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BIODIVERSITAS ISSN: 1412-033X Volume 24, Number 4, April 2023 E-ISSN: 2085-4722 Pages: 2189-2200 DOI: 10.13057/biodiv/d240431 Seaweed diversity and community structure on the west coast of Aceh, Indonesia ERNIATI1, ERLANGGA1, , YUDHO ANDIKA1, MULIANI2 1Department of Marine Science, Faculty of Agriculture, Universitas Malikussaleh. Jl. Cot Teuku Nie, East Reuleut, North Aceh 24351, Aceh, Indonesia. Tel./Fax.: +62-271-663375, email: erlangga@unimal.ac.id. 2Department of Aquaculture, Faculty of Agriculture, Malikussaleh University. Jl.

Cot Teuku Nie Reuleut, North Aceh 24351, Aceh, Indonesia Manuscript received: 29 August 2023. Revision accepted: 17 April 2023. Abstract. Erniati, Erlangga, Andika Y, Muliani. 2023. Seaweed diversity and community structure on the west coast of Aceh, Indonesia. Biodiversitas 24: 2189-2200. One of the commodities that continues to be developed by the Indonesian government in fisheries is seaweed. The potential of seaweed as a food ingredient in Aceh is very abundant. However, diversity and community structure of seaweeds on the west coast of Aceh have not been studied much.

Therefore, this study has been carried out to assess the diversity and community structure of seaweeds on the west coast of Aceh based on transect method. Sampling has been carried out in all districts/cities (6 districts and 1 city) of west coast of Aceh. Altogether, a total of 50 species have been identified; of which, maximum number of species belongs to Phaeophyta (21 species) followed by Chlorophyta (16 species) and Rhodophyta (13 species).

The estimated value of diversity (H'), uniformity (E), and dominance (D) index is 1.02, 0.50 and 0.51 respectively. Based on the univariate diversity indices analysis, it has been

found that seaweed on the west coast of Aceh is in the moderate category. Furthermore, the water quality parameters revealed the existence of conducive environmental conditions for the growth and life of seaweed. So, it is proposed that use of appropriate seaweed culture techniques can be carried out on the west coast of Aceh to able to make Aceh a seaweed center in Indonesia.

Keywords: Community structure, diversity, Indonesia, seaweed, west coast of Aceh
INTRODUCTION Seaweeds are one of the economically and ecologically important of natural resources in marine waters. Seaweeds are gaining considerable importance in recent times due to the fact of their cosmopolitan distribution, renewable nature, and wide range of applications (Barbier et al. 2019). Seaweeds are multicellular algae with a wide geographic distribution. Seaweed are often classified into three major groups based on color or pigmentation viz., Phaeophyta (brown algae), Rhodophyta (red algae), and Chlorophyta (green algae) (Messyasz et al. 2015; Belghit et al. 2017; Cermeño et al. 2020).

In general, the morphology of brown seaweed can be distinguished based on its thallus, which has a holdfast, stipe, and blade (Baweja et al. 2016). A total of 291 seaweed species are commercially used worldwide across 43 countries (Tiwari et al. 2015). Seaweeds are directly consumed in Asia, in parts of South America and in the Pacific Islands (Butcher et al. 2020), and there is increasing interest in their role in supporting human health as nutraceuticals or functional foods (Wells et al. 2017; Shannon and Abu-Ghannam 2019). However, about 99% of farmed seaweed is used for the production of thickening and gelling agents for the pharmaceutical and food industries (Buschmann et al. 2017).

The benefits of seaweed in various fields provide opportunities for the maximum utilization and development of seaweed potential, especially in Indonesian waters, and can even be an opportunity for the export market. Indonesia with 64,00,000 km2 of ocean area and 1,10,000 km of coastline length, and supported by a tropical climate, is a suitable area for the growth of various types of seaweed (Waters et al. 2019). In Indonesia seaweed cultivation was commenced as early as 1967 when Soerjodinoto and Hariadi Adnan undertook planting trials at Thousand Islands (van der Heijden et al. 2022).

