Journal of Coastal and Ocean Sciences *e-issn: 2746-4512*
Volume 7 No. 2, May 2026: 119-125 *p-issn: 2745-4355*

Effect of Light Intensity on the Abundance of *Zooxanthellae* on Branching Corals (*Acropora* sp.) at Pagang Island Waters, West Sumatra

Muhammad Zikran Desnaldi[1*], Thamrin[1], Sofyan Husein Siregar[1]
[1]Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru 28293 Indonesia
Corresponding Author: muhammad.zikran3712@student.unri.ac.id

Received: 20 April 2026; Accepted: 11 May 2026

ABSTRACT

Zooxanthellae are symbiotic microalgae that live within coral tissue, playing a vital role in photosynthesis and providing energy to the coral through their metabolic products. Various environmental factors, including light intensity, can influence the abundance of zooxanthellae in corals. This study aimed to determine the abundance of zooxanthellae in branching corals (*Acropora* sp.) based on different light intensities and to analyze the effect of light intensity on the abundance of zooxanthellae in branching corals (*Acropora* sp.). This research was conducted in May 2025 at Pagang Island Waters, West Sumatra. The method used in this research is a field experiment. The coral colonies used in the research were assigned to 4 treatments to achieve different light intensities for the samples. The results of this study indicate that there are differences in the abundance of zooxanthellae in branching corals (*Acropora* sp.) based on different light intensities. The average abundance of zooxanthellae in treatment 1 (control = 694-702 µE/m^{2}s) was 9,961,707 cells/cm^2, in treatment 2 (200 µE/m^{2}s) was 5,715,698 cells/cm^2, in treatment 3 (100 µE/m^{2}s) was 3,589,326 cells/cm^2, and in treatment 4 (0 µE/m^{2}s) was 1,530,447 cells/cm^2. This study also shows a very strong relationship between light intensity and the abundance of zooxanthellae in branching corals (*Acropora* sp.).

Keywords: Light intensity, Abundance, Branching coral

1. INTRODUCTION

Coral reefs are highly productive coastal ecosystems with great biodiversity, and they play a vital role in maintaining the balance of marine ecosystems. These ecosystems serve as habitats for a wide variety of marine life and hold significant economic value for coastal communities through fisheries and tourism. Coral reefs also serve as coastal protectors against erosion and large waves and possess significant pharmacological potential as a source of medicinal compounds. The existence of coral reef ecosystems is vital for the sustainability of marine life and the well-being of coastal communities whose livelihoods depend on marine resources. Therefore, it is crucial to ensure the sustainability of coral reef ecosystems.

One key component of the coral reef ecosystem is the presence of zooxanthellae, unicellular microalgae that live in symbiosis with coral animals. Zooxanthellae play a role in providing energy to corals through photosynthesis, while corals provide the habitat and nutrients necessary for the survival of zooxanthellae (Lakastri et al., 2018). This symbiotic relationship also influences the coral's ability to produce calcium carbonate for the formation of its calcareous skeleton, which ultimately contributes to reef structure formation (Ilmy et al., 2023). Additionally, zooxanthellae contribute to coral polyp coloration and assist in the nutrient recycling required by the coral (Rosset, 2015). Further research indicates that zooxanthellae play a crucial role in coral growth and survival through photosynthesis, which provides the host coral with energy in the form of organic compounds (Lajeunesse, 2020). This symbiosis is vital, as it provides over 90% of a coral's energy needs (Alamanda, 2018). Based on this, coral reefs are directly linked to light intensity

Light intensity is a critical environmental factor for zooxanthellae, as it directly affects photosynthesis. Changes in light intensity can affect the density of zooxanthellae within coral tissue, ultimately impacting the coral's overall health (Suliswati et al., 2016). This factor can also influence the vertical distribution of corals in aquatic environments (Nusantara et al., 2019). Drastic or prolonged changes in light intensity can cause coral bleaching by expelling zooxanthellae from coral tissue (Curran & Barnard, 2021). Consequently, this can affect coral health, including that of branching corals (*Acropora* sp.).

