Community structure of seaweeds in dry season in Minahasa Peninsula, North Sulawesi, Indonesia

Rene C. Kepel, Lawrence J. L. Lumingas, John L. Tombokan, Desy M. H. Mantiri

Faculty of Fisheries and Marine Science, Sam Ratulangi University, Manado, North Sulawesi, Indonesia. Corresponding author: R. C. Kepel, renecharleskepel65@gmail.com

Abstract. This present study was conducted to determine the biodiversity and community structure of seaweeds in dry season found along the intertidal zone of Minahasa Peninsula, North Sulawesi Indonesia. The line transect method was used to identify and quantify the seaweeds from the three established stations. Three transects were established for each station, and each transect was divided in ten quadrates. A total of 23 different species of seaweeds were identified in the study area belonging to Rhodophyta (Rhodomelaceae, Lithophyllaceae, Galaxauraceae, Gracilariaceae, Solieriaceae, Cystocloniaceae), Phaeophyta (Dictyotaceae, Scytosiphonaceae, Sargassaceae) and Ulvophyceae (Caulerpaceae, Halimedaceae, Dichotomosiphonaceae, Anadyomenaceae, Siphonocladaceae, Valoniaceae, Dasycladaceae). The most abundant seaweed species across the three stations are: *Hypnea boergesenii, Boergesenia forbesii,* and *Gracilaria edulis.* The seaweed species identified also have different densities ranging from 2.87 to 11.77 ind. per m^2. *G. edulis* had the highest density, and *Avrainvillea erecta, Cladostephus spongiosum, Actinotrichia fragilis* and *Caulerpa racemosa* had the lowest density. Species richness index, diversity index, evenness index and dominance index were calculated to determine the diversity of seaweeds in the study area. Station 2 presented the highest species richness and station 3 presented the lowest species richness. Station 2 recorded the highest diversity and station 3 recorded the lowest diversity. The evenness index had the highest value in station 2, while the lowest value was in station 3. The dominance index had the highest value in station 3, while the lowest value was recorded in station 2. The three sampling stations are divided into 2 groups based on an abundance of 23 seaweed species. The two groups are Group I (Kampung Ambong, Poopoh) and Group II (Tumbak). Apparently, the two station groups are related to the type of sediment and coverage of seagrass.
Key Words: diversity, dominance, evenness, richness, species density.

Introduction. Algae are thallophytes (plants lacking roots, stems, and leaves) that have chlorophyll *a* as their primary photosynthetic pigment and lack a sterile covering of cells around the reproductive cells (Lee 2008). The algae are unicellular or multicellular organisms, which, with the exception of cyanophytes, have cellular organelles surrounded by membranes (Pereira & Neto 2015). Marine algae can be divided broadly into macroalgae and microalgae, according to their physical sizes. Marine macroalgae are commonly known as seaweeds, which commonly include brown, red and green seaweeds, based mainly on their characteristic pigmentation (Qin 2018). Marine macroalgal groups present a large diversity (Stengel & Connan 2015).

Seaweeds, or macroalgae, are aquatic photosynthetic organisms belonging to the domain Eukaryota and the kingdoms Plantae (green and red algae) and Chromista (brown algae) (Pereira 2018). Seaweeds are generally found in the intertidal region and experience diverse chronic stresses, including desiccation, intense irradiance, ultraviolet radiation, salinity and submergence or exposure arising from periodic regular tidal rhythms (Kumar & Ralph 2017). Macroalgae, or seaweeds, grow on seabeds, rocky shores, and other substrates and represent multilayered, perennial vegetation growing photosynthetically (Singh et al 2015). They are characterized by quick growth and a relatively high ability to fix carbon dioxide (Chojnacka et al 2018). The approximately 10000 described marine macroalgal species are segregated by photosynthetic pigment content, carbohydrate food reserve, cell wall components, and flagella construction and orientation (Fleurence & Levine 2016).

Throughout the world, 4000 species of red algae, 14720 species of green algae, and 1500 species of brown algae were recorded (Norton et al 1996). The vast majority (~83%) of the seaweeds harvested and cultured are consumed by humans, either as a direct food source, or as a food additive. In total, at least 291 species are used worldwide in 43 countries. This is an increase with 50 species since 1995 and comprises 33 chlorophytes (from 32 in 1995), 75 phaeophytes (from 64 in 1995), and 163 rhodophytes (from 125 in 1995) (Tiwari & Troy 2015).

In North Sulawesi Province, 15 species of macroalgae were found in Tongkaina waters, Manado (Kepel et al 2018a), 14 species in Blongko waters, South Minahasa (Kepel et al 2018b), 8 species in Bahoi, North Minahasa (Baino et al 2019), 10 species in Kora-Kora waters, Minahasa (Kepel & Mantiri 2019), 45 species in Mantehage Island (Kepel et al 2019a), and 35 species in Minahasa Peninsula, in the rainy season (Kepel et al 2019b). Also, in polluted environmental conditions, *Ulva* sp. (Kepel et al 2018c) and *Halimeda opuntia* (Mantiri et al 2018) were recorded in the waters of Totok Bay and the waters of Blongko. Green macroalgae (*H. opuntia, Halimeda taenicola* and *Ulva prolifera*) (Mantiri et al 2019a) were found in the waters of Totok Bay and *Padina australis* (Mantiri et al 2019b) in the waters of Totok Bay, Manado Bay, Talawaan Bajo and Likupang.

This present study was conducted to determine the species composition, density and diversity of seaweeds found along the intertidal zone of Minahasa Peninsula, North Sulawesi, Indonesia, in the dry season.

