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COMPOSITION SPECIES AND PERCENTAGE OF MACROALGAE COVERAGE IN CORAL REEF ECOSYSTEMS ITS RELATION TO OCEANOGRAPHIC CONDITIONS OF THE WATERS AROUND LAE-LAE AND BARRANGLOMPO ISLANDS

Komposisi Jenis dan Persentase Tutupan Makroalga Pada Ekositem Terumbu Karang Kaitannya dengan Kondisi Oseanografi Perairan di Pulau Lae-Lae dan Barranglompo

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ABSTRACT

This study aimed to determine the differences in types and percentage coverage of macroalgae and analyze the correlation between the percentage coverage of macroalgal types and oceanographic conditions in the coral reef ecosystem of Lae-lae Island and Barranglompo Island. The study was conducted on November 20, 2011. The sampling technique followed a 50-meter long transect line perpendicular to the coastline. The estimation of macroalgal coverage used the method developed by English (1994), using a 1 x 1 meter plot and a 25 x 25 cm grid, with categories for each grid using a ¼, ½, ¾, and 1 unit scale. Two-Way ANOVA was performed to determine differences in macroalgal coverage, and Canonical Correspondence Analysis (CCA) was used to investigate the relationship between macroalgal coverage and oceanographic conditions. Thirteen species of macroalgae were found on Lae-lae Island, consisting of 8 orders, 9 families, 10 genera, and 13 species, with coverage ranging from 18.58%-53.44%. The two-way ANOVA showed no significant difference in macroalgal coverage between the flat, crest, and slope zones at both stations on Lae-lae Island ($P > 0.05$). On Barranglompo Island, 7 species were found with a relatively similar composition from 4 orders, 4 families, and 4 genera. The macroalgal coverage on Barranglompo Island ranged from 0%-26.77%. The two-way ANOVA showed that the percentage of macroalgal coverage in the flat, crest, and slope zones for both stations was significantly different ($P < 0.05$). The oceanographic conditions affecting the high percentage of macroalgal coverage on Lae-lae Island were current speed, temperature, TSS, nitrate (NO_3), and on Barranglompo Island were salinity and phosphate (PO_4).

Keywords: Composition and Percentage Coverage, Lae-lae Island and Barranglompo Island, Macroalgae, Oceanographic Conditions

ABSTRAK

Penelitian ini bertujuan untuk mengetahui perbedaan jenis dan persentase tutupan makroalga serta menganalisis keterkaitan persentase tutupan jenis makroalga dengan kondisi oseanografi perairan di ekosistem terumbu karang di pulau Lae-lae dan Barranglompo. Penelitian dilaksanakan pada tanggal 20 November 2011. Teknik sampling mengikuti transek line sepanjang 50 meter tegak lurus garis pantai. Estimasi persen tutupan makroalga digunakan metode yang dikembangkan oleh English (1994), menggunakan plot 1 x 1 meter dan kisi sebesar 25 x 25 cm, kategori untuk setiap kisi digunakan skala ¼, ½, ¾ dan 1 unit. Uji statistik *Two Way Anova* dilakukan untuk mengetahui perbedaan persentase tutupan makroalga dan *Canonical Correspondence Analysis* (CCA) untuk mengkaji hubungan antara persentase tutupan jenis makroalga dan kondisi oseanografi perairan. Ditemukan 13 species makroalga di Pulau Lae-lae terdiri atas 8 order, 9 family, 10 genera dan 13 spesies dengan persentase tutupan berkisar antara 18,58-53,44%, uji *two way anova* menunjukkan tidak ada pebedaan yang signifikan pada persentase tutupan makroalga antara zona *flat, crest dan slope* di kedua stasiun di pulau Lae-lae (P>0.05). Pulau Barranglompo ditemukan 7 species dengan komposisi yang relatif sama yang berasal dari 4 order, 4 family dan 4 genera. Persentase penutupan makroalga di Pulau Barranglompo berkisar antara 0-26,77%, uji *two way anova* menunjukkan persentase penutupan makroalga yang terdapat pada zona *flat, crest dan slope* untuk kedua stasiun berbeda nyata (P<0.05). Kondisi perairan yang memengaruhi tingginya persentase tutupan jenis makroalga di pulau Lae-lae yakni kecepatan arus, suhu, TSS, nitrat (NO_3) dan pulau Barranglompo yakni Salinitas dan Phosfat (PO_4).

