JURNAL PERIKANAN DAN KELAUTAN
Volume 28 No. 2, June 2023: 134-142

e-issn : 2721-8902
p-issn : 0853-7607

Seaweed Diversity in the Waters of Pantai Tanjung Api Paloh West Kalimantan

Keanekaragaman Jenis Rumput Laut di Perairan Pantai Tanjung Api Kecamatan Paloh Kalimantan Barat

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Received
17 January 2023

Accepted
1 May 2023

Abstract

Paloh, one of West Kalimantan's conservation areas, has a high biodiversity of marine resources, including seaweed. Seaweed has an important ecological role, such as increasing primary productivity, providing dissolved oxygen, as a food source, and as a habitat for several aquatic organisms. In addition, seaweed contains various bioactive compounds that have the potential to be used in various industrial fields. This research aimed to identify the variety of seaweed in the waters of Pantai Tanjung Api, Paloh District, Sambas Regency, West Kalimantan. Based on the abundance of seaweed, the sampling site was chosen. A quadratic transect measuring 10x10 m^2 was used for the collection. Four seaweed genera were discovered, including *Acetabularia*, *Ulva*, *Padina*, and *Sargassum*. *Ulvophyceae* and *Phaeophyceae* had the same percentage contribution. The species abundance varied between 1.04-26.75 ind/m^2, where *Padina* had the highest value. Paloh has a low level of seaweed diversity, high uniformity, and a low dominance index.

Keywords: Diversity, Seaweed, Paloh, Sambas, West Kalimantan

Abstrak

Paloh sebagai salah satu kawasan konservasi di Kalimantan Barat memiliki potensi sumberdaya hayati laut dengan tingkat keanekaragaman tinggi, termasuk rumput laut. Rumput laut memiliki peran penting ekologi yaitu meningkatkan produktivitas primer perairan, penyedia oksigen terlarut, sumber makanan dan sebagai habitat bagi beberapa organisme akuatik. Selain itu, rumput laut mengandung berbagai senyawa bioaktif yang sangat potensial dimanfaatkan di berbagai bidang industri. Tujuan utama penelitian ini adalah mengetahui keanekaragaman dari rumput laut di perairan Pantai Tanjung Api, Kecamatan Paloh, Kabupaten Sambas, Kalimantan Barat. Penentuan titik lokasi pengambilan sampel dilakukan berdasarkan keberadaan rumput laut di lapangan. Pengambilan sampel dilakukan dengan kuadrat transek berukuran 10x10 m^2. Hasil penelitian menemukan 4 jenis rumput laut yaitu *Acetabularia*, *Ulva*, *Padina*, dan *Sargassum*. Kelimpahan jenis rumput laut bervariasi antara 1,04-26,75 ind/m^2, dimana Padina memiliki nilai kelimpahan tertinggi. Perairan Paloh memiliki tingkat keanekaragaman rumput laut dalam kategori rendah, keseragaman tinggi, dan dominansi rendah.

Kata Kunci : Keanekaragaman, Rumput Laut, Paloh, Sambas, Kalimantan Barat

1. Introduction

Administratively, Pantai Tanjung Api is located in Paloh District, Sambas Regency, West Kalimantan. Due to the Decree of the Minister of Maritime Affairs and Fisheries Number 93/Kepmen-KP/2020, Paloh was designated as one of the Coastal and Small Islands Conservation Areas (KKP3K) in West Kalimantan. Paloh has a coastline of around ±63 km, with various potential marine biological resources that have the potential to be developed, such as mangroves, coral reefs, fish, and turtles (DKP, 2019), including seaweed. Seaweed is a group of low-level plants, living attached to the substrate with the help of holdfast, and several other types have air bladders to help them float on the surface of the waters (Anggadiredja et al., 2006). Seaweed grows abundantly in West Kalimantan waters, such as Lemukutan Island (Sofiana et al., 2021; Sofiana et al., 2022), Kabung Island (Safitri et al., 2021; Warsidah et al., 2022; Agustina et al., 2023), Singkawang (Kamisyah et al., 2020), and Temajuk (Aswandi et al., 2023). In general, based on the pigment content, seaweed can be classified into three groups, namely green seaweed (*Chlorophyceae*), red seaweed (*Rhodophyceae*), and brown seaweed (*Phaeophyceae*) (Anggadiredja et al., 2006).

Ecologically, seaweed plays a crucial role in the water's primary productivity, dissolved oxygen supply, food source, and habitat provider for several aquatic organisms (John & Al-Thani, 2014). Previous studies have also reported the role of seaweed in bioremediation for several pollutants, such as heavy metals (Arumugam et al., 2018). In addition, seaweed is one of the leading commodities and has important economic value. The presence of bioactive compounds in seaweed that can be used in various industrial sectors has also been extensively investigated, such as food, health, pharmaceuticals, and cosmetics (Pereira et al., 2018). The bioactive compounds in seaweed showed antibacterial, antiviral, antioxidant, antiproliferative, anti-inflammatory, and antihypertensive activities (Leandro et al., 2020). In the aquatic environment, the condition of the physio-chemical parameters greatly influences the growth of seaweed. In addition, environmental parameters also affect the morphological shape of the thallus and the content of chemical compounds (Pereira *et al*., 2021).