Material and Method

Study area. This research was conducted in the dry season, from June to early October 2019. The research locations were in the coastal waters of Kampung Ambong, East Likupang Sub-District, North Minahasa Regency (station 1), coastal waters of Poopoh, Tombariri Sub-District, Minahasa Regency (station 2), and coastal waters of Tumbak, Pusomaen Sub-District, Southeast Minahasa Regency (station 3), North Sulawesi Province, Indonesia (Figure 1). Data collection of seaweeds was carried out in 3 points, namely station 1, station 2, and station 3. In station 1, there was a lower density of seagrass near the coast. Towards the sea, the substrate was rocky. In the station 2, the substrate is mostly rocky. In the station 3, the substrate is mostly muddy and largely covered with seagrass near the coast, while towards the sea there are fringing reefs.

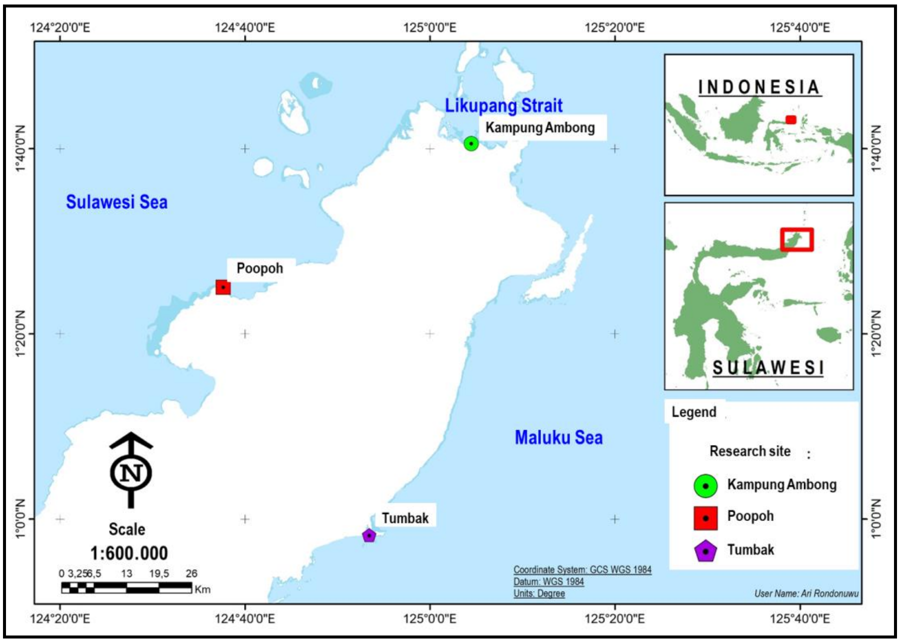

Figure 1. Research locations in Minahasa Peninsula.

Sampling techniques. This research was conducted using the Line Transect method with the quadratic sampling technique (Krebs 1999). The placement of transects in each location for seaweed data collection was carried out in 3 lines of 100 m long transects drawn perpendicular to the coastline with the assumption that the distribution of the community is even. The distance between transects is 5 m and the distance between squares is 10 m. The samples were collected at the lowest ebb, from squares sized 1 m^2.

The first square is placed near the land where the first seaweeds are found and the last square in the last part of the seaweeds. Likewise, the other nine points are determined systematically between the first square and the last predetermined square, randomly, by specifying the transect length then dividing it by the sum of squares. The results are randomized based on the square size that can enter the results of the calculation. Inventory is carried out by a roaming survey method at the specified research locations. Determination of the individual seaweed contained in the square is carried out by counting each stand.

Sample identification. The identification of the samples was carried out using the following materials: Trono & Ganzon-Fortes (1988), Calumpong & Meñez (1997), and Trono (1997).

Species density. Species density is calculated after the following formula (Krebs 1999):

Species Density = number of individuals per species/the area of the sample

Richness index. The richness index (R) is calculated using the following formula (Ludwig & Reynolds 1988):

$R = (S - 1)/\ln(n)$

Where: S is the total number species in a community; n is the total number of individual organisms in a community.

Diversity index. The Shannon Index (H') is calculated using the following formula (Ludwig & Reynolds 1988):

$$H' = -\sum\left(\frac{ni}{N}\right)\ln\sum\left(\frac{ni}{N}\right)$$

Where: ni is the number of individuals of ith species; N is the total number for all S species in the population.

Evenness index. The evenness index (E) is calculated using the following formula (Ludwig & Reynolds 1988):

$$E = \frac{H'}{H' \max}$$

Where: H' is the evenness index; H' max is the maximum value.

Dominance index. The dominance index is calculated using the following formula (Odum 1971):

$$D = \sum\left(\frac{ni}{N}\right)^2 = \sum Pi^2$$

Where: D is the dominance index; ni is the number of individuals of ith species; N is the total number for all species; Pi is ni/N.

Correspondence analysis. The correspondence analysis (CA) provides a geometric presentation in which the studied variable is mapped into points in the cross axis. This CA is suitable for analyzing variables and observations that have been presented in the form of contingency tables or matrices (Lebart et al 1982). The CA application in this study aims to provide the best presentation simultaneously between species groups (i rows) and station groups (j columns), to get the correct correspondence or relationship between the two variables studied (species and stations). The notation used is:

$k = \sum\sum k_{ij}$ = effective total individuals (total amount)

$f_{ij} = k_{ij}/k$ = relative frequency

$f_{i.} = \sum f_{ij}$ = relative marginal frequency

$f_{j.} = \sum f_{ij}$ = relative marginal frequency

In this case, the distance between 2 species, i and i', is given by the formula (distance $\chi 2$):

$$d^2(i, i') = \sum_{j=1}^{p} \frac{1}{f_{.j}} \left(f_{ij}/f_{i.} - f_{i'j}/f_{i'.}\right)^2$$

In the same way, the distance between 2 stations, j and j', is given by the formula:

$$d^2(j, j') = \sum_{i=1}^{n} \frac{1}{f_{i.}} \left(f_{ij}/f_{.j} - f_{ij'}/f_{.j'}\right)^2$$

According to Lebart et al (1982), this weighted distance has the advantage of meeting the principle of "equivalence distribution". Another advantage of using distance $\chi 2$ in CA is that variable and observation roles are symmetrical and are not affected by the presence of double absences on distance stability.