Branching corals, particularly those of the genus Acropora, are one of the dominant coral groups found in reefs and exhibit relatively rapid growth and recovery (Loupatty et al., 2023). This genus exhibits varied growth forms and plays a crucial role in forming complex coral reef structures. The presence of zooxanthellae in *Acropora* sp. is crucial for supporting coral growth and reef formation (Mulyani et al., 2020). This genus belongs to a group of corals sensitive to environmental changes, making it a frequently used bioindicator of coral reef ecosystem health (Luthfi et al., 2018).

One area with coral reefs is Pag-Ing Island; this region has a marine area with a fairly extensive coral reef ecosystem, home to various coral species. The relatively clear and sheltered water conditions make this area an ideal habitat for coral growth, including *Acropora* sp. Branching corals (*Acropora* sp.) are the most commonly encountered species and dominate the reef flats in the waters around Pagang Island. Research on the effects of light intensity on zooxanthellae has been conducted, including by Ain et al. (2019), who investigated the effects of varying light intensities on zooxanthellae abundance in *Acropora* sp. corals in the waters around Kasiak Island, West Sumatra Province.

2. RESEARCH METHOD

Time and Place

Sampling was conducted on one side of Pagang Island at a depth of 2–3 m, in accordance with the distribution of branching corals (*Acropora* sp.), which dominate the waters on the northern side of the island (Figure 1).

Figure 1. Locations of the Study's Sampling Points

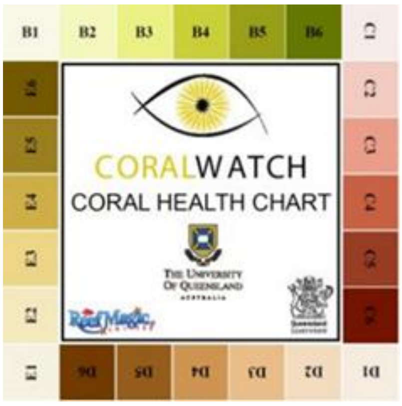

Figure 2. Coral Health Chart (Coralwatch, 2024)

Procedures

Selection of Coral Colonies

The selection of branching coral colonies (*Acropora* sp.) was conducted using purposive sampling. The selection of coral colonies as research subjects was conducted using scuba gear at a depth of 2–3 m. The health of the coral colonies at the site was assessed using a coral health chart (Figure 2). Healthy coral colonies were selected as research subjects on the assumption that they still contained a significant number of zooxanthellae.

The Effect of Light Intensity on Coral Colonies

The coral colonies under study were subjected to four treatments to expose them to varying light intensities. The coral colonies were treated for 48 hours as follows: Treatment 1: coral colony branches left uncovered with plastic, serving as the control group (light intensity at the time of the study). Treatment 2: a branch of the coral colony covered with 1 black plastic sheet to obtain a light intensity of 200 $\mu E/m^2s$. Treatment 3: a branch of the coral colony covered with a combination of 1 black plastic sheet and 1 blue plastic sheet to obtain a light intensity of 100 $\mu E/m^2s$. Treatment 4: a coral colony branch covered using a combination of two black plastic sheets to achieve a light intensity of 0 $\mu E/m^2s$.

The plastic was tied to the coral colony branch using a binding cord, and a hole was made at the bottom of the plastic (near the tie) to allow water to flow in and out (Figure 3). Before securing the plastic, light intensity in each treatment was first measured using a modified lux meter. Each treatment was repeated three times, resulting in a total of 12 coral colony branch tips.

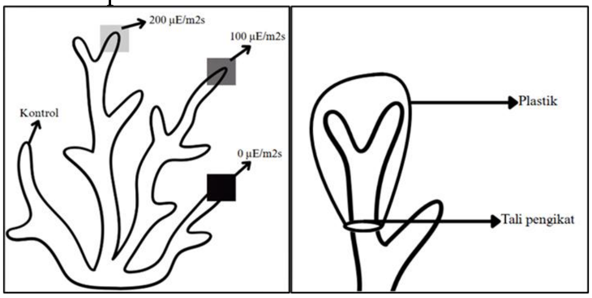

Figure 3. Sketch of Light Intensity Treatments

Coral Colony Sampling

The tips of the coral colony branches were cut to approximately 5 cm using pliers, yielding coral colony fragments. The coral fragments were then placed in jars and treated with 10% formalin. The jars were labelled and placed in a cooler filled with ice. The samples were then transported to the laboratory.

