Jurnal Ilmu Kelautan **P-ISSN: 2460-0156**
SPERMONDE (2021) 7(2): 12-20 **E-ISSN: 2614-5049**

ECO-PHYSIOLOGICAL STUDY OF *PORITES LUTEA* IN MARGINAL CORAL REEF HABITAT

Mudasir Zainuddin[1], Jamaluddin Jompa[2], Syafyudin Yusuf[2]*, Muhammad Farid Samawi[2], Shinta Werorilangi[2]

Submitted: July 22, 2021 Accepted: February 7, 2022 Online Published: February 14, 2022

[1]Magister Program for Marine Science and Fisheris Faculty, Universitas Hasanuddin
[2]Marine Science Departement, Marine Science and Fisheris Faculty, Universitas Hasanuddin
Corresponding Author:
*Syafyudin Yusuf
E-mail: s.yusuf69@gmail.com

ABSTRACT

Marginal coral reefs are located in a limited aquatic environment, causing coral organisms to live under threat and only certain species of coral are able to survive. *Porites lutea* is one species of coral that is able to live in normal and marginal coral reef conditions. The purpose of this study is to determine the ecology of *Porites lutea*, the physiological ability of *Porites lutea*'s Productivity (P) and Respiration (R), coral reef habitat conditions and environmental factors that affect the distribution of *Porites lutea*l in normal and marginal locations. This study used the belt transect method, measurement of coral colony volume, physiological productivity (P) and respiration (R), transect picture for substrate cover and coral reef conditions and CTD to measure environmental indicators such as temperature, salinity, turbidity, chlorophyll and DO. The results shows that the density of *Porites* coral is higher at normal coral reef locations (Pak Kasim), the highest volume range is 25-100 cm3, with the largest size in the 451-475 cm3 class. P/R values is higher at normal coral reef sites, especially in reef slope areas. Coral reef habitat cover is dominated by abiotic components with poor coral reef conditions in marginal and normal environments. Water temperature was significantly different (P=0.039) between two normal and marginal locations with a range of 27.08 - 27.51 ºC, Salinity was significantly different (P=0.145) with a salinity 33.44ppt at normal locations and 32.88 ppt at marginal locations. The chlorophyll and oxygen number was not significantly different between the two locations, the range of chlorophyll 0.03 – 0.15 mg/L and oxygen 2.49 – 5.23 mg/L. The turbidity factor was significantly different between locations (P=4.86E-07) where the marginal location in Sample was more turbid than the normal location in Pak Kasim. This study shows that there are differences between normal and marginal waters in environmental conditions and physiological reactions of *Porites lutea*, but this coral is able to survive to show their resilience to environmental stresses.

Keywords: Coral physio-ecology, *Porites lutea*, P/R ratio, marginal coral reefs.

INTRODUCTION

The understanding of the ability of coral reefs to survive in extreme or marginal conditions is still very little compared to the knowledge and understanding of the role of the large coral reefs area. The role of coral reefs is very large, but coral organisms have a very fragile nature so that some species experience a serious threat of death (Carpenter, 2008). In recent decades, coral reefs have been under pressure, both from anthropogenic and natural factors (Hinrichsen, 1999; Nurdin et al., 2019; Yusuf & Jompa, 2012). From anthropogenic activities, coral reefs are under pressure in the form of fishing that is not environmentally friendly, pollution, mining, sedimentation and residential waste (Sahetapy et al., 2017).

Marginal coral reefs are coral reefs that are in a limited condition, which is at the threshold of life for corals (Goodkin et al., 2011a), one of the marginal environmental conditions that make corals very threatened is eutrophication and high sedimentation in a waters. which causes corals to become stressed and cause coral death if these conditions persist (Christopher & Mphys, 2007; Risk & Edinger, 2011). In marginal water conditions or high turbidity there are corals that are able to survive in these conditions and dominate the coral reef cover at that location (Christopher & Mphys, 2007; Hennige et al., 2008).

Marginal coral reef environment is very close to the survival threshold of organisms, especially from the factors of water temperature, light penetration, salinity, turbidity, nutrients and aragonite saturation. For coral organisms, living in varied and extreme marginal water conditions, supported by the structure and physiological functions of the body and resistance to unique and specific coral species. However, there is very little information that explains in detail about the limiting factors in the ecology of marginal waters (Glynn, 1996; Goodkin et al., 2011b; Guinotte et al., 2003; Kleypas et al., 1999; Riegl, 2003; Wicks, 2009)

In marginal conditions, there are coral reefs that can survive in extreme or marginal conditions, where there are coral species that can survive in these conditions, such as *Porites lutea*, *Porites lobata* and from the genus *Galaxea*. Knowledge of the environmental parameters that drive the distribution

of corals and symbionts, and the physiological tolerance of these symbionts to environmental stressors, is critical to understanding how coral reefs or coral communities survive in marginal conditions. Research on marginal corals and their dinoflagellate symbionts (zooxanthellae) can provide useful analogues for understanding the ecology of coral reefs experiencing deteriorating conditions (Goodkin et al., 2011a; Perry & Larcombe, 2003).