Two series of coefficients for each element of the two corresponding groups are calculated to interpret certain axes in the CA. This data display in the two-way contingency table through CA is done using the STATGRAPHICS Centurion packaging program through the Correspondence Analysis menu selection.

Results and Discussion

Species composition. There were 23 species of seaweeds identified from 16 families belonging to Rhodophyceae, Phaeophyceae, and Ulvophyceae (Table 1).

Density parameter and number of species. The density of seaweeds found along the intertidal zone of station 1 is presented in Figure 2. In station 1, there were 10 species having a density from 0.03 to 3.10 ind./m² with an average density of 0.98 ind./m². The highest density was observed for *Hypnea boergesenii* (3.10 ind./m²), while the lowest density was observed for *Cladostephus spongiosum* (0.03 ind./m²). Kepel et al (2019b) observed in the same station during the rainy season a density of 0.03-23.77 ind./m², with an average density of 3.92 ind./m², with the highest density for *Amphiroa fragilissima* (23.77 ind./m²), and the lowest density for *Hydroclathrus clathratus* (0.03 ind./m²).

The number of seaweeds in this research is reduced by 10 species in the dry season. 25 species were identified in the same station in the rainy season (Kepel et al 2019b). Species of *C. spongiosum* appeared in station 1 in the dry season.

Table 1

Summary of identified seaweeds species

No	Class	Order	Family	Species
1	Rhodophyceae	Ceramiales	Rhodomelaceae	*Laurencia papillosa*
2		Corallinales	Lithophyllaceae	*Amphiroa fragilissima*
3		Nemaliales	Galaxauraceae	*Galaxaura rugosa*
4				*Actinotrichia fragilis*
5		Gracilariales	Gracilariaceae	*Glacilaria edulis*
6				*Glacilaria salicornia*
7				*Glacilaria textorii*
8				*Ceratodictyon spongiosum*
9		Gigartinales	Solieriaceae	*Kappaphycus alvarezii*
10			Cystocloniaceae	*Hypnea boergesenii*
11	Phaeophyceae	Dictyotales	Dictyotaceae	*Padina australis*
12		Ectocarpales	Scytosiphonaceae	*Hydroclathrus clathratus*
13		Fucales	Sargassaceae	*Turbinaria ornata*
14	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa racemosa*
15			Halimedaceae	*Halimeda macroloba*
16				*Halimeda opuntia*
17			Dichotomosiphonaceae	*Avrainvillea erecta*
18		Cladophorales	Anadyomenaceae	*Anadyomene wrightii*
19		Siphonocladales	Siphonocladaceae	*Boergesenia forbesii*
20				*Boodlea composita*
21			Valoniaceae	*Dictyosphaeria cavernosa*
22		Dasycladales	Dasycladaceae	*Bornetella oligospora*
23				*Bornetella sphaerica*

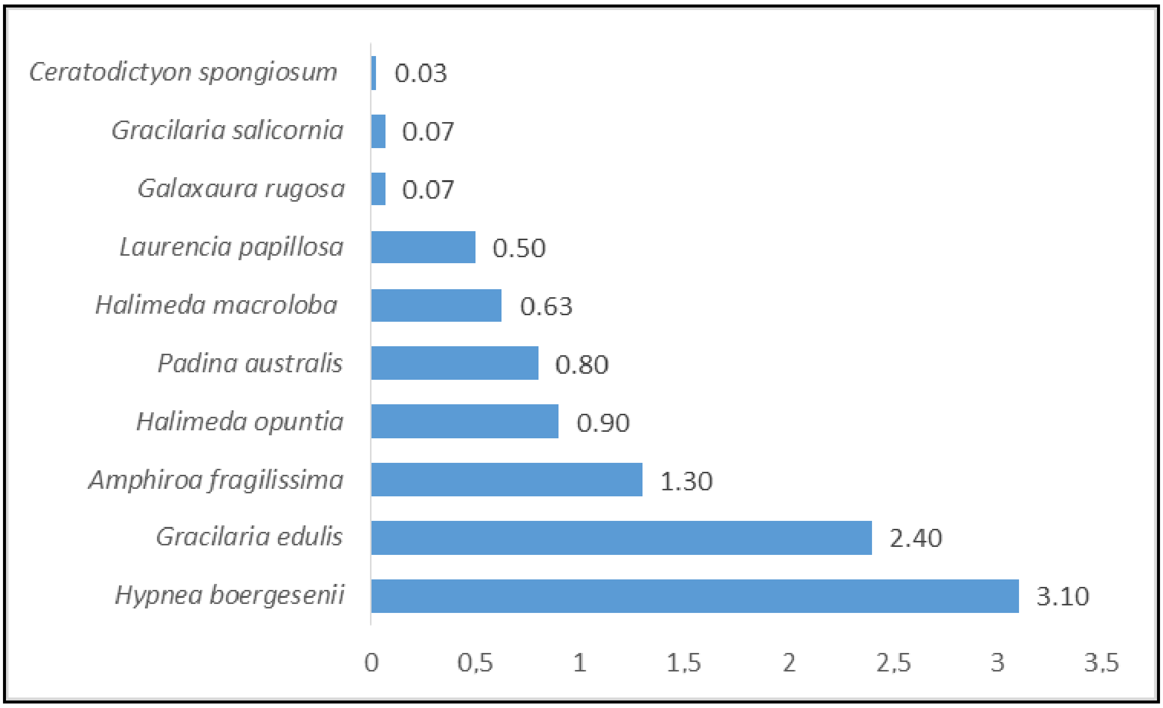

Figure 2. Density of seaweeds (ind./m²) in station 1.