Currently, Indonesia is a significant contributor to global seaweed production, particularly the red seaweeds Kappaphycus alvarezii and Eucheuma denticulatum, which are used to produce carrageenan, and Gracilaria species, which are used to produce agar (Rimmer et al. 2021). Indonesia is the second seaweed-producing country in the world after China and Indonesia controls the world seaweed market share in 2021 of

12.3% or US$ 345 million (WHO 2022). In Indonesia, seaweed forming is carried out in 15 provinces namely Banten, Central Java, East Java, West Java, West Nusa Tenggara, East Nusa Tenggara, West Sulawesi, Central Sulawesi, South Sulawesi, South East Sulawesi, East Kalimantan, North Kalimantan, North Sulawesi, Gorontalo, Maluku (Rimmer et al. 2021).

In 2019 there was also some small production from Sumatra Island (total 9232 tonnes wet weight), Bali (850 tonnes wet weight) and Papua (Papua and West Papua provinces total 2575 tonnes wet weight), indicating that there is some level of production from all of the major islands in the archipelago (Rimmer et al. 2021). Aceh is one of the provinces in Indonesia with an area of 57,956 km2 with a coastline of 2,817.90 km. The area and length of marine waters in Aceh provides opportunities for the use and development of seaweed. Aceh province has different BIODIVERSITAS 24 (4): 2189-2200, April 2023 2190 coastal characteristics.

For instance, the east coast of Aceh has the characteristics of a muddy beach while the west coast of Aceh has a sandy and craggy substrate. Based on the living habitat of seaweed that commonly grows on sandy and craggy beaches, the west coast of Aceh is more overgrown with seaweed. However, diversity and community structure of seaweeds on west coast of Aceh provinces and its potential for seaweed farming has not been studied.

Furthermore, the assessment of status and trends in macroalgal cover and quality is an emerging priority for ocean and coastal management (D'Arin and Piazzi 2021). In this regard, the present study has been carried to assess the potential and structure of seaweed communities in the waters of the west coast of Aceh. From this research data, it is hoped that it will become a reference for the government to develop seaweed from Aceh Province and can make Aceh one of the provinces that become the center of seaweed in Indonesia.

MATERIALS AND METHODS Study area This research was conducted from July to August 2022 on the west coast of Aceh Province, Indonesia with 6 districts and 1 city. The districts are Aceh Besar, Aceh Jaya, Simeulue, West Aceh, Aceh Singkil, South Aceh, and Banda Aceh City. The research location is shown in Figure 1. Procedures Determination of observation stations Research stations and coordinates for observing seaweed on the west coast of Aceh per district and city are shown in Table 1. Table 1.

Coordinate point of observation of seaweed community structure District/city Village Coordinate point Aceh Besar Layeun 05°20'58.80"N 95°14'24.40"E Lamnga 05°37'05.70"N 95°23'55.40"E Banda Aceh Ulee Lheue 05°33'36.30"N 95°17'07.90"E Aceh

Jaya Ketapang 02°27`08. N 96°13`07. E Crak Mong 02°27`18. N 96°13`20. E Ceunamprong 02°27`28. N 96°13`37. E Simeulue Maudil 02°28`09. N 96°12`27. E Inor 02°28`37. N 96°11`49. E Angkoe 02°30`39. N 96°09`39. E Aceh Barat Lhok Bubon 04°11'51.5"N 96°01'54.5"E Lhok Bubon 0 4°11'53.9"N and 96°01'47.0"E Lhok Bubon 0 4°11'43.5"N and 96°01'37.4"E Aceh Selatan Haloban 03°33'8.21"N 96°59'31.18"E Figure 1. Map showing the study location in Ache Province, Indonesia ERNIATI et al.

Seaweeds on the west coast of Aceh, Indonesia 2191 Sampling techniques Macroalgae groups can be studied by destructive methods through the total erosion of substrates (Piazzi and Ceccherelli 2020), photographic methods related to the determination of the main taxa/morphological group (Piazzi et al. 2019) and visual census techniques (Díez et al. 2012). Data collection is carried out using descriptive research methods, which are based on situations or events determined at a certain time and place to obtain an overview of the local situation and conditions.