In some Indonesian waters, the marginal condition of coral reefs can be found such as around Bone Bay, the coast of Southeast Sulawesi including outside the mouth of Kendari Bay, and also parts of the Wakatobi National Park such as on Kaledupa Island and the west side of Hoga Island (Norman et al., 2012). The condition of marginal coral reefs has not been widely studied in Indonesia

Hoga Island and Kaledupa Island are a group of islands located in the Wakatobi Marine National Park island group which is known to be an island that has good coral reefs, where the Wakatobi Marine National Park is located in the middle of the world's coral triangle.

The coral reefs of the Wakatobi Marine National Park are classified as abundant which includes about 50,000 ha of coral reefs, based on research results that show the richness of species and genera of sclerectin corals is much higher than other areas in the world's coral triangle (Clifton et al., 2013).

Coral reefs in Wakatobi continued to decline from year to year from 2002 to 2015 especially on Hoga Island, based on data collected by Bahar et al., (2016). Coral reefs on Hoga Island and Sampela are very different, on Hoga Island the water conditions are good and clear so that it is dominated by hard corals, while in Sampela the water conditions at that location are very cloudy, where the sedimentation rate is higher and consistent so it will be abundant and dominated by cover. sandy substrate where the hard coral assemblage found is dominated by corals from the families Faviidae and Poritidae (Salinas-de-León et al., 2013)

This study focused on coral physiology, particularly *Porites lutea* corals in different systems, population size of *Porites lutea* corals in different coral systems, and adaptation of *Porites lutea* corals to different systems so as to provide an overview of future coral alternatives.

MATERIALS AND METHODS

This research was carried out for one month, from June 26-July 29 2018 at the Operation Wallacea Research Center (OPWAL), Hoga Island, Wakatobi National Park, Southeast Sulawesi-Indonesia. This research station was carried out at two locations, namely Sampela station on Kaledupa Island and Pak Kasim station on Hoga Island.

Figure 1. Map of research sites on Hoga and Kaledupa Islands, Wakatobi.

Coral Colony Size Distribution (Colony Surface Area)

Measurement of coral colony area using a meter tool by measuring the length, width and height of the coral colony, then this data is processed using a semi-spherical or semi-circular formula for data analysis

Physiology

Measurement of coral physiology parameters was carried out to see the differences in the physiological responses of corals found at two different locations of coral reef ecosystems. The variables measured were photosynthesis (p) and respiration (r). So this research will determine the ability of photosynthesis and ability of respiration then the two values are used as the ratio of p/r. p and r measurements are carried out in the laboratory, which begins with taking coral colonies from the sea. Collection of coral colonies using a hammer and chisel. The search for coral colonies that are large enough is then carved to obtain coral colonies then measurements are carried out in the laboratory by providing day and night conditions. where the day treatment is given using ultraviolet (UV) light and the night treatment is closed by giving no light at all.

Habitat Cover and Coral Reef Conditions

This activity was carried out to collect coral distribution data, coral collection using the belt transect method with modifications using quadrants, where the length of the belt transects used was 10 x 2 m. To make it easier to take pictures, a 1 x 1 m quadrant is used to get 20 picture frames in one belt transect. each depth was repeated 6 times with each transect distance of 5 m.

Measurement of Environmental Parameters

Measurement of environmental parameters carried out in this study, namely temperature, DO, turbidity, chlorophyll, and salinity, which in this study used Conductivity Temperature Depth (CTD). The Conductivity Temperature Depth (CTD) was lowered to a depth of 9 m at each station for 4 days. This tool automatically records the data needs that are needed every second.Analisis Data

Calculate the Area of Corals

The area of coral colonies is calculated using the hemisphere formula with the following formula:

Circle Formula:

$$A = \pi r^2$$

Half Circle (Hemisphere):

$$A = 2\ \pi r^2$$

Where:
A=Area
π = 3.14
r = mean coral diameter (1/2 length x 1/2 width x height of the coral)

T Test

T test analysis to see the relationship between two different coral ecosystems between marginalized corals and corals with normal environment.

RESULTS AND DISCUSSION

Based on the coral colony distribution data of *Porites lutea*, it was found that the number of colonies at Pak Kasim's location was more with the number of 460 colonies and 369 colonies at the Sampela location. The graph in figure 1 below is the result of data analysis on the density of Porites lutea coral colonies per 20 m2 with 6 replications for each zone.