In station 2, there were 16 species, with a density of 0.03-2.87 ind./m² and an average density of 0.83 ind./m². *Boergesenia forbesii* had the highest density of 2.87 ind./m².

Avrainvillea erecta and *Actinotrichia fragilis* had the lowest densities, of 0.03 ind./m² (Figure 3). In the same station in the rainy season, the densities were 0.07-19.90 ind./m² with an average density of 3.05 ind./m². The highest density was for *Gracilaria edulis* (19.90 ind./m²), while the lowest density was for *Kappaphycus alvarezii* (0.07 ind./m²) (Kepel et al 2019b).

The number of seaweeds in the dry season in this research is reduced by 16 species, compared to that from the research of Kepel et al (2019b) from the same station in the rainy season (26 species). Species of *A. erecta, C. spongiosum* and *Anadyomene wrightii* appeared in station 2 in the dry season.

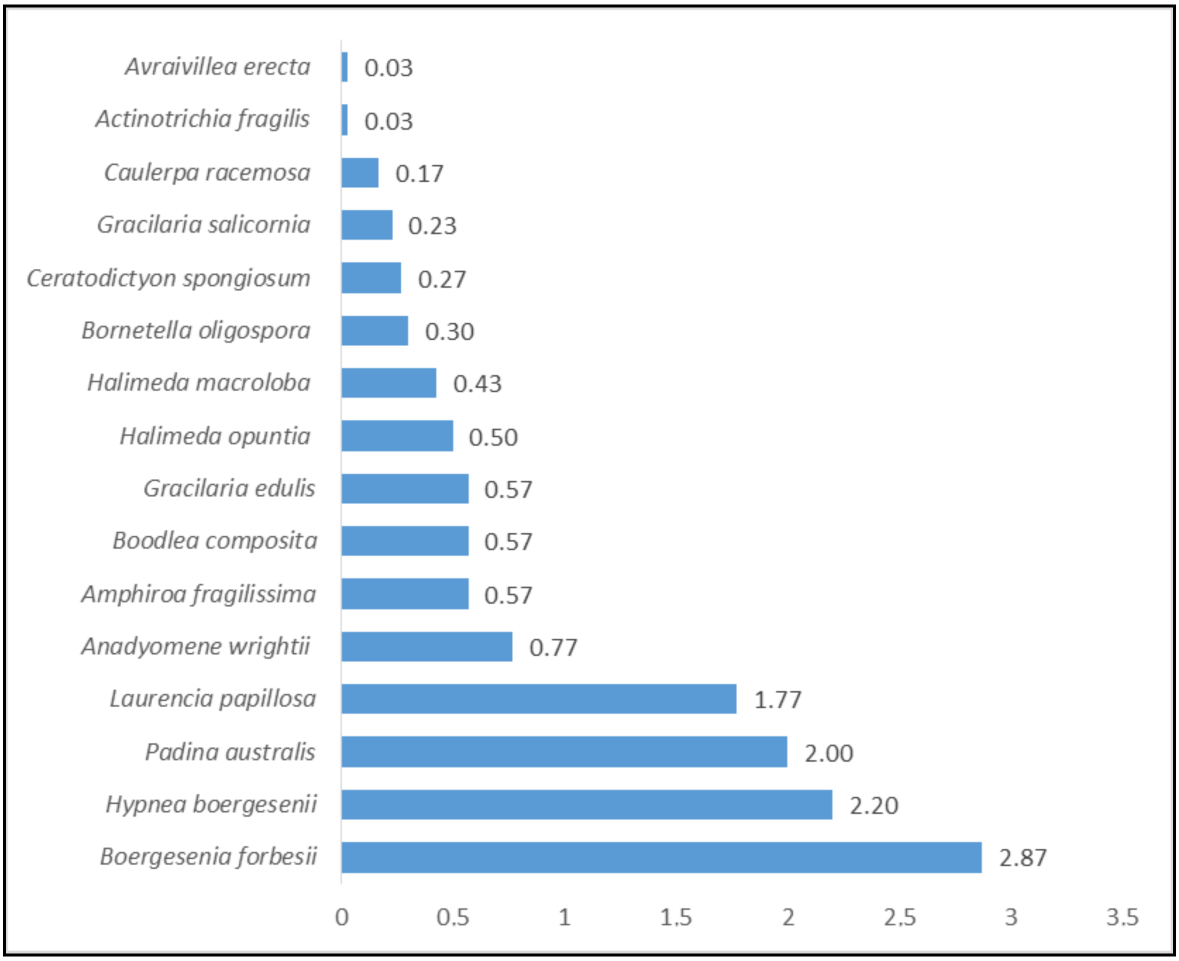

Figure 3. Density of seaweeds (ind./m²) in station 2.

There were 17 species in station 3, with densities from 0.03 to 11.37 ind./m² with an average density of 1.54 ind./m². *G. edulis* has the highest density (11.77 ind./m²). The lowest density was presented by *C. racemosa* (0.03 ind./m²) (Figure 4). In the same station in the rainy season, a density of 0.07-11.37 ind./m² with an average density of 2.90 ind./m² was recorded. *Bornetella sphaerica* had the highest density (11.37 ind./m²). The lowest density was recorded for *Amphiroa rigida* (0.07 ind./ m²) (Kepel et al 2019b).