Measurement of Aquatic Environmental Parameters

Environmental parameters were measured at the water surface of the study site. Environmental parameters were measured daily to determine daily fluctuations. The environmental parameters recorded were oceanographic parameters, including temperature, salinity, current velocity, depth, turbidity, and light intensity.

Collection of Zooxanthellae

Zooxanthellae were collected following the method described by Fachrurrozie et al. (2012), which involved placing coral fragments into a 500-ml beaker containing 100 ml of seawater. The beaker was heated on a hot plate, raising the water temperature to approximately 45°C for 10 minutes to release the zooxanthellae from within the coral polyps. Next, the coral fragments were removed and returned to the jar. Meanwhile, the seawater in the beaker, which now contained zooxanthellae, was poured into a sample bottle and treated with 10% formalin. The bottle was labelled and placed in a cool box filled with ice cubes.

Zooxanthellae Count

Zooxanthellae were counted using a microscope. Seawater containing zooxanthellae was collected using a dropper pipette and dispensed through the gap between the hemocytometer and the cover slip until it was evenly distributed on both sides of the hemocytometer's corner blocks (Narfa & Utami, 2024). The haemocytometer is then observed using an Olympus CX21 microscope at 10×10 magnification. Only zooxanthellae present in the 5 central squares, one in the center and one in each corner of the haemocytometer grid, are counted. Visible zooxanthellae are counted using a hand counter.

Measuring the Surface Area of Coral Fragments

The surface area of coral fragments was measured by determining the length and diameter of the fragments using a ruler. The measurement results were then substituted into the formula proposed by Rauf et al. (2015), as follows:

$$Lf = La + Lb$$

Description:

Lf	=	Surface area of the coral fragment
La	=	Surface area of a hemisphere ($L = \frac{1}{2}(4\pi r^2)$)
Lb	=	Surface area of a cylindrical surface ($L = 2\pi r \times t$)

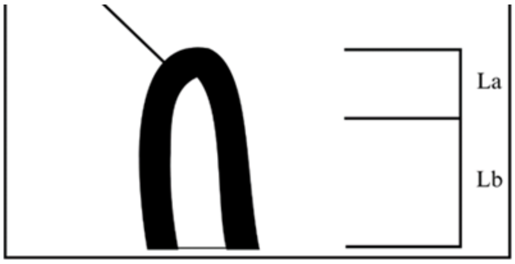

Figure 4. Sketch of the Measurement of the Surface Area of a Coral Fragment

Calculation of Zooxanthellae Abundance

Zooxanthellae abundance was calculated based on the number of zooxanthellae found per unit area of coral (cells/cm²). Zooxanthellae abundance was calculated using the formula proposed by Effendi & Aunurohim (2013), as follows:

$$D = \frac{Q \times P \times 10.000}{L}$$

Description:

D	=	zooxanthellae abundance (cell/ cm^2)
Q	=	number of zooxanthellae counted (sel)
P	=	Sample volume (ml)
L	=	Area of the coral fragment (cm^2)
10.000	=	Convert mm² to cm²

Analysis of the Effect of Light Intensity on Zooxanthellae Abundance

An analysis of the effect of light intensity on zooxanthellae abundance was conducted using simple linear regression. This analysis examined the relationship between one independent variable (X = light intensity) and one dependent variable (Y = zooxanthellae abundance). The analysis was performed using SPSS version 26.