The highest density of coral colonies was recorded in the Reef flat area for both normal and margin sites. However, specifically on the Reef Flat, the density of 59 colonies/20 m2 was recorded in the normal waters of Pak Kasim's location. The coral colony density value was higher than the sample location of 41 colonies/20 m2. In other areas, namely Reef Crest, Reef Slope and Reef Base, the density of Porites lutea coral colonies was less than 10 colonies/20 m2, except for Reef Crest at Sample location with a density of 12 colonies/20 m2.

The lowest density of *Porites lutea* colony was at the Reef Slope and Reef Base at Pak Kasim's location. When compared between normal and marginal locations, from the colony density it appears that at the Sample location the density of *Porites lutea* colonies is still relatively larger even though the difference is only 2 colonies.

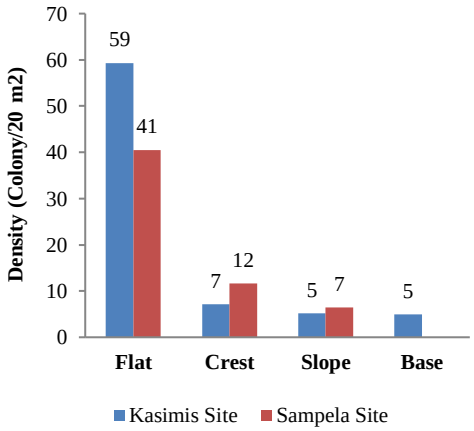

Figure 2. Density of coral colonies of *Porites lutea* at depths and zones at Kasims and Sampela Site, Wakatobi.

At the Sample location there is no data on the Reef Base because the representative for the zone was not found. Based on the results of the T analysis test, it can be concluded that the density of the coral colonies of *Porites lutea* is not significantly different, this is indicated by the T value greater than 0.05 in each zone, where the T value in the reef flat area is 0.246, while the T value in the reef crest zone is 0.147 and the T value is 0.147. T on the reef slope zone is 0.464.

Volume of Coral Colony of *Porites lutea*

The results of the analysis of the volume of the coral colony of Porites lutea using the hemispherical formula in the Microsoft excel program at Pak Kasim and Sample locations can be seen in the graph below. A total of 469 colonies from the Pal Kasim location and 369 colonies from the Sample location whose dimensions were measured could be classified by volume size based on the class 0-25 cm3, up to 476-500 cm3. From the size class, it can be divided into 3 groups, namely group A, the volume 0-25 to 75-100 cm3 dominantly comes from the location of Mr. Kasim. Group B, volume 101-125 cm3 to 151-175 cm3 where the number of colonies was more in the Sample location with very little difference. Group C in the class group 176-200 to 476-500 tends to have more Pak Kasim locations except for the volume class 276-300 which is dominant in Sampela. The largest volume size of Porites lutea coral at the study site was less than 500 cm^2 at Pak Kasim's location.

The volume of the number of coral colonies of Porites lutea in the reef base zone of Pak Kasim's location is very small compared to other areas above

it. While the coral colonies of Porites lutea which were mostly found ranged from 51-75 cm3 as many as 5 colonies and there was the largest colony ranging from 451-475 cm^3 with 1 colony.

Productivity and Respiration Value

The results of photosynthetic (Net Primary Productivity_P) and Respiration (R) measurements on *Porites lutea* coral samples from the two locations Sampela and Pak Kasim were used as a comparison material between clear coral reefs and coral reef margins as well as comparisons between coral resource zones (Table 1). In general, the P and R values at the Sampela location were higher than at the Pak Kasim location, where the P and R values at the Sampela were 3.328 and 3.131 (mgO_2/L/hour) than at the Pak Kasim location, the P value was 2.706 and the R value was 2.137 (mgO2/L/hour). Furthermore, if we look at the zone, it turns out that *Porites lutea* can give higher P and R values in the reef slope zone than the reef crest with P and R values of 2.573 and 2.466 (mgO_2/L/hour).

Table 1.The average value of the productivity (P) and respiration (R) results of the *Porites lutea* coral samples.

Category	P	R
General	3.017	2.634
Kasimis Site	2.706	2.137
Sampela SIte	3.328	3.131
Reef Crest	2.573	2.466
Reef Slope	3.461	2.802

In the above, the comparison of the P and R values in general from the overall data shows that the P (Productivity) value is still higher than the R (respiration) measurement value. Based on the location, it can be seen that the productivity and respiration values are higher at the sample location than Pak Kasim, where the productivity value is 3,328 and the respiration value is 3,131 (mg O2/L/hour) in Pak Kasim and the productivity value is 2,706 and the respiration value is 2,137 (mg O_2). /L/Hour) on the sample.