Data collection was carried out through the sample survey method by taking a small part of the population with a size of 10 m x 10 m, which can describe the nature of the object of study (Wibowo et al. 2018). As for tidal data obtained by the line transect method, a cruising survey was previously carried out to determine the location. At each sampling, stations are installed with 3 transect lines with a length of 50 m towards the sea, perpendicular to the coastline with a distance between transects of 500 m. The square plot used is 50×50 cm in size with a total of 5 plots on each transect.

The distance between the plots is 10 m, where the first point of laying on the transect starts from the place where seaweed is found on the shoreline. The plot is laid out zigzag on the transect line. The outline of the research transect line and the placement of the plot on the transect is presented in Figure 2. Seaweed identification Seaweed samples found at all observation sites were identified by observing the morphology present in each macroalgae sample and adjusted to the identification book of the Al-Yamani et al. (2014), and Coppejans et al. 2017.

Data analysis Analysis of community structure The structure of the seaweed community is calculated from the density, diversity index, uniformity and dominance index of the Shannon-Weanner formula. The formula used for density uses formula (i), formula diversity index (ii), formula uniformity index (iii) and dominance index (iv). Where Ni is the wet weight of the species in grams, A area of observation area and N the total wet weight of the entire seaweed. Figure 2.

Overview of laying transects and plots at 1 research station (i) (ii) (iii) (iv) RESULTS AND DISCUSSION Diversity of seaweed Based on the results, there were 50 species of

seaweed found in 6 districts and 1 city of Aceh Province, consisting of 3 classes (Table 2). Maximum number of species were identified from Phaeophyta (17 species; 34%) and Rhodophyta (17 species; 34%) followed by Chlorophyta (16 species; 32%) (Figure 3). The types of seaweeds identified on the west coast of Aceh Province are presented in Figure 4, 5, 6. Density of seaweed The density of seaweed per district and city on the West Coast of Aceh is presented in Figure 7.

There is a significant variation in the density of seaweed species in 6 districts and 1 city in Aceh Province in each region, as presented in Tables 3, 4, 5. Index of diversity, uniformity, dominance The value of the diversity index (H'), uniformity (E), and dominance (D) of the research results can be seen in Table 6. Dendrograms were made to determine the similarity grouping of ecological indices of seaweed observed on the west coast of Aceh (Figure 8).

Water quality parameters The results average of the parameters of water quality where seaweed lives per district/city are shown in Table 7. Figure 3. Percentage of Chlorophyceae, Phaeophyceae and Rhodophyceae at West coast of Aceh, Indonesia BIODIVERSITAS 24 (4): 2189-2200, April 2023 2192 Table 2. Diversity of seaweed on the west coast of Aceh, Indonesia Class Chlorophyta Rhodophyta Phaeophyta Avrainvillea amadelpha Acanthophora spicifera Dictyota ceylanica Boergesenia forbesii Amphiroa fragilissima Dictyota fasciola Bryocladia thwaitesii Dermonema virens Padina antillarum Bryopsis plumosa Ellisolandia elongate Padina australis Caulerpa lentillifera Eucheuma spinosum Padina minor Caulerpa racemose Galaxaura rugosa Sargassum binderi Caulerpa sertularioides Gelidiella acerosa Sargassum crassifolium Chaetomorpha antennina Gracilaria coronofipolia Sargassum duplicatum Chaetomorpha linum Gracilaria sanicornia Sargassum fluitan Cladophora sericea Gracilaria verrucosa Sargassum granuliferum Halimeda discoidea Gracilaria Corticata Sargassum ilicifolium Halimeda macroba Hypnea cornuta Sargassum linearifolium Halimeda opuntia Hypnea musciformis Sargassum muticum Ulva intestinalis Hypnea pannosa Sargassum polycystum Ulva rotundata Jania adhaerens Sargassum vulgare Valoniopsis pachynema Kappaphycus striatum Turbinaria decurrens Pterocholla capillacea Turbinaria ornata Figure 5 . Red seaweeds of Aceh Provinces, Indonesia: A. Acanthophora spicifera; B. Amphiroa fragilissima; C. Dermonema virens; D. Ellisolandia elongate; E. Eucheuma spinosum; F.