Kata Kunci: Komposisi dan Persentase Tutupan, Pulau Lae-lae dan Barranglompo, Makroalga, Kondisi Oseanografi

INTRODUCTION

Macroalgae are thallus plants found in almost all coastal waters of Indonesia, especially on coral reef flats. These benthic macroalgae consist of the divisions Chlorophyta (green algae), Phaeophyta (brown algae) and Rhodophyta (red algae) which are generally attached to a substrate (McConnaughey & Zottoli, 1983; Pongtuluran & Rompas, 2022). Macroalgae live as phytobenthos by attaching or attaching themselves to mud, sand, coral, dead coral fragments, shells, rocks or wood substrates and are epiphytic in nature, living attached to other plants (Firdaus, 2019).

Ira (2018) and Handayani (2019) stated that in the tropical level, macroalgae are one of the primary producers and function as a nursery for marine biota, as a place to find food, symbionts, and even contribute to providing lime as a material for forming coral reefs (Sianipar et al., 2022) in several types of calcareous macroalgae. Coral reefs are marine ecosystems whose lives interact with various components of flora and fauna that are closely related to oceanographic factors (physics, chemistry and dynamics) of their habitat (McCook, 2001; Rasher et al., 2011; Vieira et al., 2016; Sianipar et al., 2022). Macroalgae in coral reef ecosystems grow and spread based on the suitability of their habitat or substrate and other influencing factors such as competitors, grazing herbivorous fish, eutrophication, sunlight, climate, geographical location, habitat profile and characteristics of the macroalgae themselves (Jompa & McCook, 2002; Swierts & Vermeij, 2016; Riniatsih et al., 2017).

The Spermonde Islands are located in the Makassar Strait and are a fairly extensive area for the distribution of macroalgae. One of them is Lae-lae Island, which is directly adjacent to the mainland, with an average depth of 10 meters and the substrate is dominated by muddy sand and Barranglompo is approximately 5 kilometers from the mainland with an average depth of 30 meters with a substrate dominated by coral (A Faizal, 2023). Lae-Lae Island and Barrang Lompo have different water conditions, especially in terms of water quality. Lae-lae

Island is directly adjacent to the mainland of Makassar city with high activity so that it contributes significantly to changes in water quality conditions. The supply from the mainland is thought to have a negative effect on water quality that affects the distribution and cover of macroalgae. Barranglompo Island is further from the mainland so that water quality does not experience major changes due to contributions from industrial activities, hospitals and agricultural activities such as on Lae-Lae Island (Ahmad Faizal et al., 2012). Based on these considerations, a study of the composition of types and cover of macroalgae in relation to the oceanographic conditions of the waters on Lae-lae and Barranglompo Islands.

METHODS

Place and Time

This research was conducted from September 2011 to January 2012, which included literature studies, proposal preparation, field data collection, sample analysis, data analysis, and preparation of the final research report.