When compared as a whole in the reef slope zone, it can be seen that the P (productivity) and (R) respiration values are higher in the reef slope zone compared to the reef crest zone. Where the productivity value in the reef slope zone is 3,461 and the respiration value is 2,802 (mg O_2/L/hour) while the reef crest zone has a productivity value of 2,573 and a respiration value of 2,466 (mg O_2/L/hour).

Although the Productivity (P) value in general is greater than the R value of Porites lutea, the sample from the Reef Crest area of Pak Kasim's location has an R value higher than the P value, namely 2,576 R value and 2,478 (mg O_2/L/hour) P-value. his. A striking difference in P and R values was recorded in the Reef Slope area of Pak Kasim's location, namely 2,934 (mg O_2/L/hour) P value and R value 1,698 (mg O_2/L/hour).

At the Sample location, the R and P values at the Reef Slope zone were higher than at the Reef Crest zone. There is no difference between the values of R and P in the two regions. The results of the measurement of productivity (P) of samples from the reef slope area were recorded at 3,398 and R 3,906 (mg O_2/L/Hour). Meanwhile in the Reef Crest area, the P value was recorded at 2,668 (mg O_2/L/hour) and the lower R value was 2,356 (mg O_2/L/hour).

P and R Value

P and R values observations from *Porites lutea* coral in this study are physiological descriptions of two locations with different aquatic environments, it turns out that in marginal coral reef waters, coral animals are more productive in producing oxygen or primary productivity than in clear or normal waters.

P/R Ratio

Based on the results of the P/R ratio analysis, *Porites lutea* samples taken at the reef crest and reef slope can be seen in figure 3 below.

In general, the P/R ratio of the overall coral samples from both Pak Kasim and Sampela locations on the reef crest and reef slope areas obtained a P/R ratio value of 1.15 per hour. While the comparison of the P/R ratio at the two locations, it can be seen that Pak Kasim has a higher P/R ratio than the P/R ratio in Sampela, where the P/R ratio value for Pak Kasim is 1.27 per hour while the P/R ratio in the sample is 1.27 per hour. The sample is 1.06 per hour.

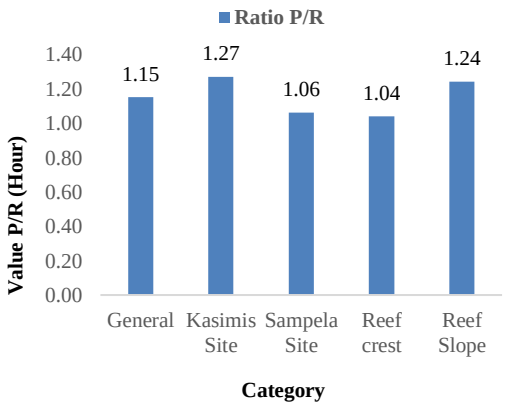

Figure 3. P/R values for each site category and area of normal and marginal coral reefs in Wakatobi.

Comparison of the P/R ratio in general at the reef slope zone, it can be seen that the P/R ratio value at the reef slope zone is higher than the P/R ratio at the reef crest zone, where the P/R ratio value at the reef slope zone is 1.24 per hour. and the value of the P/R ratio at the reef crest is 1.04 per hour. It can be concluded that the P/R ratio at the reef crest zone and the reef slope is not significantly different, this is indicated by the value obtained from the T test analysis results obtained a large value of 0.05 where the value obtained is 0.07 at the reef crest zone and 0.06 at the reef crest zone. reef slope.

Living Hard Coral

The results of the analysis of coral reef habitat cover data using CpCe at each depth or reef zone. In general, when compared to the percentage value of live coral cover, in all reef zones, live coral cover at Pak Kasim Location was higher than at Sampela Location. The highest live coral cover was recorded at a depth of 5 m in the reef crest area. Pak Kasim Location was 28 percent much higher. compared to that recorded at the Sample Location at the same depth of 14 percent. At a depth of 10 m in the reef area, the slope of the live coral is 21 percent higher than at a depth of 8 meters at 10 percent of the sample location. Lower live coral cover of 14 percent and 8 percent was recorded in the reef flat areas of Pak Kasim and Sampela locations. Especially at a depth of 15 meters, there is no sample at the Sampela location, but at the Pak Kasim location live coral covers 23 percent of the substrate.

Analysis of the condition of coral reefs based on live coral cover, it can be concluded that the condition of the coral reefs at the Sampela location is all classified as poor because the cover value is less than 25 percent. Meanwhile at Pak Kasim's location, the condition of the coral reefs is poor at reef flat, reef slope and ref base with a cover value between 14-23 percent, only the 5 m reef crest is classified as 'medium'

Environmental Parameters

In this study, there were 5 environmental parameters that were measured to support the discussion of the relationship between the physiological processes of coral porites lutea and the life of coral communities and coral reef ecosystems at two different locations, namely normal locations and marginal locations of coral reefs.