The number of seaweeds in this research in the dry season is reduced by 17 species, compared to the one from the rainy season (26 species), in the same station (Kepel et al 2019b). Species of *C. spongiosum, Hydroclathrus clathratus, A. fragilissima, H. boergesenii* and *Laurencia papillosa* appeared in station 3 in the dry season.

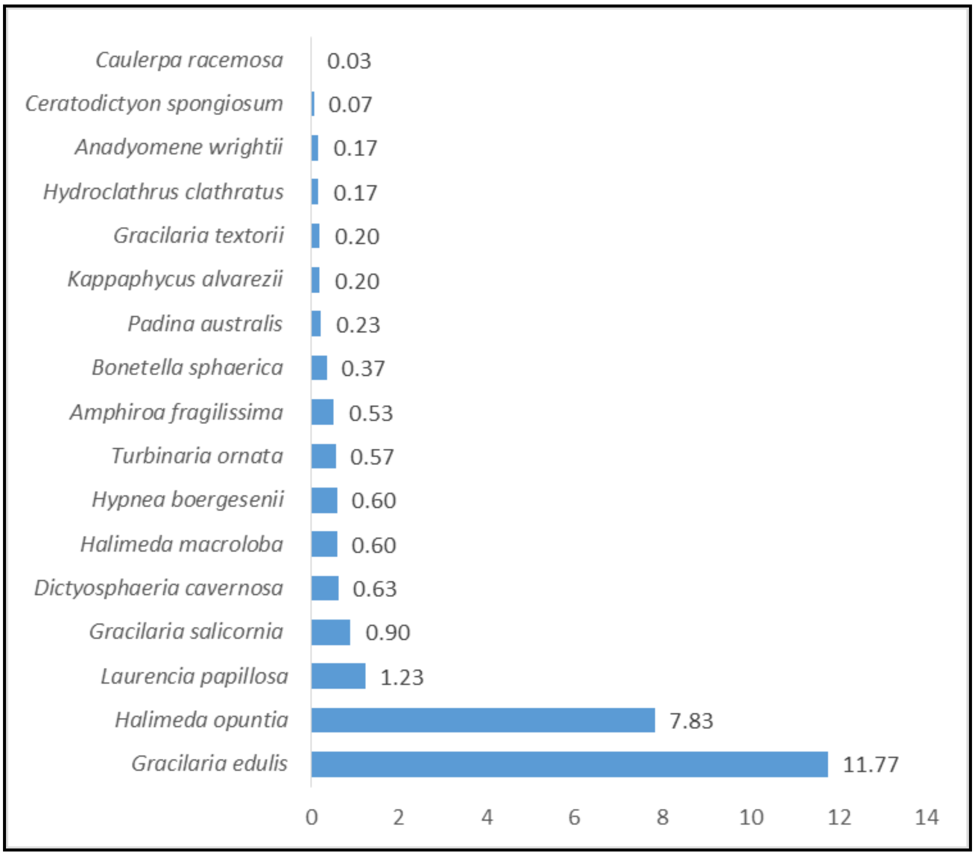

Figure 4. Density of seaweeds (ind./m²) in station 3.

Richness index, diversity index, evenness index, dominance index. The values of the richness index (R), diversity index (H´), evenness index (E), and dominance index (D) are presented in Table 2.

Table 2

Value of seaweeds community indices

Station	*D*	*H´*	*E*	*R*
1	0.211	1.816	0.789	1.583
2	0.170	2.299	0.829	2.493
3	0.362	1.808	0.638	2.319

Note: R - the richness index; H ′ - the diversity index; E - evenness index; D - the dominance index.

Based on the results in Table 2, it appears that the highest species richness index value was in station 2 (2.493) and then in station 3 (2.319). The lowest value was in station 1 (1.583). The values are lower than the ones in the rainy season, with values between 2.615 and 3.214 (Kepel et al 2019b). Thus, the richness index value in the dry season indicates low to moderate species richness.

The highest diversity value was 2.299, in station 2. Station 1 followed with 1.816, while the lowest value was found in station 3 (1.808). There are differences between the diversity index values from the rainy season (2.242-2.621) and the dry season (1.808-2.299) (Kepel et al 2019b). Thus, the diversity index value in the dry season indicates a moderate diversity.

The evenness index value was highest in station 2 (0.829), followed by station 1 (0.789), while the lowest was in station 3 (0.638). There are small differences for the evenness index value from the rainy season (0.696-0.805) compared with the ones from the dry season (Kepel et al 2019b). Thus, the evenness index value in the dry season indicates moderate to high homogeinity and pattern of species distribution.

The dominance index value was the highest in station 3 (0.362), then in station 1 (0.211). The lowest value was in station 2 (0.170). There are differences between the dominance index values from the rainy season (0.107-0.154) and the dry season (Kepel et al 2019b). Thus, the dominance index value in the dry season indicates a low species dominance.

Apparently, the influence of seasons (rainy and dry) is important to the number of species, abundance, richness, diversity, eveness, and dominance of species. The influence of a long dry season (a few months) resulted in a change of the macroalgae community structure.

Correspondence analysis. CA is carried out based on the abundance data in a two-way contingency tables, namely 23 rows of species and 3 station columns. In this analysis, the total inertias obtained for the 2 axes were 0.5333 (80.4%), 0.1304 (19.6%), with a total of 100% (Table 3).