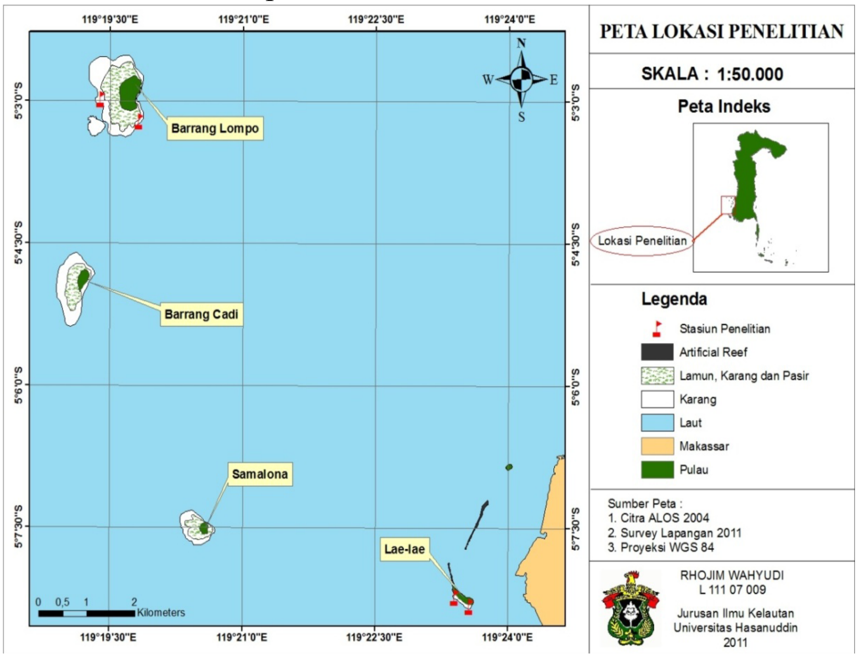

Figure 1. Research Location Map

Sample identification was carried out at the Marine Biology Laboratory, Department of Marine Sciences, FIKP-UNHAS and water quality data processing was carried out at the Oceanography Chemistry Laboratory, Department of Marine Sciences, FIKP-UNHAS.

Tools and Materials

The tools used during the research include: GPS (Global Positioning System) to determine the position/point of the research station; writing instruments for recording data; digital camera for documentation; current kite to measure the direction and speed of the current; salinometer for measuring water salinity, thermometer for measuring water temperature, sample bottles for water sample containers for nutrient processing (phosphate, nitrate), and TSS; meter for line transects, 1 x 1 meter quadrant transects for estimating macroalgae abundance, diving equipment for diving; slate for writing instruments in the water; and underwater camera for documentation in the water. The materials used are H_2SO_4 as a preservative for nitrate and phosphate samples, Whatman filter paper 0.45 µm diameter 43 mm, Whatman GF/C filter paper diameter 43 mm and label paper for sample information.

Research Procedure

The determination of the observation location station was determined as many as 2 (two) locations or islands, namely Lae-lae and Barranglompo islands. On each island, sampling was carried out at two stations in the coral reef ecosystem. In one station it was divided into three repetitions perpendicular to the coastline and in one repetition it was divided into three zones, namely the reef flat zone, reff crest and reef slope. Data collection of macroalgae cover was carried out in each zone at the same time as the measurement of oceanographic parameters.

Sampling Technique and Data Analysis

Total Suspended Solid (TSS)

Water samples were taken at each predetermined point, then put into a bottle and stored in a cool box. The sample was then taken to the laboratory. TSS measurement was carried out using the gravimetric method. The filter paper was first heated in an oven at 105□C for 2 hours, then weighed (a grams). A sample of 500 ml was filtered, then dried in an oven at 105°C for 2 hours, then cooled in a desiccator. The filter paper was weighed (b grams) (Parsons et al., 2013; Seth & Shanmugam, 2016). The TSS value was then calculated by:

$$TSS = \frac{(b-a)}{C} \times 1000$$

Where:
C = sample volume
a = weight of empty filter paper
b = weight of final filter paper

Nitrate Measurement

Nitrate (NO_3) measurement was carried out by taking a water sample then putting it into a sample bottle and preserving it with H_2SO_4. The samples were then analyzed in the laboratory using a spectrophotometer (DREL brand. 2800). Knowing the optimum range of nitrate can be analyzed using the APHA method, (1992) (Rice et al., 2012; Seth & Shanmugam, 2016; Rice et al., 2017).

Phosphate Measurement

Phosphate (PO_4) measurement was carried out by taking a water sample then putting it in a sample bottle and preserving it with H_2SO_4. The samples were then analyzed in the laboratory using a spectrophotometer (DREL brand. 2800). Knowing the optimum range of phosphate can be analyzed using the APHA method, (1992) (Rice et al., 2012; Seth & Shanmugam, 2016; Rice et al., 2017).

Current speed and direction

Current speed was measured using the Drift Float Method (current kite) and current direction using a compass and stop watch. Data processing using the following equation:

$$V = \frac{S}{t}$$

Where:
V = Current speed (meters/second)
s = Distance (meters)
t = Time (seconds)

Temperature and Salinity

Temperature is measured using a thermometer and is carried out directly in the field at each observation station. Water samples are put into a container that has been provided and then the thermometer is dipped and the temperature scale that is read is recorded. Salinity measurements using a hand refractometer. Measurements are carried out in situ.