Galaxaura rugosa; G. Gelidiella acerosa; H. Gracilaria coronofipolia; I. Gracilaria sanicornia; J. Gracilaria verrucosa; K. Gracilaria Corticata; L. Hypnea cornuta; M. Hypnea musciformis; N. Hypnea pannosa; O. Jania adhaerens, P. Kappaphycus striatum; Q. Pterocholla capillacea A B C D E F G N K L M J H I O P Q ERNIATI et al. Seaweeds on the west coast of Aceh, Indonesia 2193 Figure 4. Green seaweeds of Aceh Provinces,

Indonesia: A. Avrainvillea amadelpha; B. Boergesenia forbesii; C. Bryocladia thwaitesii; D. Bryopsis plumosa; E. Caulerpa lentillifera; F. Caulerpa racemosa; G. Caulerpa sertularioides; H. Chaetomorpha antennina; I. Chaetomorpha linum; J. Halimeda discoidea; K. Halimeda macroba; L.

Halimeda opuntia; M. Ulva intestinalis; N. Ulva rotundata; O. Valoniopsis pachynema. Table 3. The density (ind/m2) of Green Seaweed (Chlorophyta) Types of seaweed 1 2 3 4 5 6 7 Total Avrainvillea amadelpha 105 105 Boergesenia forbesii 0.09 4.92 5.01 Bryocladia thwaitesii 0.25 0.25 Bryopsis plumosa 18.55 18.55 Caulerpa lentillifera 86.8 10.95 97.75 Caulerpa racemose 33.77 33.77 Caulerpa sertularioides 3.66 1.51 5.17 Chaetomorpha antennina 0.26 3.4 0.28 3.94 Chaetomorpha linum 0.04 3.67 0.87 4.58 Cladophora sericea 1.97 1.97 Halimeda discoidea 0.05 3.2 5.09 8.34 Halimeda macroba 5.71 5.71 Halimeda opuntia 30.09 17.29 712 17.66 9.6 2659.47 3446.11 Ulva intestinalis 0.51 0.51 Ulva rotundata 14.60 14.60 Valoniopsis pachynema 13.6 54.59 68.19 Total 30.09 33.65 23.52 924 78.73 69.98 2659.47 3819.44 Note: 1. Aceh Besar, 2. Banda Aceh, 3. Aceh Jaya, 4. Siemeulue, 5. Aceh Barat, 6. Aceh Selatan, 7.

Aceh Singkil A B C D E F G H I J K L M N O BIODIVERSITAS 24 (4): 2189-2200, April 2023 2194 Table 4. The density (ind/m2) of Red Seaweed (Rhodophyta) Types of seaweed 1 2 3 4 5 6 7 Total Acanthophora spicifera 0.03 1.68 5.41 6.8 221.07 234.99 Amphiroa fragilissima 0.69 0.69 Dermonema virens 1.31 1.31 Ellisolandia elongate 0.85 0.85 Eucheuma spinosum 351.20 351.20 Galaxaura rugose 0.23 0.09 0.32 Gelidiella acerosa 41.2 0.1 41.30 Gracilaria coronofipolia 3.25 3.25 Gracilaria sanicornia 1.14 30.5 4.91 85.07 121.61 Gracilaria verrucosa 33.1 33.10 Gracilaria Corticata 0.57 0.57 Hypnea cornuta 0.61 0.61 Hypnea musciformis 0.22 0.22 Hypnea pannosa 2.76 1.79 1.38 5.93 Jania adhaerens 330.13 330.13 Kappaphycus striatum 0.05 0.26 0.31 Pterocholla capillacea 3.7 3.70 Total 34.27 5.15 42.41 48.00 1.79 11.01 987.47 1130.09 Note: 1. Aceh Besar, 2. Banda Aceh, 3. Aceh Jaya, 4. Siemeulue, 5. Aceh Barat, 6. Aceh Selatan, 7. Aceh Singkil Figure 6.