The results of temperature measurements for 5 days showed the results where, Pak Kasim's temperature was higher than that of Sampela with an average temperature value of 27.38 0C for Pak Kasim, while the average temperature for Sampelea was 27.24 0C. Temperature measurement shows a value that fluctuates every day, where the highest and lowest temperature values in Pak Kasim were recorded at 27.510C on the second day and the lowest temperature value was recorded at 27.34 0C on the third day to the fourth day, while in Sampela the highest temperature value was recorded. 27.410C on the third day and the lowest temperature was recorded on the fourth day with a temperature value of 27,080C. The difference in temperature at the locations of Pak Kasim and Sampela can be concluded to be significantly different, this is indicated by the small T test value of 0.05 where the T test value obtained is 0.039

Dissolved oxygen measurement for 5 days, obtained the highest average value in Pak Kasim compared to Sampela, where the average value obtained was 3.48 mg/l in Pak Kasim while in Sampela the average value for dissolved oxygen was 2.90 mg/l. The highest dissolved oxygen value on Pak Kasim was recorded on the first day with a value of 5.23 mg/l while the lowest dissolved oxygen value on Pak Kasim was found on the fourth day with a value of 2.61 mg/l. while in Sample the highest dissolved oxygen value was recorded on the first day with a value of 3.88 mg/l while the lowest dissolved oxygen value was recorded at 2.49 mg/l. Based on the results of the T test analysis, it can be concluded that the dissolved oxygen in Pak Kasim and Samples is not significantly different where the value obtained is greater than 0.05, namely 0.164.

In general, the turbidity at both locations was clearly visible, where the highest turbidity was recorded in Sampela compared to Pak Kasim where the average turbidity value found in Sampela was 13.81 NTU while in Pak Kasim the turbidity was recorded at 4.25 NTU. The results of observations for 5 days showed that the highest turbidity value in Sampela was recorded on the fourth day with a value of 14.49 NTU while the lowest turbidity value was recorded on the second day with a value of 13 NTU. Meanwhile, Pak Kasim found the highest turbidity value was recorded on the first day with a value of 5.86 NTU while the lowest turbidity value was recorded on the fourth day with a value of 2.55 NTU. The results of the T-test analysis obtained showed a value less than 0.05 where the value obtained was 4.86238E-07. So it can be concluded that the turbidity at these locations is significantly different.

The value of dissolved chlorophyll in the waters at both locations was clearly visible where the value of dissolved chlorophyll content in the sample was greater than that of Mr. Kasim with an average value of 0.15 mg/l in the sample, while that of Mr.

Kasim showed a value of 0.12 mg/l. Based on the results of recording for five days, the highest chlorophyll content value was obtained on the second day with a value of 0.30 mg/l and the lowest chlorophyll content value was recorded on the fourth day with a value of 0.03 mg/l in Sampela, while the highest chlorophyll content value was recorded in Pak Kasim on the fourth day. The fifth with a value of 0.15 mg/l and the lowest chlorophyll content value was recorded on the first day with a value of 0.118 mg/l on Pak Kasim. Based on the results of the T test analysis carried out, it can be concluded that the dissolved chlorophyll at that location was not significantly different, this was indicated by the results of the T test values obtained that were greater than 0.05 where, the value of the T test analysis results was 0.257.

Measurements of seawater salinity at the two locations showed differences in values, where the average salinity value was higher for Pak Kasim than Sampela, this can be seen from the average salinity value recorded on Pak Kasim of 33.44 0/00 while in Samples it had a value of 33.44 0/00 an average of 28.79 0/00. Based on the results of measuring water salinity for five days, it shows that the highest salinity value was recorded on the second day with a value of 33.54 0/00 while the lowest value was recorded on the fifth day with a value of 33.350/00 and the lowest value of 33.35 0/00 on Pak Kasim while in Sample, the highest value was recorded on the third day with a value of 33 0/00 and the lowest value was recorded on the fifth day with a value of 2.96 0/00. The results of the T test analysis on salinity showed that the T value was greater than 0.05, which is 0.145, so it can be concluded that the temperature at that location was not significantly different.

The results of data collection on *Porites lutea* corals on reef flat, reef crest, reef slope and deep zones, it was found that in the reef flat zone the number of *Porites lutea* colonies was found to be higher at Pak Kasim's location, while at the reef crest and reef slope more *Porites lutea* colonies were found. on Samples. This is in line with research conducted by Goodkin et al., (2011b) where it was found and reported that the growth of *Porites* coral colonies was able to live and survive in areas with high stress environments but had slow growth rates.