Table 3

Inertia and chi-square decomposition

Dimension	*Singular Value*	*Inertia*	*Chi-Square*	*%*	*Cumulative Percentage*
1	0.7303	0.5333	904.4664	80.3534	80.3534
2	0.3611	0.1304	221.1436	19.6466	100.0000
TOTAL		0.6637	1125.610		

Figure 5 is a dendrogram that classifies seaweed species and Figure 6 is a dendrogram that classifies the species from the three sampling stations into 2 groups based on an abundance of 23 species. The two groups are Group I (Kampung Ambong, Poopoh), and Group II (Tumbak). Apparently, the two station groups are related to the type of sediment and coverage of seagrass. Grouping by species and station in this study (the dry season) is the same as the grouping found by Kepel et al (2019b) in the rainy season.

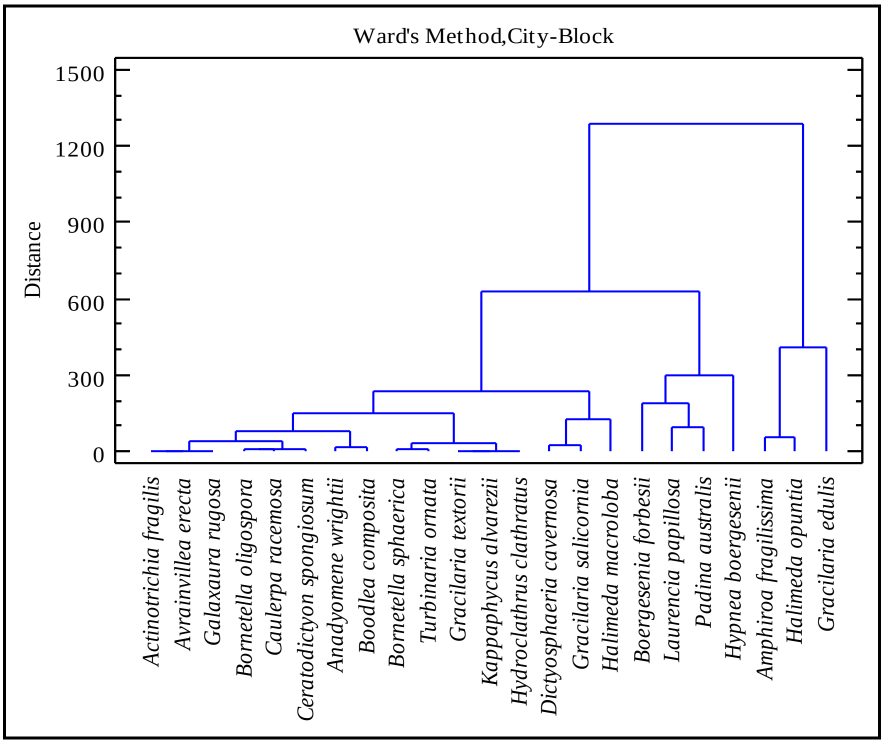

Figure 5. Cluster analysis dendrogram (seaweeds).

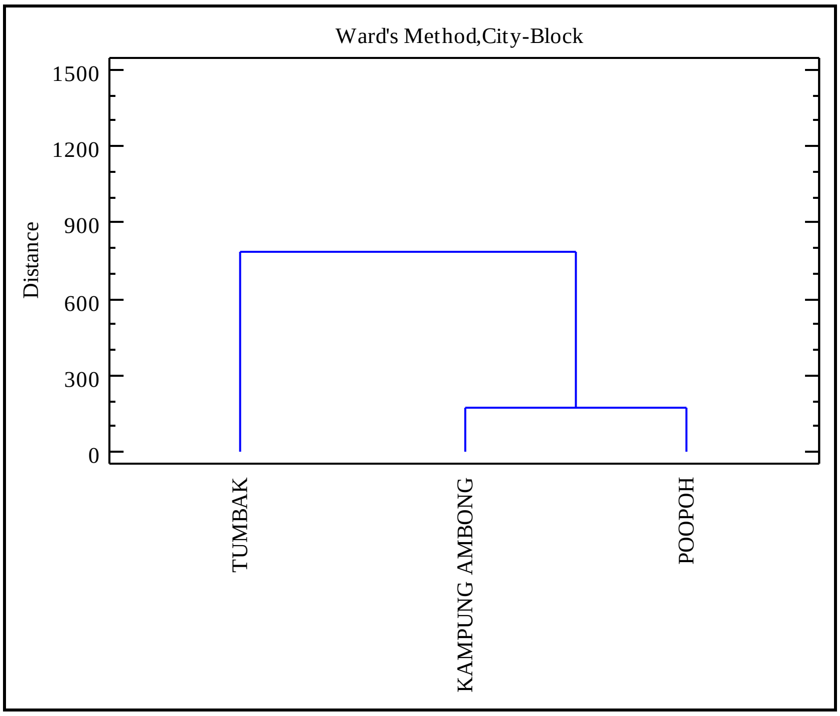

Figure 6. Cluster analysis dendrogram (stations).

Overall, seaweeds are grouped in 2 station groups, namely group I, consisting of station 1 and station 2 (Kampung Ambong, Poopoh) with rocky substrate, and group II consisting of station 3 (Tumbak), with mostly muddy substrate (Figure 7).