Macroalgae Condition and Density Assessment

The method of measuring macroalgae cover using a 1 x 1 meter quadrant transect. The sampling technique used was to follow a 50 meter long transect line perpendicular to the coastline. At every 10 meters, measurements were taken by placing a quadrant transect (Figure 2). The substation was placed at a depth of 2-3 meters in the reef flat area or a depth of 3-5 meters in the reef slope area.

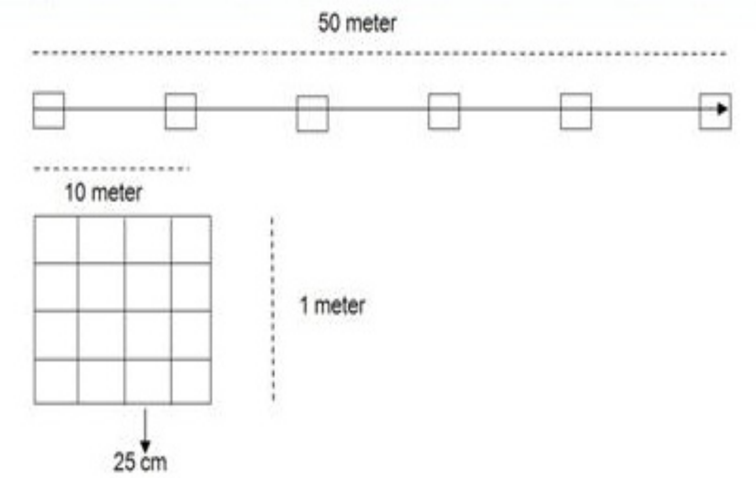

Figure 2. Sampling Technique Using the Quadrant Method

Identification of Macroalgae Samples

The samples taken were identified at the Marine Biology Laboratory, Department of Marine Science, Hasanuddin University, Makassar by matching the samples with illustrated books and determination keys. Identification is based on the FAO species identification guide for fishery purposes (Baldwin, 2003), Marine Plants on the Reefs of the Spermonde Archipelago (Verheij, 1993), Philippine Seaweeds (Trono Jr & Ganzon-Fortes, 1988), Seaweeds of India (Jha et al., 2009), Innovative Saline Agriculture (Seth & Shanmugam, 2016)

Macroalgae Condition and Density

To calculate the estimated percentage of macroalgae cover, the method developed by English et al. (1997) was used, using a 1 x 1 meter plot and a 25 x 25 cm grid (Figure 2). The categories for each grid used a scale of ¼, ½, ¾ and 1 unit. Next, the percentage of cover is calculated using the following equation:

$$C = \frac{\sum(Ci)}{A} x100$$

Where:
C : Percentage of cover
$\sum Ci$: Number of cover units for each grid for each type of macroalgae
A : Total number of grids used (16 units)

To calculate the composition of macroalgae species, the formula used is:

$$\text{Species composition (\%)} = \frac{\text{ni}}{\text{N}} \times 100\ \%$$

With:
ni : Number of individuals of each type observed
N : Total number of individuals

Data Analysis

All data (station data and its replications) were then analyzed descriptively in the form of graphs, tables and diagrams. To determine the difference in the percentage of macroalgae cover, a Two Way Anova statistical test was carried out using the SPSS version 12.0 program. To examine the relationship between macroalgae cover and oceanographic conditions. Canonical Correspondence Analysis (CCA) was used. The calculation process was carried out with the help of Excel-Biplot computer software.

RESULT

Macroalgae Type Composition

13 types of macroalgae were found from two research stations with different compositions between station 1 and station 2 on Lae-lae Island.