Assessment of displacement and mortality affecting a critical ecosystem is very important or it is necessary to measure the structural characteristics of corals (Burns et al., 2015), where mortality and damage to coral reefs can also be caused by damage by ship collisions and caused by other factors such as disease. coral or coral bleaching, can be caused by macroalgae competition with corals. (Jompa & McCook, 2003; Yusuf, 2015; Yusuf & Jompa, 2012). This study found that the number of Porites lutea coral colonies was almost evenly distributed, ranging from the small size of 12.56 cm2 (0-25 cm2) to the largest 474.14 cm2 (451-475 cm2). This is in line with the research conducted by Septiyawati et al., (2017) where in the findings of almost uniform coral sizes found in coral areas (Pak Kasim's location) with sizes ranging from 0-25 cm2 to the largest size. In the reef flat zone, the dominant or highest size ranged from 51-75 centimeters squared in both Pak Kasim and Sample locations, where at Pak Kasim locations 100 colonies were found, while in Samples 61 colonies were found. The reef crest zone at Pak Kasim's location is dominated by colonies measuring 76-100 cm2 and 151-175 cm2 with the number of colonies being 6 each, while in Sampela it is dominated by colony sizes ranging from 151-175 cm2 with a total of 14 colonies. In the reef slope zone, the size of the coral colonies at Pak Kasim's location was dominated by colony sizes ranging from 51-75 cm2 with the number of colonies as many as 6 colonies, while in Samples was dominated by colony sizes ranging from 151-175 cm2 with the number of colonies as many as 7 colonies. The high finding of *Porites lutea* coral colonies in Sampela was due to *Porites lutea*'s ability to adapt to a marginal environment where turbidity was found of 14.021711 NTU. 51 of 2004 that the quality standard of seawater turbidity is <5 NTU, while the findings obtained in the field are greater than 5 NTU where the water conditions in Sample are classified as cloudy or marginal. The reef base zone is dominated by colony sizes ranging from 51-75 cm2 with a total of 5 colonies.

Corals that live in two different water conditions where Pak Kasim's location has water conditions with good conditions while in Samples have limited or marginal water conditions, have different ratios of photosynthesis or Net Primary Productivity (NPP) and respiration (R). *Porites lutea* coral was used, which at Pak Kasim's location had a lower NPP than Sampela and a higher R value than Sampela in the reef crest zone. Based on the results of the T test, the results were not significantly different, while at the reef slope the NPP and R values in Sampela were higher than Pak Kasim's location with significantly different values. To determine the effectiveness of biological processes that occur in an organism, the P/R Ratio is used on *Porites lutea* corals, where if the value obtained is greater than 1 then *Porites lutea* corals are considered as active producers and autotrophs and if the value obtained is less than one, it is considered heterotrophs (Septiyawati et al., 2017). The results of the research conducted showed that the P/R value

obtained was more than 1, this indicates that the *Porites lutea* coral at Pak Kasim and Sample locations acts as a producer and is an active autotroph.

Analysis of the number of coral colonies of *Porites lutea* based on the number of colony findings, it can be concluded that the highest number of colonies found was found in the reef flat zone at Pak Kasim Location and Sampela Location, while the least number of colonies was found at the reef base area at Pak Kasim Location and reef slope at Sampela Location.

The percentage of live coral cover was higher at Pak Kasim's location in each zone where the reef flat zone with a depth of 2 m had a coral cover of 14 percent, on the reef crest zone with a depth of 5 m it had a live coral cover percentage of 28 percent, on the reef slope zone. with a depth of 10 m has a live coral cover percentage of 21 percent while the reef base zone with a depth of 15 m has a coral cover percentage of 23 percent. These results are in line with previous studies where the condition of live coral at Pak Kasim's location between a depth of 5 m and a depth of 10 m decreased by a percentage of 21 percent in 2015 (Bahar et al., 2016). While in Samples, the percentage of live coral cover in the reef flat is 8 percent, reef crest is 14 percent and reef slope is 10 percent. This result is in line with the results of a study conducted in 2006 where the condition of live coral in Samples was low (Smith, 2006). The condition of other biotic substrates at Pak Kasim's location is higher than that of Sampela in each zone, where the reef flat zone has a percentage of other biotic cover of 24 percent, the reef crest zone has a cover percentage of 34 percent, the reef slope zone has a percentage cover of 32 percent and the reef base has a cover percentage of 23 percent. other biota cover conditions were higher than live coral cover conditions at Pak Kasim's location, while other biotic cover conditions in Sampela were low with a cover percentage of 8 percent on the reef flat zone, on the reef crest zone with a cover of 16 percent and on the reef slope zone has a cover percentage of 8 percent this is in line with the low coral cover found in Sampela.

