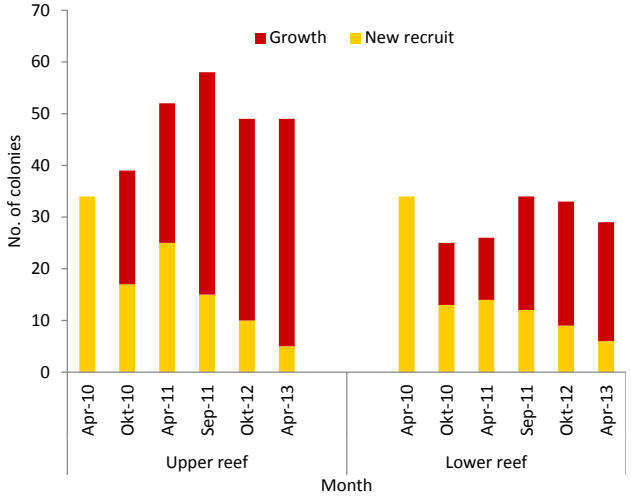

Figure 6. The total numbers of juvenile coral in the upper and lower reefs of Lhok Weng, Pulau Weh, Indonesia from April 2010 to April 2013.

The overall juvenile coral showed an increased density (52 colonies/25m^2) in the upper reef but an almost same density as previous month (26 colonies/25m^2) in the lower reef from October 2010 to April 2011. The overall juvenile coral densities for both stations increased from April 2011 to September 2011 having the numbers of 58 colonies/25m^2 in the upper reef and 34 colonies/25m^2 in the lower reef. The overall juvenile coral densities for both stations decreased from September 2011 to April 2013 having the numbers of 49 colonies/25m^2 in the upper reef and 29 colonies/25m^2 in the lower reef, respectively. The overall juvenile densities were higher in upper reef compared to the lower reef for all of the six sampling months.

The density of overall juvenile coral is higher in the upper reef compared to the lower reef throughout the sampling period. One of the possible reasons might be because of the higher light intensity in the upper reef than the lower reef. This statement can be further supported by the corresponding result of higher correlation between juvenile coral density and light intensity in the upper reef (r^2 = 0.7469) than the lower reef (r^2 = 0.1293) (Figure 7).

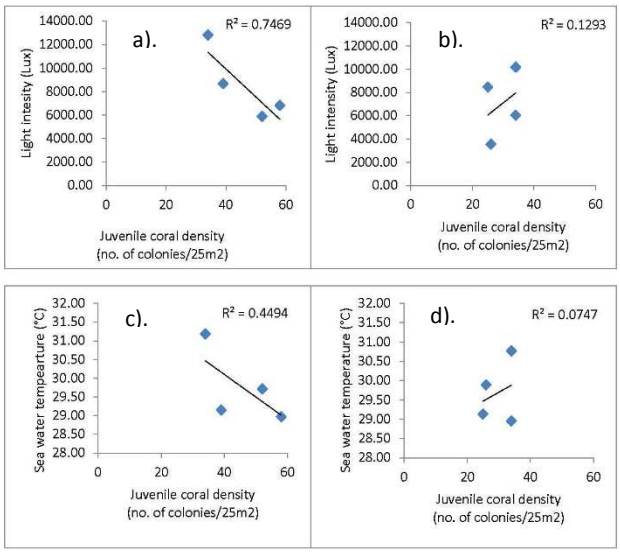

Figure 7. Correlation between juvenile coral density and light intensity in the (a) upper and (b) lower reefs of Lhok Weng, Pulau Weh, Indonesia. Correlation between juvenile coral density and sea water temperature in the (c) upper and (d) lower reefs of Lhok Weng, Pulau Weh, Indonesia.

According to Phongsuwan (1991), higher recruitment rate was found in the upper zone than the lower zone of Phuket reef due to higher intensity of sunlight in the upper zone.

4. Conclution

The bleaching event posed an adverse effect on the coral reef and coral recruits whereas the storm did not seem to affect the recruitment. The sea water temperature and light intensity showed more sign of affecting on the recruitment in the upper reef in this study. More than 60% live coral was die cause by increase sea surface temperature in Pulau Weh, Indonesia. Coral recruitment in Lhok Weng, Pulau Weh, Indonesia varied between stations, between times and among different coral species. The recruitment was higher in the upper reef compared to the lower reef. The growth of juvenile corals was also higher in the upper reef than in the lower reef. The recruitment was lower in the months which interfered by disturbances (bleaching event and storm) compared to the months without disturbances. The percentage survival of juvenile corals was higher in the normal months (without disturbance).

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