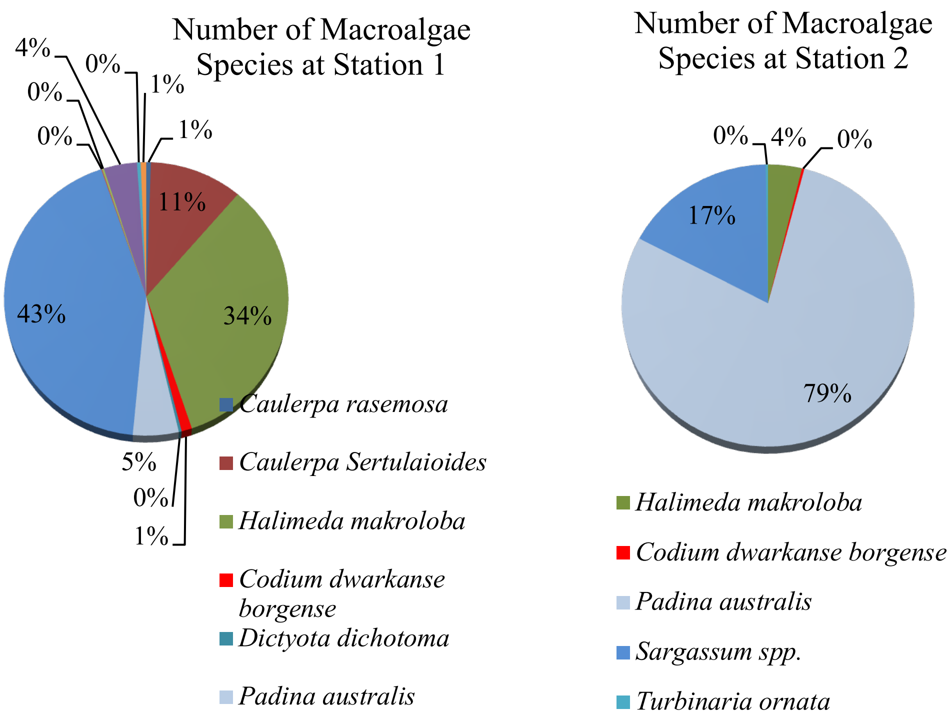

Figure 3. Percentage of Macroalgae Types Found at Both Stations on Lae-lae Island

The macroalgae found at station 1 on Lae-lae Island consisted of 8 orders, 9 families, 10 genera and 12 species (Figure 3). Three species of them belong to the Chlorophyceae Class, five species from the Phaeophyceae Class and four other species from the Rhodophyceae Class (Table 1). At station 2, 4 orders, 4 families, 5 genera and 5 species were found (Figure 5). Two species of them are from the Chlorophyceae Class, three species from the Phaeophyceae Class but no macroalgae from the Rhodophyceae Class were found (Table 1).

Seven types of macroalgae were found from both stations with relatively the same composition. The seven types of macroalgae came from 4 orders, 4 families and 4 genera (Figure 4). At station 1, macroalgae from Class Chlorophyceae were found one species, class Phaeophyceae four species and Class Rhodophyceae only one species (Table 1).

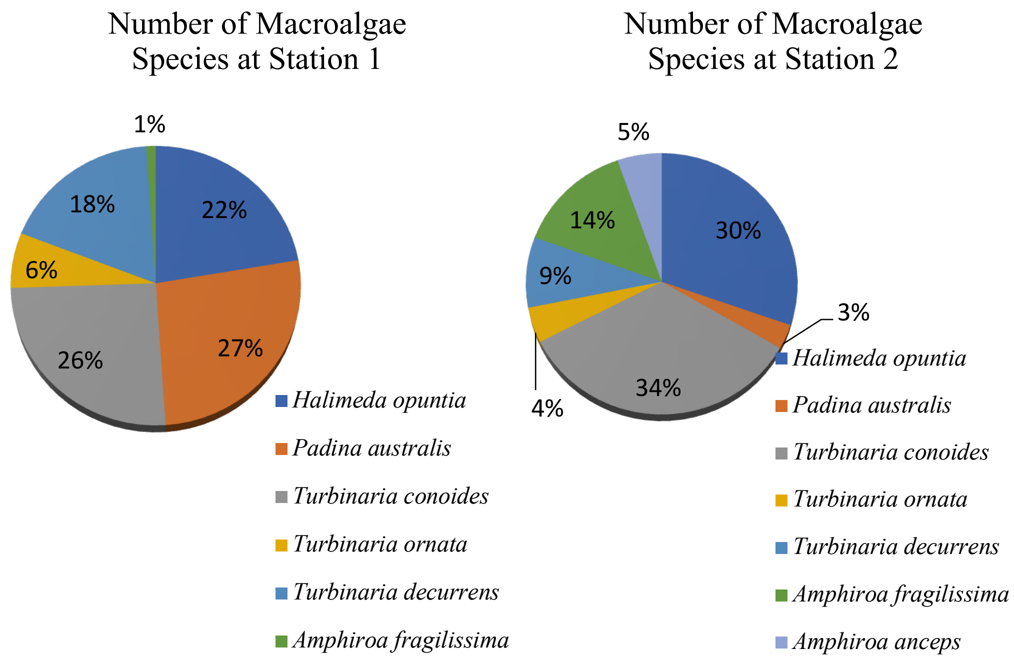

Figure 4. Percentage of Macroalgae Types Found at Both Stations on Barranglompo Island