Brown seaweeds of Aceh Provinces, Indonesia: A. Dictyota Ceylanica; B. Dictyota fasciola; C. Padina antillarum; D. Padina australis; E. Padina minor; F. Sargassum binderi; G. Sargassum crassifolium; H. Sargassum duplicatum; I. Sargassum fluitan; J. Sargassum granuliferum; K. Sargassum ilicifolium; L. Sargassum lineariforium; M. Sargassum muticum; N. Sargassum polycystum; O. Sargassum vulgare; P. Turbinaria decurrens; Q. Turbinaria ornata A B C D H K L M N O P E F I G Q J ERNIATI et al. Seaweeds on the west coast of Aceh, Indonesia 2195 Table 5. The density Density (ind/m2) of brown seaweed (Phaeophyta) Types of seaweed 1 2 3 4 5 6 7 Total Dictyota ceylanica 8.4 0.08 0.3 8.78 Dictyota fasciola 2.58 2.58 Padina antillarum 26.8 26.80 Padina australis 0.57 1.31 0.82 0.39 4.18 732.53 739.80 Padina minor 27.2 0.04 27.24 Sargassum binderi 412.2 412.20 Sargassum crassifolium 148.2 148.20 Sargassum duplicatum 21.29 21.29 Sargassum

fluitan 418.2 418.20 Sargassum granuliferum 955.4 955.40 Sargassum ilicifolium 1.09 1.09 Sargassum lineariforium 114.6 114.60 Sargassum muticum 2710.2 2710.20 Sargassum Polycystum 177.01 12.74 189.75 Sargassum vulgare 4.6 4.60 Turbinaria decurrens 0.76 0.76 Turbinaria Ornata 2.6 0.21 2.81 Total 0.57 3.89 1.91 4823.8 182.29 39.31 732.53 5784.291 Note: 1. Aceh Besar, 2. Banda Aceh, 3. Aceh Jaya, 4. Siemeulue, 5. Aceh Barat, 6. Aceh Selatan, 7. Aceh Singkil Table 6.

Diversity, uniformity, dominance index by district/city District / City Station Diversity Category Uniformity Category Dominance Category Aceh Besar 1 0 Low 0 Low 1 High 2 0.24 Low 0.18 Low 0.89 High Banda Aceh 1 1.4 Moderate 0.67 High 0.31 Low Aceh Jaya 1 1.66 Moderate 0.75 High 0.25 Low 2 0.72 Low 0.37 Low 0.67 Moderate 3 0.96 Low 0.49 Moderate 0.56 Moderate Aceh Barat 1 0.59 Low 0.28 Low 0.76 High 2 0.15 Low 0.1 Low 0.94 High 3 1.68 Moderate 0.7 High 0.23 Low Aceh selatan 1 0.87 Low 0.39 Low 0.52 Moderate 2 1.34 Moderate 0.68 High 0.34 Low 3 1.13 Moderate 0.81 High 0.34 Low Simelue 1 1.62 Moderate 0.77 High 0.23 Low 2 1.29 Moderate 0.56 Moderate 0.38 Low 3 1.46 Moderate 0.6 Moderate 0.29 Low Aceh Singkil 1 1.22 Moderate 0.68 High 0.41 Low Table 7. Water quality parameters in all study sites District / City Current (m/s) Temperature (C) pH DO (mg/l) Salinity (Substrate Aceh Besar 0.20±0.08 30.10±1.19 8.20±0.65 9.23±2.11 34.00±0.90 Rocks, sand, coral rubble, muddy sand Banda Aceh 0.19±0.08 32.40±1.19 8.40±0.65 10,20±2.11 33.00±0.90 Rocks, sand, coral rubble, muddy sand Aceh Jaya 0.10±0.08 30.00±1.19 9.80±0.65 8.50±2.11 35.00±0.90 Rocks, stones, sand, shards, sand Aceh Barat 0.11±0.08 31.10±1.19 8.40±0.65 10.60±2.11 34.50±0.90 Rocks, sand, coral rubble, muddy sand Aceh Selatan 0.10±0.08 29.40±1.19 8.30±0.65 10.20±2.11 33.60±0.90 Rocks, sand, coral rubble, slightly muddy sand Simelue 0.32±0.08 28,70±1.19 7.72±0.65 4.68±2.11 32.47±0.90 Rocks, sand, coral rubble, slightly muddy sand Aceh Singkil 0.19±0.08 30.20±1.19 8.20±0.65 7.20±2.11 33.00±0.90 Rocks, sand, coral rubble, slightly muddy sand BIODIVERSITAS 24 (4): 2189-2200, April 2023 2196 Figure 7.