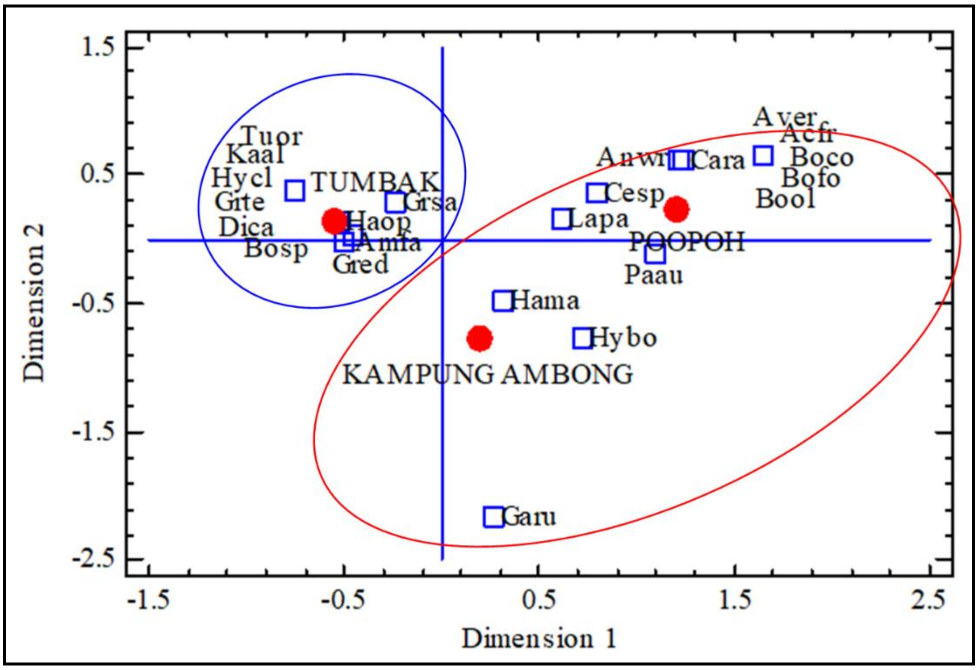

Figure 7. Correspondent map. Acfr (*Actinotrichia fragilis*), Amfa (*Amphiroa fragilissima*), Anwr (*Anadyomene wrightii*), Aver (*Avrainvillea erecta*), Bofo (*Boergesenia forbesii*), Boco (*Boodlea composita*), Bool (*Bornetella oligospora*), Bosp (*Bornetella sphaerica*), Cara (*Caulerpa racemosa*), Cesp (*Ceratodictyon spongiosum*), Dica (*Dictyosphaeria cavernosa*), Garu (*Galaxaura rugosa*), Gred (*Gracilaria edulis*), Grsa (*Gracilaria salicornia*), Grte (*Gracilaria textorii*), Hama (*Halimeda macroloba*), Haop (*Halimeda opuntia*), Hycl (*Hydroclathrus clathratus*), Hybo (*Hypnea boergesenii*), Kaal (*Kappaphycus alvarezii*), Lapa (*Laurencia papillosa*), Paau (*Padina australis*), Tuor (*Turbinaria ornata*).

Group I is represented by the seaweeds that inhabit station 1 and station 2, with rocky substrate, consisting of 13 species: *Galaxaura rugosa, Halimeda macroloba, Hypnea boergesenii, Laurencia papillosa, Padina australis, Anadyomene wrightii, Ceratodictyon spongiosum, Caulerpa racemosa, Avrainvillea erecta, Actinotrichia fragilis, Boodlea composita, Boergesenia forbesii, Bornetella oligospora.*

Group II is represented by the seaweeds inhabiting station 3, with muddy sand substrate, consisting of 10 species: *Bornetella sphaerica, Dictyosphaeria cavernosa, Gracilaria textorii, Hydroclathrus clathratus, Kappaphycus alvarezii, Gracilaria salicornia, Halimeda opuntia, Amphiroa fragilissima, Gracilaria edulis, Turbinaria ornata.*

Conclusions. The results of the seaweed inventory in the dry season in the coastal waters of Minahasa Peninsula, Indonesia, totaled 23 species. The seaweed community structure shows that the values of diversity, evenness and species richness are lower than in the rainy season, while the value of dominance is higher than in the rainy season. The highest density found in the 3 stations was for *G. edulis*, while the lowest densities were observed in the case of *A. erecta, C. spongiosum, A. fragilis* and *C. racemosa.* Overall, seaweeds are grouped into 2 station groups, group I consisting of station 1 and 2 with rocky substrate, and group II consisting of station 3 with mostly muddy substrate.

Acknowledgements. This research was supported by Sam Ratulangi University, The Ministry of Research, Technology and High Education, The Republic of Indonesia - year 2019.

References

Baino I., Kepel R. C., Manu G. D., 2019 [Biodiversity of macroalgae in coastal waters of Bahoi, West Likupang Sub-District, North Minahasa Regency]. Jurnal Ilmiah Platax 7(1):134-141. [In Indonesian].

Calumpong H. P., Meñez E. G., 1997 Field guide to the common mangroves: seagrasses and algae of the Philippines. Bookmark, Inc, Makati City, Philippines, 197 p.

Chojnacka K., Wieczorek P. P., Schroeder G., Michalak I., 2018 Algae biomass: characteristics and applications. Springer, Berlin, 146 p.

Fleurence J., Levine I., 2016 Seaweed in health and disease prevention. Academic Press, Cambridge, Massachusetts, USA, 476 p.

Kepel R. C., Lumingas L. J. L., Tombokan J. L., Mantiri D. M. H., 2019b Biodiversity and community structure of seaweeds in Minahasa Peninsula, North Sulawesi, Indonesia, North Sulawesi, Indonesia. AACL Bioflux 12(3):880-892.

Kepel R. C., Lumingas L. J. L., Watung P. M. M., Mantiri D. M. H., 2019a Community structure of seaweeds along the intertidal zone of Mantehage Island, North Sulawesi, Indonesia. AACL Bioflux 12(1):87-101.