At station 2 on Barranglompo Island, from class Chlorphyceae one species was found, from Class Phaeophyceae four species were found and from Class Rhodophyceae two species were found (Table 1).

Table 1. Types of Macroalgae Found at Each Research Location

Systematics				
Class	**Order**	**Family**	**Genus**	**Species**
Chlorophyceae	Bryopsidales	Caulerpaceae	*Caulerpa*	*Caulerpa racemosa*
				Caulerpa sertulaioides
		Halimedaceae	*Halimeda*	*Halimeda macroloba*
				Halimeda opuntia
		Codiaceae	*Codium*	*Codium dwarkanse borgense*
Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyota*	*Dictyota dichotoma*
			Padina	*Padina australis*
	Fucales	Sargassaceae	*Sargassum*	*Sargassum* spp.
			Turbinaria	*Turbinaria conoides*
				Turbinaria decurrens
				Turbinaria ornata
Rhodophyceae	Corallinales	Corallinaceae	*Amphiroa*	*Amphiroa fragilissima*
				Amphiroa anceps
	Cryptonemiales	Cryptonemiaceae	*Halymenia*	*Halymenia durvilleai*
	Gigartinales	Hypneaceae	*Hypnea*	*Hypnea spinella*

Information: only found on Lae-lae Island
only found on Barranglompo Island
found on Barranglompo Island and Lae-lae Island

Macroalgae Coverage Percentage

The percentage of macroalgae cover at both stations during the study ranged from 18.58%-53.44%. The lowest percentage of cover was obtained at station II slope zone (18.58%) while the highest percentage on Lae-lae Island was obtained at station I flat zone (53.44%) (Figure 5). The percentage of macroalgae cover at station 1 was ±2 times greater than that at station 2. However, the two-way ANOVA test showed no significant difference in the percentage of macroalgae cover between the flat, crest and slope zones at both stations on Lae-lae Island. (P>0.05) (Figure 5).

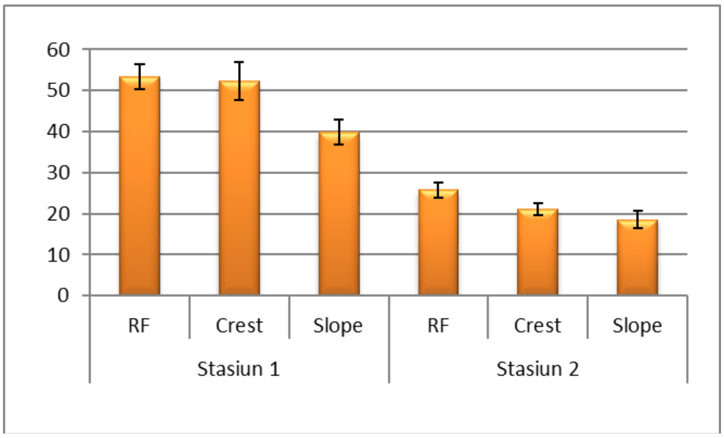

Figure 5. Average Total Percentage of Macroalgae Cover (based on ANOVA) on Lae-lae Island

The percentage of macroalgae cover at both research stations on Barranglompo Island ranged from 0%-26.77% (Figure 6). The lowest percentage of coverage was obtained at station I slope zone with no macroalgae coverage (0%) while the highest was obtained at station II flat zone (26.77%). Two way ANOVA test showed that the percentage of macroalgae coverage in the flat, crest and slope zones for both stations was significantly different (P<0.05).