Density of Chlorophyta, Phaeophyta and Rhodophyta at West coast of Aceh (ind/m2) Figure 8. Dendogram of the ecological index on the west coast of Aceh, (1) Aceh Besar, (2) Banda Aceh, (3) Aceh Jaya, (4) Siemeulue, (5) Aceh Barat, (6) Aceh Selatan, (7) Aceh Singkil Discussion Diversity of seaweed Seaweed is a major producer in the aquatic food chain, and a major component of ecosystems because it is considered a natural food biological resource for various organisms (Carina et al. 2021).

Several characteristics of seaweed such as the ability to grow and adapt to extreme conditions make it a potential candidate for various applications such as human food, value-added products, pharmaceutical purposes, and as an energy raw material (Abomohra et al. 2016). Several years ago, seaweed was only used to support the water

cycle and its biomass was used for composting. Aceh's west coast waters have a total of 50 species of seaweed. The number of seaweed species indentified on the west coast of Aceh in the present study is more than Ambon Bay which has 21 species (Litaay 2014), Lampung Bay which has 27 species (Handayani 2017), Awur Bay which has 8 species (Pramesti et al.

2016), and Carita Bay which has 18 species (Kadi 2017). The difference in the number of seaweed species found in several areas indicates that the presence of seaweed is influenced by several factors, such as season, geographical location, regional topography, and bottom substrate. Chemical and physical factors in water affect the distribution and morphological characteristics and growth of seaweeds, such as the maximum growth in a certain month is affected by water temperature, nitrogen concentration, and turbidity (Sfriso and Facca 2013). Ecology, season, and spatial, greatly affect morphology, such as thallus size, vesicle or air bladder, stipe, axis, and holdfast (Camacho et al. 2015; Mattio et al. 2015; Hoang et al. 2016).

Phaeophyta or brown seaweed dominates the waters of the west coast of Aceh with 17 species. Of which, genus Sargassum represents 10 species. In Indonesia, the genus Sargassum represents 58 species; however only 12 have been utilized for commercial purpose. Sargassum polycystum, Sargassum aquifolium, and Sargassum ilicifolium are the most commonly found brown seaweed in Indonesia (Puspita et al. 2020). Since Sargassum species can move from one water to another, it is also treated as an invasive seaweed (Milledge et al. 2016; Sissini et al. 2017; Pinteus et al. 2018). According to Dixon et al.

(2012), Sargassum is a macroalgae with a complex morphology so a combination of morphological and molecular analysis methods can facilitate species identification. This biota has been shown to be able to grow in various water conditions, including on various types of small islands because it is resistant to extreme conditions through modification of the talus to attach firmly to the substrate (Lalegerie et al. 2020). Green algae have a very high abundance in Indonesia, especially Caulerpa sp, Halimeda sp. and Ulva sp. are often exists in high abundance (Puspita et al. 2020). Green algae have the highest chlorophyll content vegetation (Haryatfrehni et al.

2015) and are found living in shallow waters and with fast currents, ranging from freshwater to marine waters. Its life also varies, ranging from colonial, ERNIATI et al. Seaweeds on the west coast of Aceh, Indonesia 2197 filamentous, sheet-shaped, or tube-shaped (Harmoko and Sepriyaningsih 2020). Green seaweed is the second dominant group in the waters of the west coast of Aceh with 16 species. Among the 16 species, Halimeida opuntia has the highest density in the west coast of Aceh. Mayakun

et al. (2012) reported that Halimeda species are often found in tropical waters.