3. RESULT AND DISCUSSION

Water Quality Parameters

Pagang Island is one of the western islands of Sumatra, facing the Indian Ocean. Geographically, the island is situated at coordinates 01°09′34″ South Latitude and 100°20′55″ East Longitude. Pagang Island is part of the administrative area of Koto XI Tarusan Subdistrict, South Pesisir Regency, West Sumatra Province, located not far from the Mandeh Tourism Area. The island has hilly topography, white-sand beaches, and some rocky shores, covering approximately 10 ha. The island is home to a wide variety of vegetation, including coconut trees, various types and species of mangroves, grasses, and shrubs. Based on the measurement results, the water was found to have a temperature range of approximately 28–31°C, a salinity of approximately 30–32‰, current speeds of approximately 0.09–0.13 m/s, depths of approximately 2.19–2.47 m, water clarity of approximately 2.00–2.20 m, and light intensity of approximately 643–702 µE/m²s. The variation in values of each aquatic environmental parameter recorded daily was due to unpredictable weather fluctuations during the study period. The results of the measurements of aquatic environmental parameters during the study are shown in Table 1.

Table 1. Water quality

Day	Temperature (°C)	Salinity (‰)	Current Speed (m/s)	Depth (m)	Brightness (m)	Light Intensity (µEm²s)
1	29	31	0,13	2,21	2,20	694
2	28	30	0,09	2,47	2,00	643
3	31	32	0,10	2,19	2,15	702

Table 1 shows that the aquatic environmental parameters at the time of sampling remained within the growth range for both corals and zooxanthellae. The growth of zooxanthellae and corals is generally strongly influenced by water temperature and salinity. Zooxanthellae can grow optimally at 28–32°C and salinities of 30–35‰ (Ilmy et al., 2023). In addition to temperature and salinity, current velocity can also affect zooxanthellae growth. Current velocities are relatively low, averaging 0.04–0.08 m/s with a maximum range of 0.13–0.28 m/s, and these conditions still support coral growth, including Acropora species (Tanto et al., 2023). Thus, the observed differences in zooxanthellae abundance are not caused by variations in environmental parameters but are more influenced by light intensity treatments.

Zooxanthellae Abundance Based on Different Light Intensities

The results of the zooxanthellae abundance calculations based on different light intensities are shown in Figure 5.

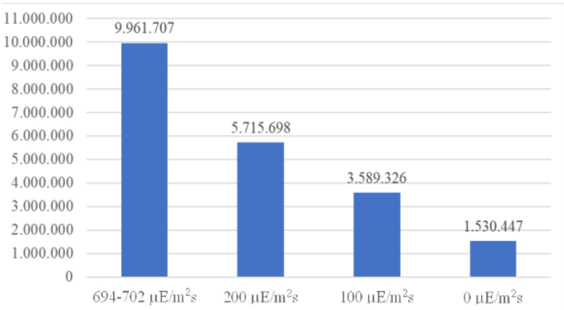

Figure 5. Zooxanthellae Abundance (cells/cm²)

Based on the research findings, the abundance of zooxanthellae in branching corals (*Acropora* sp.) decreased with decreasing light intensity. Under control conditions (694–702 µE/m²s), the number of zooxanthellae reached 9,961,707 cells/cm². However, when light intensity was reduced to 200 µE/m²s, the number decreased to 5,715,698 cells/cm² and continued to decline to 3,589,326 cells/cm² at 100 µE/m²s. The lowest value was found under no-light conditions (0 µE/m²s), at 1,530,447 cells/cm². This decrease indicates that there are differences in zooxanthellae abundance in branching corals

(*Acropora* sp.) based on varying light intensities.

These results align with a study conducted by Fachrurrozie et al. (2012) in the waters around Pari Island, Thousand Islands, which found that zooxanthellae abundance in Acropora corals decreased significantly under low light intensity. A similar finding was reported by Nusantara et al. (2019), who noted that lighting, particularly UV radiation, significantly affects the number of zooxanthellae in coral tissue. Limited light conditions can cause zooxanthellae to be expelled from coral tissue, thereby reducing their abundance and potentially triggering bleaching (coral bleaching).