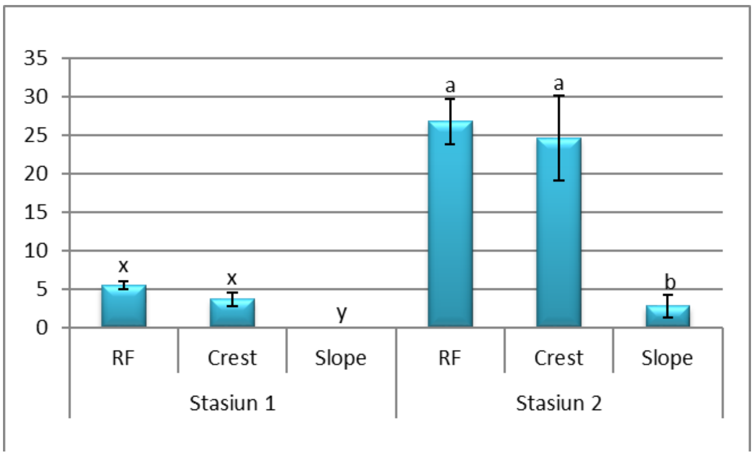

Figure 6. Average Total Percentage of Macroalgae Coverage (based on ANOVA) Barranglompo Island

Relationship Between the Percentage of Macroalgae Coverage and Oceanographic Conditions of Waters

To see the relationship between the percentage of macroalgae coverage and oceanographic conditions of waters, the Canonical Correspondence Analysis (CCA) method was used with the help of Biplot software. The CCA results showed that there were three groups formed, namely, the first group at station II (Lae-lae Island), the second group at station I (Lae-lae Island) and the third group at stations I and II (Barranglompo Island) (Figure 7).

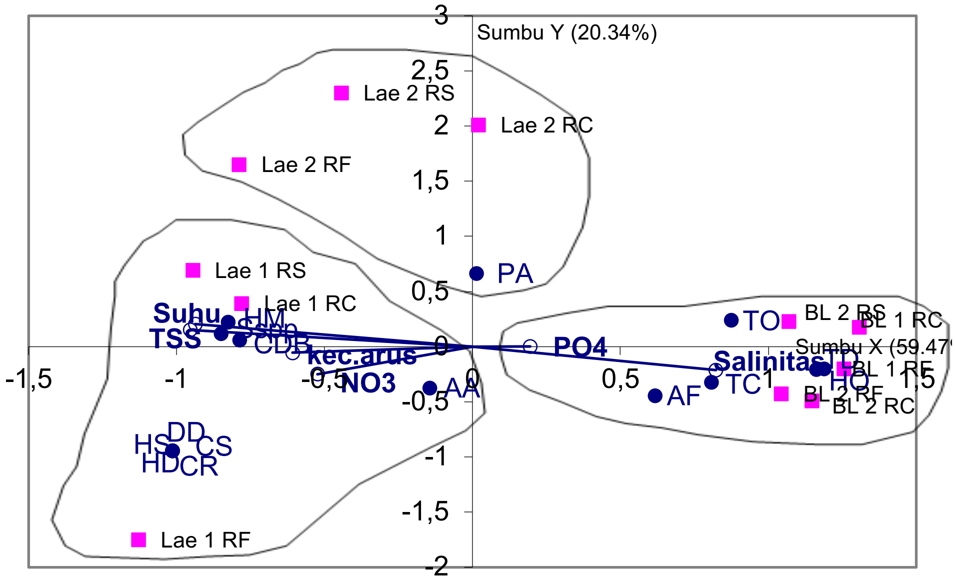

Figure 7. Results of Canonical Correspondence Analysis (CCA)

The first group (station II Lae-lae Island) and the second (station I Lae-lae Island) are characterized by oceanographic variables of TSS, nitrate, temperature, and current speed. Although the oceanographic characteristics of both are the same, differences in the type of algae cover were found at the two stations. Station II Lae-lae Island's macroalgae characteristics are from the type Padina australis. The second group located at station I Lae-lae Island with macroalgae characteristics from the types *Caulerpa racemosa, Caulerpa sertularioides, Halimeda macroloba, Codium dwarkanse Borgesen, Dictyota dichotoma, Padina australis, Sargassum* spp., *Turbinaria conoides, Amphiroa fragilissima, Amphiroa anceps, Halymenia durvilleai*, and *Hypnea spinella* (Table 2).