Papila and Arfah (2013) has also reported the second highest biomass of Halimeda sp from eastern Indonesia based on parameters of diversity, density, frequency of presence, and dominance value compared to other genera of green seaweed. However, Halimeda species are not included in seaweed production data of Indonesia Gazali and Zamani (2019) also reported the wide distribution of H. opuntia on the coast of West Aceh. H. opuntia is a type of calcareous seaweed and is classified in the order Briopsidales (Nurhayati et al. 2017). This seaweed is often found in coral reef areas where the beach conditions are calm and somewhat sheltered and lives in colonies.

Seaweeds that have economic value in Indonesia include eucheumatoid seaweeds (genus Eucheuma and Kappaphycus), and the genera Gracilaria, Gelidium, Sargassum, and Turbinaria (Hendri et al. 2020). Most of the red algae live in waters, only less than 2% live in fresh waters. Euchema spinosum is a species of the Rhodophyta class that is commonly found in the waters of the west coast of Aceh. Euchema spinosum mostly grows in tidal areas or areas that are always submerged in water and attached to the substrate at the bottom of the waters.

Euchema spinosum belongs to the class of red algae (Rhodophyceae) in the form of a cylindrical thallus, smooth surface, dark brown green-brown, green-yellow, or red-purple (Diharmia et al. 2011). Structure community Community studies can be carried out functionally and structurally. Functionally, it can be known by looking at the function and position of an organism in the food chain and food pyramid. Structurally, a community can be determined by species diversity, abundance, distribution and dominance (Odum and Barret 1971).

Species diversity describes a comparison that combines the number of species (species richness) and the distribution of the number of individuals among species. Species richness describes what species live in a species community, which can be calculated from the number and variety of species. The high or low value of the diversity index can be caused by several things such as the number of groups or individuals obtained. The diversity index is a good predictor for determining the dominance of an area.

If one or several species are more abundant than the others, the diversity index value will be low. The diversity index (H') on the west coast of Aceh from 6 districts and 1 city is included in the low and medium criteria with an average value of H'=1.02. Diversity 1-3 is included in the moderate category. Wibowo et al. (2018) has stated that the greater the value of the Diversity Index means the more species you get, the value of the Diversity Index is very dependent on the total abundance of individuals of each

species.

Diversity is strongly influenced by internal factors such as competition between species in utilizing space and food as well as external factors that cause environmental disturbances such as water pollution, exploitation of fishery resources or low biological productivity. Maharani et al. (2021) has stated that places that have a stable substrate consisting of coral and rubble have a higher species diversity compared to a less stable substrate consisting of sand or silt. In the sand substrate there are fewer types of macroalgae than coral substrates and coral rubble because sand is a type of substrate that is easily carried away by waves (Ferawati et al. 2014). Nurlela et al.

(2019) has stated thatthe uniformity index is an index of community structure used to determine the balance of an individual's composition. A high uniformity index indicates that the ecosystem is in a stable condition. Population uniformity will be small if the E value is smaller then the distribution of the number of individuals of each type is not the same and there is a tendency for one particular species to dominate in the waters. Wibowo et al. (2018) has stated that the Uniformity Index value shows the level of distribution of individuals for each species.

The greater the value of E, the population shows uniformity in the number of each type of community, which can be said to be the same or not much different. The uniformity index on the west coast of Aceh is 0.50. This shows that E (uniformity) <0.6 which means uniformity on the west coast of Aceh is moderate. Nurlela et al. (2019) has stated that the even and grouped distribution pattern of macroalgae is caused by environmental factors and biological factors of macroalgae. The dominance index indicates that there is very tight competition between members of the seaweed community. The dominance of a species in a community is caused by the uneven number of individuals in each species (Pramesti et al. 2016). Nurlela et al.

(2019) has stated that a dominance index value is also affected by the low and high value of macroalgae species diversity. Based on the results of calculating the average dominance index value on the west coast of Aceh, 0.51, it is included in the medium category, based on the dominance index value of 0.5-0.75, meaning that no species dominates the waters of the west coast of Aceh. Water quality parameters The factors that influencing the community structure of seaweeds are often divided into 3, namely oceanography, topographic and biological.