The condition of dead coral substrate was recorded that in each zone the condition of dead coral was higher in Sampela than at Pak Kasim's location in each zone, where it can be seen that the condition of dead coral in Samples in the reef flat zone had a percentage cover of 10. by 4 percent, and the percentage of dead coral cover on the reef slope zone was 2 percent, while at Pak Kasim's location the percentage of dead coral cover was 1 percent on the reef flat zone, on the reef crest zone it had a percentage cover of 1 percent, on the reef slope zone of 1 percent and in the reef base zone it has a percentage of 1 percent.

The high percentage of dead coral cover in Sampela was due to the high turbidity (Turbidity) in Sampela. This is based on the results of research conducted by Salinas-de-León et al., (2013) explaining that sclerectine corals are strongly influenced by sedimentation or turbidity which can result in high light penetration resulting in slowed growth and disruption of calcification resulting in death of hard corals. The condition of abiotic substrate cover was higher in the Sample area than in Pak Kasim's location in each zone. The abiotic substrate cover condition in the Samples in the reef flat zone has a percentage of 82 percent, in the reef crest zone it has a percentage of 66 percent and in the reef slope zone it has a percentage of 80 percent.

This is in line with the results of research conducted by Smith, (2006) in Sampela, the study showed a high percentage of abiotic cover in Samples, especially in the reef slope zone with a percentage of 75 percent. while at Pak Kasim's location it was found that the percentage of abiotic cover was 62 percent in the reef flat zone, at the reef crest zone it was found to be 37 percent, at the reef slope zone the percentage of biotic cover was 53 percent and at the reef base zone it was 53 percent. This is in line with the data presented by Bahar et al., (2016) that there was an increase in the percentage of abiotic substrate cover from 2011 by 18 percent to 39 percent in 2015. Based on the results of the study, it can be seen that the condition of live coral at Pak Kasim's location is higher than that of Sampela, both in the reef flat zone, the reef crest zone, and the reef slope zone. It can also be seen that in the four zones at Pak Kasim's location, it can be seen that the percentage of live coral cover in the reef crest zone is higher than the reef base, reef slope and reef flat zones. In Sampela, it can be seen that live coral cover is higher in the reef crest zoan than the two existing zones. The low or lack of live coral found in Sampela is due to the high turbidity (turbidity) in these waters, thus affecting the growth rate and high mortality rate of live coral in Sampela, this is in line with the statement of Tarigan and Edward, (2010), that turbidity is affected by the content of suspended solids, so that the high suspended solids in a water will affect the reduced penetration of light entering the waters, resulting in not optimal photosynthesis process.

CONCLUSION

Based on the results of the research above, it was concluded that the number of coral colonies was more commonly found in Pak Kasim, especially in the reef flat zone and the variation in size showed

that the growth process and coral recruitment varied in each different habitat. The P/R ratio in both locations showed that coral *Porites lutea* is heterotrophic but at a certain depth or reef slope zone at the sample the P/R ratio is lower than at the Pak Kasim location and the reef crest zone at the Sampela and Pak Kasim locations. The environmental factors that affect the distribution of *Porites lutea* coral are turbidity and temperature.

Acknowledgments

A big thanks to Dr. Syafyudin Yusuf who was patient with me in preparing my thesis, thank you to Professor Jamaluddin Jompa for all his understanding, thank you to Dr. ir Shinta Werorilang for all his inputs and a big thank you to Mr. Dr.Ir. Muhammad Farid Samawi for all his motivation and patiently dealing with me as a writer, a big thank you to OPWALL for all the help and facilities provided while on Hoga Island and a big thank you to Bethan Greenwood for the help and direction while on Hoga Island.

REFERENCES

Bahar, A., Husain, A. A., & Tambaru, R. 2016. Dampak Kegiatan Wisata Bahari Terhadap Ekosistem Pulau Hoga , Kabupaten Wakatobi. *Prosiding Simposium Nasional III Kelautan Dan Perikanan 2016*, *September*, 42–50.

Burns, J. H. R., Delparte, D., Gates, R. D., & Takabayashi, M. 2015. Utilizing underwater three-dimensional modeling to enhance ecological and biological studies of coral reefs. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, *40*(5W5), 61–66. https://doi.org/10.5194/isprsarchives-XL-5-W5-61-2015

Carpenter, K. E. 2008. One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts One-Third of Reef-Building Corals Face Elevated Extinction Risk from Climate Change and Local Impacts. May 2014, 3–8. https://doi.org/10.1126/science.1159196

Christopher, J., & Mphys, W. 2007. Physical condition on Marginal Coral Reefs. March.

Clifton, J., Unsworth, R. K. F., & Smith, D. J. 2013. Marine research and conservation in the Coral Triangle. *Marine Research and Conservation in the Coral Triangle*, *January 2014*, 1–258.

Glynn, P. W. 1996. Coral reef bleaching : facts , hypotheses and implications. 1996.