Light intensities in treatments 2 (200 μE/m²s), 3 (100 μE/m²s), and 4 (0 μE/m²s) are suboptimal for zooxanthellae growth. The light intensity required by zooxanthellae for photosynthesis ranges from 550–600 μE/m²s. A decrease in light intensity below this range can cause stress and coral bleaching (Kuhl et al., 1995; Suharsono, 2004). Coral animals regularly release small amounts of zooxanthellae as part of a normal physiological process to regulate their symbiotic population. However, when experiencing stress due to unfavorable environmental conditions, such as reduced light intensity or increased temperature, corals rapidly and massively expel zooxanthellae as an adaptive response to prevent the accumulation of damaged zooxanthellae resulting from disrupted photosynthesis (Fujise et al., 2014). This release serves as a defence mechanism for corals, helping them survive amid detrimental environmental pressures (D'Angelo & Wiedenmann, 2019).

Results from Treatment 4, with a light intensity of 0 μE/m²s, showed the presence of zooxanthellae, albeit in lower numbers than in the other treatments. This is because zooxanthellae possess resilience and phenotypic plasticity, enabling them to adapt to various environmental conditions such as fluctuations in light intensity and temperature. This plasticity is crucial for maintaining the symbiotic relationship with the coral under stress and for the coral's survival in changing habitats (Smith et al., 2021). Therefore, zooxanthellae can adapt quickly to less favorable environments. Additionally, the presence of zooxanthellae in treatment 4 may be due to the relatively short duration of coral closure, which allowed som*e* to survive in conditions without direct light exposure before undergoing further degradation.

The Effect of Light Intensity on Zooxanthellae Abundance

The results of the analysis of the effect of light intensity on zooxanthellae abundance are shown in Figure 6.

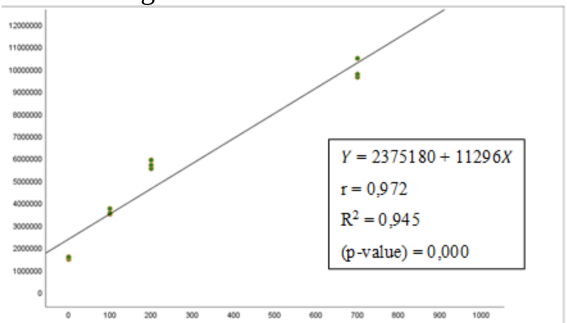

Figure 6. Effect of Light Intensity on Zooxanthellae Abundance

Based on a simple linear regression analysis, the effect of light intensity on zooxanthellae abundance was determined. The regression equation (Y = 2,375,180 + 11,296X) illustrates how changes in light intensity affect zooxanthellae abundance. The constant value (a = 2,375,180) indicates a zooxanthellae abundance of 2,375,180 cells/cm² when light intensity = 0 μE/m²s. The regression coefficient (b = 11,296X) indicates that zooxanthellae abundance will increase by 11,296 cells/cm² if light intensity increases by 1 μE/m²s. The correlation coefficient (r = 0.972) indicates a very strong relationship between light intensity and zooxanthellae abundance. The coefficient of determination (R^2 = 0.945) indicates that light intensity accounts for 94.5% of the variation in zooxanthellae abundance, while other factors influence the remainder. Meanwhile, the significance value (p-value = 0.000) < 0.05 indicates that light intensity has a significant effect on zooxanthellae abundance. This means there is a very strong relationship between light intensity and zooxanthellae abundance in branching corals (*Acropora* sp.).

These results align with the study by Lieng & Efriyeldi (2020), which reported that environmental factors, including light intensity, highly influence *zooxanthellae* abundance. This is supported by the findings of Sayekti et al. (2017), who reported that light intensity is closely related to the content of zooxanthellae's photosynthetic pigments, so that reduced light can limit the symbiont's photosynthetic capacity. Another study by Nusantara et al.

(2019) also confirms that light is a key environmental factor determining coral health, with reduced light availability due to turbidity or sedimentation leading to decreased zooxanthellae density and increased bleaching risk.