The oceanography conditions in water include temperature, intensity light, depth, salinity, pH, current, and waves, while topographic factors are basic substrate conditions in the water. Meanwhile, biological factors such as herbivores, as well as the competition

between the types of seaweed influence the structure of the seaweed community. The results of the measurement of temperature parameters in coastal waters in the province of Aceh ranged from 28.70 to 32.40°C with an average value of 30.27°C.

The temperature of the location is still within the normal range that can be tolerated by seaweed (Susanto et al. 2021). Water temperature on the surface is influenced by meteorological conditions such as rainfall, evaporation, air humidity, air temperature, wind speed, and intensity of solar radiation (Sulistiawati et al. 2020). Temperature can affect BIODIVERSITAS 24 (4): 2189-2200, April 2023 2198 photosynthesis in the sea both directly and indirectly. The direct effect is temperature which plays a role in controlling enzymatic reactions in photosynthesis.

High temperatures can increase the maximum rate of photosynthesis, while the indirect effect is in changing the hydrological structure of the water column which can affect the distribution of phytoplankton. Dissolved Oxygen (DO) is a very important parameter because oxygen is needed by aquatic biota both for metabolic and respiration processes. Dissolved oxygen is a limiting factor for all living organisms. Dissolved oxygen is a basic need for the life of living things in water (Sulistiawati et al. 2020). Dissolved oxygen on the west coast of Aceh supports the growth of seaweed with values ranging from 4.68 to 10.60 ppm.

Meanwhile, the high content of dissolved oxygen was caused by high waves and currents which increased the process of entering oxygen from the air. The value of dissolved oxygen in coastal waters in Aceh is still supportive for seaweed growth > 4 ppm (Susanto et al. 2021). Moreover, pH or degree of acidity is one of the chemical parameters of the waters that affect the life and growth of seaweed. According to Asni (2015), seaweed can generally grow in the pH range of 6.5-9.5. Th e m easurement results of pH on the west coast of Aceh show a condition that is ideal for growth seaweed with a value ranging from 7.72 to 9.80.

The 2 types of substrates used as the place life seaweed include soft substrate which covers mud, sand, or a mixture of sand and mud. It also involves a hard substrate, which covers dead corals, live corals, and rocks (Ferawati et al. 2014). Seaweed that grows and lives on the west coast of Aceh is a combination of soft (sand and muddy sand) and hard substrate (rock and coral rubble). Parameters of salinity/salt content also affect the deployment, abundance, and growth of seaweed in coastal waters.

Rumput laut merupakan spesies yang memiliki toleransi yang cukup tinggi namun perubahan salinitas perairan rumput laut yang signifikan dapat menurunkan laju pertumbuhan dan hasil produksi (Susanto et al. 2021). The results of salinity

measurements on the west coast of Aceh ranged from 32.47 to 35 ppt, this indicated that the salinity still supports the life and growth of seaweed. In accordance with the opinion Yuliyana et al. (2015), seaweed will experience slow growth if the salinity is too low (20 ppt) or higher than the corresponding salinity range and a certain time distance.

A wave with or without pressure is relatively strong and causes thallus seaweed damage, some of the species can still survive. Based on the results of current velocity measurements from all research locations, the average value is 0.17 m/s. According to Serdiati and Widiastuti (2010), the movement of water which caused wave surface helps the distribution of elements and other water chemistry physics both physically horizontal and vertical in some regions' waters. Moreover, good current for seaweed growth occurs between 20-40 cm/sec.

In conclusion, based on the study results, it is evident that seaweed diversity on the west coast of Aceh is in moderate condition with highest species diversity in brown seaweed followed by green and red seaweed. The observed water quality parameters revealed the existence of conducive environmental conditions for the growth and life of seaweeds. So, it is proposed that use of appropriate seaweed culture techniques can be carried out on the west coast of Aceh to able to make Aceh a seaweed center in Indonesia.

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