Kepel R. C., Mantiri D. M. H., 2019 [Biodiversity of macroalgae in coastal waters of Kora-Kora, East Lembean Sub-District, Minahasa Regency]. Jurnal Ilmiah Platax 7(2):49-59. [In Indonesian].

Kepel R. C., Mantiri D. M. H., Nasprianto, 2018a [Biodiversity of macroalgae in coastal waters of Tongkaina, Manado City]. Jurnal Ilmiah Platax 6(1):160-173. [In Indonesian].

Kepel R. C., Mantiri D. M. H., Paransa D. S. J., Paulus J. J. H., Nasprianto, Wagey B.T., 2018c Arsenic content, cell structure, and pigment of *Ulva* sp. from Totok Bay and Blongko waters, North Sulawesi, Indonesia. AACL Bioflux 11(3):765-772.

Kepel R. C., Mantiri D. M. H., Rumengan A., Nasprianto, 2018b [Biodiversity of macroalgae in coastal waters of Blongko, Sinonsayang Sub-District, South Minahasa Regency]. Jurnal Ilmiah Platax 6(1):174-187. [In Indonesian].

Krebs C. J., 1999 Ecological methodology, Second Edition. Addison Wesley Longman Inc., New York, 620 p.

Kumar M., Ralph P. 2017 Systems biology of marine ecosystems. Springer, Berlin, 355 p.

Lebart L., Morineau A., Fénelon J. P., 1982 [Processing of statistical data. Methods and Programs]. Dunod, Paris, 510 p. [In French].

Lee R. E., 2008 Phycology. Fourth Edition. Cambridge University Press, 547 p.
Ludwig J. A., Reynolds J. F., 1988 Statistical ecology: a primer on methods and computing. A Willey Interscience Publication, New York, 337 p.
Mantiri D. M. H., Kepel R. C., Manoppo H., Paulus J. J. H., Paransa D. S., Nasprianto, 2019b Metals in seawater, sediment and *Padina australis* (Hauck, 1887) algae in the waters of North Sulawesi. AACL Bioflux 12(3):840-850.
Mantiri D. M. H., Kepel R. C., Rumengan A. P., Kase A. O., 2019a Analysis of antioxidant and chlorophyll in green algae from Totok bay and Tongkaina waters, North Sulawesi. Ecology, Environment & Conservation 25(August Suppl. Issue):135-140.
Mantiri D. M. H., Kepel R. C., Wagey B. T., Nasprianto, 2018 Heavy metal content, cell structure, and pigment of *Halimeda opuntia* (Linnaeus) J.V. Lamouroux from Totok Bay and Blongko waters, North Sulawesi, Indonesia. Ecology, Environment & Conservation 24(3):1076-1084.
Norton T. A., Melkonian M., Andersen R. A., 1996 Algal biodiversity. Phycologia 35:308-326.
Odum E. P., 1971 Fundamentals of ecology. Third Edition. W. B. Saunders Co, Philadelphia, 574 p.
Pereira L., 2018 Therapeutic and nutritional uses of algae. CRC Press, Boca Raton, Florida, USA, 673 p.
Pereira L., Neto J. M., 2015 Marine algae: biodiversity, taxonomy, environmental assessment, and biotechnology. CRC Press, Boca Raton, Florida, USA, 390 p.
Qin Y., 2018 Bio-active seaweeds for food applications: natural ingredients for healthy diets. Academic Press, Cambridge, Massachusetts, USA, 322 p.
Singh B., Bauddh K., Bux F., 2015 Algae and environmental sustainability. Springer, Berlin, 194 p.
Stengel D. B., Connan S., 2015 Natural products from marine algae: methods and protocols. Humana Press, Totowa, New Jersey, USA, 440 p.
Tiwari B. K., Troy D. J., 2015 Seaweed sustainability: food and non-food applications. Academic Press, Cambridge, Massachusetts, USA, 470 p.
Trono G. C., 1997 Field guide and atlas of the seaweed resources of the Philippines. Bookmarks Inc, Makati City, Philippines, 306 p.
Trono G. C., Ganzon-Fortes E. T., 1988 Philippine seaweeds. National Book Store Inc., Metropolitan Manila, Philippines, 330 p.

Received: 15 October 2019. Accepted: 19 November 2019. Published online: 21 February 2020.
Authors:
Rene Charles Kepel, Sam Ratulangi University, Faculty of Fisheries and Marine Science Unsrat, Indonesia, North Sulawesi, Manado 95115, Jln. Kampus Unsrat Bahu, e-mail: renecharleskepel65@gmail.com
Lawrence Janneman Lucky Lumingas, Sam Ratulangi University, Faculty of Fisheries and Marine Science Unsrat, Indonesia, North Sulawesi, Manado 95115, Jln. Kampus Unsrat Bahu, e-mail: ljllumingas@yahoo.com
John Leonard Tombokan, Sam Ratulangi University, Faculty of Fisheries and Marine Science Unsrat, Indonesia, North Sulawesi, Manado 95115, Jln. Kampus Unsrat Bahu, e-mail: leonardtombokan@yahoo.com
Desy Maria Helena Mantiri, Sam Ratulangi University, Faculty of Fisheries and Marine Science Unsrat, Indonesia, North Sulawesi, Manado 95115, Jln. Kampus Unsrat Bahu, e-mail: desy_mantiri@yahoo.com
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
How to cite this article:
Kepel R. C., Lumingas L. J. L., Tombokan J. L., Mantiri D. M. H., 2020 Community structure of seaweeds in dry season in Minahasa Peninsula, North Sulawesi, Indonesia. AACL Bioflux 13(1):392-402.