Reduced light intensity entering the water can be caused by sedimentation, leading to turbidity in waters around coral reefs. However, water conditions at the time of sampling in this study were clear, with minimal turbidity, allowing light to penetrate to a depth of 2–3 meters. This indicates that the differences in zooxanthellae abundance observed in the study results were influenced by the treatment of covering the tips of coral colonies, rather than by turbid water conditions. According to Rauf et al. (2015), increased water turbidity due to sedimentation can reduce the number of zooxanthellae in corals by reducing the light intensity reaching coral tissues, thereby inhibiting the photosynthetic process in the zooxanthellae. In addition to sedimentation, water depth also affects the light intensity received. The deeper the water, the lower the light intensity available for zooxanthellae photosynthesis (Syafni et al., 2022). Limited light conditions reduce the efficiency of zooxanthellae's photosynthesis, resulting in a reduced food supply for the coral. This decrease in food supply can hinder the overall growth and health of the coral.

4. CONCLUSION

Based on the results of a study on the effect of light intensity on zooxanthellae abundance in branching corals (*Acropora* sp.) in the waters around Pagang Island, West Sumatra, it can be concluded that there are differences in zooxanthellae abundance in branching corals (*Acropora* sp.) based on different light intensities, and there is a very strong influence of light intensity on zooxanthellae abundance in branching corals (*Acropora* sp.). Based on the results of this study, it is recommended to conduct further research on zooxanthellae abundance while accounting for other limiting factors, such as temperature, salinity, current, depth, light intensity, sedimentation, and nutrients, within the same coral species.

REFERENCES

Alamanda, R.A. (2018). *Efektivitas Intensitas Cahaya kaitannya dengan Gradasi Warna pada Terumbu Karang Zoanthus sp.* Universitas Lampung.

Curran, A., & Barnard, S. (2021). What is the Role of *Zooxanthellae* during Coral *Bleaching*? Review of *Zooxanthellae* and their Response to Environmental Stress. *South African Journal of Science*, 117(7-8), 1-7.

D'Angelo, C., & Wiedenmann, J. (2019). Coral Bleaching Signals and Mechanisms: A Review. *Frontiers in Marine Science*, 6: 734.

Effendi, F.W., & Aunurrohim, A. (2013). Densitas *Zooxanthellae* dan Pertumbuhan Karang *Acropora formosa* dan *Acropora nobilis* di Perairan Pembangkit Listrik Tenaga UAP (PLTU) Paiton, Probolinggo, Jawa Timur. *Jurnal Jurusan Biologi, FMIPA Institut Teknologi Sepuluh November*, 1-7.

Fachrurrozie, A., Patria, M.P., & Widiarti, R. (2012). Pengaruh Perbedaan Intensitas Cahaya terhadap Kelimpahan *Zooxanthellae* pada Karang Bercabang (Marga: *Acropora*) di Perairan Pulau Pari, Kepulauan Seribu. *Jurnal Akuatika*, 3: 115-124.

Fujise, L., Koike, K., & Yamashita, H. (2014). Moderate Thermal Stress causes Active and Immediate Expulsion of Photosynthetically Damaged *Zooxanthellae* (*Symbiodinium*) from Corals. *PLOS ONE*, 9(11): e114321.

https://coralwatch.org/monitoring/using-the-chart/ (Diakses Pada Tanggal 25 November 2024).

Ilmy, N., Palupi, R.D., & Rahmadani, R. (2023). Kelimpahan *Zooxanthella* pada Karang *Scleractinia* berdasarkan Kedalaman di Perairan Bungkutoko Sulawesi Tenggara. *Journal Sapa Laut*, 8(2): 77-83.

Kuhl, M.Y.C., Dalsgaard, T., Jorgensen, B.B., & Revsbech, N.P. 1995. Microenvironment and Photosynthesis of *Zooxanthellae* in *Scleractinian* Corals Studied with Microsensor for O_2, pH, and Light. *Journal of Marine Ecology.*

Lajeunesse, T. C. (2020). Zooxanthellae. *Current Biology*, 30(19), R1110-R1113.

Lakastri, L., Purnomo, P.W., & Muskananfola, M.R. (2018). Pengaruh Kedalaman terhadap Produktivitas Primer dan Densitas *Zooxanthellae* pada Karang Dominan di Pulau Cemara Kecil, Karimunjawa. *Management of Aquatic Resources Journal (MAQUARES*), 7(4): 440-446.