Table 2. Grouping (CCA) Based on the X, Y Axes

Group	Stasiun	Percentage Coverage of Characteristic Macroalgae Types	Oceanography Characteristics
I	II Lae-lae Island	High *Padina australis*	Nitrate, TSS, Temperature, and Current Velocity
II	I Lae-lae Island	High *Halimeda macroloba*; high *Sargassum* spp.; high *Codium Dwarkense Borgesen*; low *Dictyota dichotoma*; low *Hypnea spinella*; low *Halymenia durvilleai*; low *Amphiroa anceps*; low *Caulerpa rasemosa*; low *Caulerpa sertulaioides*	Nitrate, TSS, Temperature, and Current Velocity
III	I dan II Barranglompo Island	Low *Turbinaria ornata*; high *Turbinaria decurrens*; high *Turbinaria conoides*; high *Amphiroa fragilissima*; high *Halimeda opuntia*	Phosphate, Salinity

DISCUSSION

In general, the oceanographic conditions of the waters are relatively the same between groups 1 and 2, but the difference is in the percentage of macroalgae cover. In the first group, station II of Lae-lae Island, only 5 species of macroalgae were found and were dominated by the *Padina australis* species. In group two, the percentage of cover of various types was found, namely 13 species of macroalgae (Table 2). Irwandi & Nurgayah (2017) stated that there is a close relationship between differences in substrate and composition of macroalgae types. The difference in the characteristics of the percentage of macroalgae cover in groups 1 and 2 and the characteristics of relatively the same oceanographic conditions are suspected to be due to the different substrate conditions observed visually, where group 1 has a sand substrate and dead coral fragments and in group 2 the type of substrate is in the form of coral fragments or solid dead coral fragments. In the third group, namely at stations I and II (Barranglompo Island) which are characterized by phosphate concentration and salinity. The types of macroalgae found were *Halimeda opuntia, Padina australis, Turbinaria conoides, Turbinaria ornata, Turbinaria decurrens, Amphiroa fragilissima* and *Amphiroa anceps*.

The CCA results (Figure 7) show a relationship between the coverage of macroalgae species and the oceanographic conditions of the waters on Lae-lae Island, namely a current speed of 0.01-0.04 m/sec, the current speed for macroalgae ranges from 20-40 m/sec if >40 can damage macroalgae (Arfah & Patty, 2016), currents are important for stirring nutrients in the waters (Subiakto et al., 2019; Silaban & Kadmaer, 2020), a temperature of 30-32°C is still considered safe for macroalgae growth (Arfah & Patty, 2016) the highest temperature limit is 34.5°C and the unsafe limit for tropical waters is 15-30°C (Prasetyaningsih & Rahardjo, 2016), TSS >20 mg/l according to the concentration of suspended solids for marine biota (Ministry of Environment, 2004) , nitrate (NO_3) 0.047-0.144 mg/L is classified as a good concentration for macroalgae growth (Irwandi & Nurgayah, 2017). On Barranglompo Island, namely Salinity 28-30 ppt is still classified as a general range for growth, and phosphate (PO_4) 0.40-0.46 mg/l is categorized as a low concentration for macroalgae growth (Patty et al., 2015).

CONCLUSION

The differences in the types of macroalgae found only on Lae-lae Island were 8 species, namely *Caulerpa racemosa, Caulerpa sertulaioides, Halimeda macroloba, Codium dwarkanse Borgesen, Dictyota dichotoma, Sargassum* spp., *Halymenia durvilleaei*, and *Hypnea spinella*. While on Barranglompo Island there were 2 species, namely *Halimeda opuntia* and *Turbinaria decurrens*. The percentage of macroalgae cover on Lae-lae Island ranged from 18.58–53.44%. The lowest percentage of cover was at station II of the slope zone, which was 18.58% while the highest was at station I of the flat zone, which was 53.44%. Barranglompo Island ranged from 0–26.77%, the lowest percentage of cover was at station I of the slope zone, which was 0% while the highest was at station II of the flat zone, which was 26.77%. Oceanographic conditions of the waters that affect the high percentage of macroalgae cover on Lae-lae Island are current speed, temperature, TSS, nitrate (NO_3). On Barranglompo Island, namely Salinity and phosphate (PO_4).

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