Goodkin, N. F., Switzer, A. D., McCorry, D., DeVantier, L., True, J. D., Hughen, K. A., Angeline, N., & Teng Yang, T. 2011a. Coral communities of Hong Kong: Long-lived corals in a marginal reef environment. *Marine Ecology Progress Series*, *426*(March), 185–196. https://doi.org/10.3354/meps09019

Goodkin, N. F., Switzer, A. D., McCorry, D., DeVantier, L., True, J. D., Hughen, K. A., Angeline, N., & Teng Yang, T. 2011b. Coral communities of Hong Kong: Long-lived corals in a marginal reef environment. *Marine Ecology Progress Series*, *426*(Perry 2003), 185–196. https://doi.org/10.3354/meps09019

Guinotte, J. M., Buddemeier, R. W., & Kleypas, J. A. 2003. Future coral reef habitat marginality: Temporal and spatial effects of climate change in the Pacific basin. *Coral Reefs*, *22*(4), 551–558. https://doi.org/10.1007/s00338-003-0331-4

Hennige, S. J., Smith, D. J., Perkins, R., Consalvey, M., Paterson, D. M., & Suggett, D. J. 2008. Photoacclimation, growth and distribution of massive coral species in clear and turbid waters. *Marine Ecology Progress Series*, *369*(January 2014), 77–88. https://doi.org/10.3354/meps07612

Hinrichsen, D. 1999. Reefs at risk. In *Defenders* (Vol. 74, Issue 3).

Jompa, J., & McCook, L. J. 2003. Coral-algal competition: Macroalgae with different properties have different effects on corals. *Marine Ecology Progress Series*, *258*, 87–95. https://doi.org/10.3354/meps258087

Kleypas, J. A., McManu, J. W., & Mene, L. A. B. 1999. Environmental limits to coral reef development: Where do we draw the line? *American Zoologist*, *39*(1), 146–159. https://doi.org/10.1093/icb/39.1.146

Norman, Y., Ihsan, N., & Arsyad, M. 2012. Analisis Distribusi Arus Permukaan Laut Di Teluk Bone Pada Tahun 2006-2010. *Jurnal Sains Dan Pendidikan Fisika*, *8*(3), 288–295.

Nurdin, M., Litaay, M., Priosambodo, D., & Moka, W. 2019. *Jurnal Ilmu Alam dan Lingkungan*. *10*(1), 15–28.

Perry, C. T., & Larcombe, P. 2003. Marginal and non-reef-building coral environments. *Coral Reefs*, *22*(4), 427–432. https://doi.org/10.1007/s00338-003-0330-5

Riegl, B. 2003. Possible refugia for reefs in times of environmental stress. May 2014. https://doi.org/10.1007/s00531-003-0328-9

Risk, M. J., & Edinger, E. N. 2011. Impacts of Sediment on Coral Reefs. June *2018*. https://doi.org/10.1007/978-90-481-2639-2

Sahetapy, D., Widayati, S., & Sangadji, M. 2017. Dusun Katapang Kabupaten Seram Bagian Barat (Community Activity Impact on Coral Reefs Ecosystem in The Coastal Waters Katapang Orchard West Seram District). 13, 105–114.

Salinas-de-León, P., Dryden, C., Smith, D. J., & Bell, J. J. 2013. Temporal and spatial variability in coral recruitment on two Indonesian coral reefs: Consistently lower recruitment to a degraded reef. *Marine Biology*, *160*(1), 97–105. https://doi.org/10.1007/s00227-012-2066-7

Septiyawati, F., Jompa, J., Werorilangi, S., & Smith, D. 2017. Kajian Respon FisiologisOrganisme Karang Keras yang Hidup pada Kondisi Alam yang Marginal. 1–25.

Smith, D. J. 2006. *Wakatobi Field Report July-August 2006*. *August*, 1–250. http://www.opwall.com/uploads/2017/11/Opwall-Indonesia-Wakatobi-Marine-Science-Report-2006.pdf

Tarigan, M. S., & . E. 2010. Kandungan Total Zat Padat Tersuspensi (Total Suspended Solid) Di Perairan Raha, Sulawesi Tenggara. *MAKARA of Science Series*, *7*(3), 109–119. https://doi.org/10.7454/mss.v7i3.362

Wicks, L. C. 2009. Persistence of corals in marginal habitats : the role of the environment , and symbiont diversity and ecophysiology. 220.

Yusuf, S. 2015. Investigation of coral reef degradation due to "Ship grounding." Proceeding of International Conference on Marine Science and Fisheries. Makassar, 10-11 September 2014, September 2014, 11–19.

Yusuf, S., & Jompa, J. 2012. First Quantitative Assessment of Coral Bleaching on Indonesian Reefs. *Icrs2012.Com*, *July*, 6. http://www.icrs2012.com/proceedings/manuscripts/ICRS2012_17D_6.pdf