Lieng, L., & Efriyeldi, E. (2020). Density Zooxanthella based on the Life Form of Coral on Marak Island, West Sumatra Province. *Asian Journal of Aquatic Sciences, 3*(3): 209-216.

Loupatty, S.R., Limmon, G.V., Kaya, S.M.J., & GD, M. (2023). Distribution and Condition of Hard Coral (*Scleractinian*) Species in the Waters of Airlouw and Seri Village. *Agrikan Jurnal Agribisnis Perikanan*, 16(1): 129-140.

Luthfi, O.M., Rahmadita, V.L., & Setyohadi, D. (2018). Melihat Kondisi Kesetimbangan Ekologi Terumbu Karang di Pulau Sempu, Malang menggunakan Pendekatan Luasan Koloni Karang Keras (*Scleractinia*). *Jurnal Ilmu Lingkungan*, 16(1), 1-8.

Mulyani, M.S., Purnomo, P. W., & Supriharyono, S. (2020). Pengaruh berbagai Temperatur terhadap Pelepasan Densitas *Zooxanthellae* pada Karang *Acropora* sp. dalam Skala Laboratorium. *Jurnal Pasir Laut*, 4(1): 36-41.

Narfa, N., & Utami, E. (2024). Perbandingan Densitas *Zooxanthellae* pada Karang Keras di Perairan Rebo Kabupaten Bangka. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 17(2): 187-191.

Nusantara, D.P., Purnomo, P.W., & Supriharyono, S. (2019). The Effect of Ultra Violet Intensity on the Release of *Zooxanthellae* in Coral *Acropora* sp. in Laboratory Scale. *Saintek Perikanan: Indonesian Journal of Fisheries Science and Technology*, 15(1): 46-53.

Rauf, K.P., Supriharyono, S., & Purnomo, P.W. (2015). Kelimpahan *Zooxanthellae* pada *Acropora* sp. berdasarkan Kedalaman Perairan dan Naungan yang Berbeda di Pulau Pari Kepulauan Seribu Jakarta. *Diponegoro Journal of Maquares*, 4(1): 46–54.

Rosset, S., D'Angelo, C., & Wiedenmann, J. (2015). Ultrastructural Biomarkers in Symbiotic Algae Reflect the Availability of Dissolved Inorganic Nutrients and Particulate Food to the Reef Coral Holobiont. *Frontiers in Marine Science*, 2, 103.

Sayekti, S., Harpeni, E., & Muhaemin, M. (2017). Pengaruh Intensitas Cahaya terhadap Kandungan Klorofil-a dan -c *Zooxanthellae* dari Isolat Karang Lunak *Zoanthus* sp. *Maspari Journal*, 9(1):61-68.

Smith, J. A., Nguyen, T. H., & Lee, C. Y. (2021). Phenotypic Plasticity and Resilience of Symbiotic Dinoflagellates (*Symbiodinium*) under Environmental Stress. *Frontiers in Marine Science*, 8: 645321.

Suharsono, S. (2004). *Jenis-Jenis Karang di Indonesia*. Pusat Penelitian Oseanografi – LIPI.

Suliswati, S., Harpeni, E., & Muhaemin, M. (2016). Effect of Light Intensity on the Cell Density, Diameter and Cell Volume *Zooxanthellae* from Isolate Softcoral *Zoanthus* sp. *Aquasains*, 5(1): 477-482.

Syafni, N.D., Thamrin, T., & Efriyeldi, E. (2022). Analisis Densitas *Zooxanthella* pada Karang *Acropora* sp. di Perairan Pulau Talam Tapanuli Tengah, Sumatera Utara. *Jurnal Zona*, 6(2): 72-77.

Tanto, T.A., Nurjaya, I.W., Bengen, D.G., Hartanto, T., Saenudin, S., & Suhaemi, S. (2023). Hubungan Parameter Arus Laut dan Lifeform Karang pada beberapa Pulau-Pulau Kecil di Kota Padang. *Majalah Ilmiah Globe*, 25(1).