Inventory of potential biological natural resources including seaweed, is one of the strategies that can be done in formulating sustainable conservation area management. The diversity of seaweed is also very supportive of increasing the primary productivity of water. Therefore, this study aims to determine the diversity of seaweed in the waters of Pantai Tanjung Api, Paloh District, Sambas Regency, West Kalimantan.

2. Material and Method

2.1. Time and Place

This research was carried out in January 2021 in the waters of Pantai Tanjung Api, Paloh District, Sambas Regency, West Kalimantan (Figure 1). The determination of site locations according to the presence of seaweed. Measurement of aquatic environmental parameters was conducted in situ together with a sampling of seaweed using three repetitions.

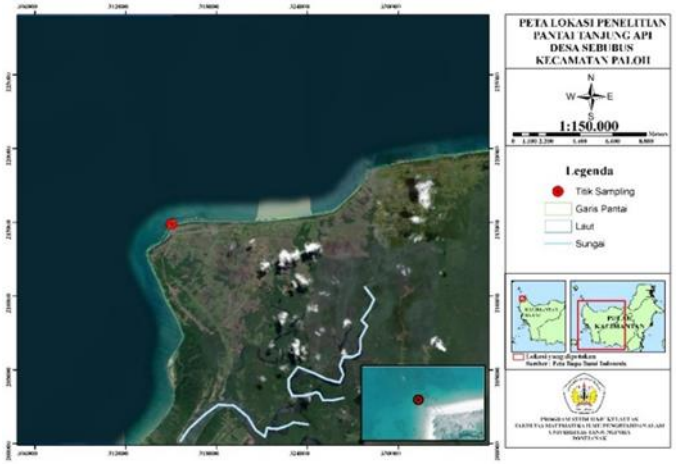

Figure 1. Research location in the waters of Pantai Tanjung Api, Paloh District, Sambas Regency, West Kalimantan

2.2. Data Collection

Seaweed samples were collected using a 10x10 m^2 squared transect in the tidal zone (Figure 2). Calculation of the individual number of each type of seaweed was done directly at the research site. Each type of seaweed found was put into a sample bottle, and then 70% alcohol was added. Identification up to the genus level was carried out at the Marine Science Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Tanjungpura.

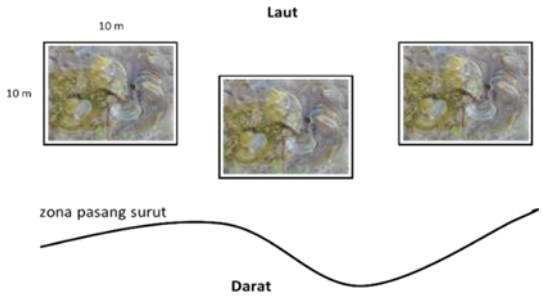

Figure 2. Quadratic transects for seaweed samples collection

2.3. Data Analysis

Data analysis carried out included abundance (K), relative abundance (KR), diversity index (H'), uniformity index (E), and dominance index (C). Calculation of the seaweed abundance was done using the formula (APHA, 2009), as follows:

$$K = \frac{ni}{A}$$

Where K is the abundance of seaweed (ind/m^2), ni is the number of individuals of the genus-i (ind), and A is the observation area (m^2).

Relative abundance (KR) was calculated using the formula (APHA, 2009), as follows:

$$K = \frac{\text{abundance of the genus}}{\text{total abundance}} \text{ x } 100\%$$

The diversity index (H') of seaweed is calculated using the formula according to (Shannon & Wiener, 1949), as follows:

$$H' = \sum pi \ln pi$$

Where H' is the diversity index, pi is the proportional abundance of each genus, is given pi = ni/N; ni is the number of individuals of the genus-i (ind); and N is the individual total abundance of the genus (ind). The diversity index can be classified into three categories, such as H' <1 then diversity is in a low category, 1<H'<3 indicates that diversity is medium level, and if the value of H'> 3 then diversity is in the high category (Odum, 1993).

The uniformity index (E) of seaweed is calculated using the formula (Odum, 1993), as follows:

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

Where E is the uniformity index, H' is the diversity index, H_{max} is the maximum possible value of species diversity, is expressed H_{max} = ln S, and S is the total number of the genera. The uniformity index (E) value ranges from 0 – 1. If the uniformity index value is close to 0, it indicates that the distribution of a species is uneven and in communities, there is a tendency for a species to dominate. Meanwhile, if the value of E is close to 1, then the distribution of seaweed species is indicated to be the same and no species dominates in a population (Krebs, 1985).

The dominance index (C) of seaweed is calculated using the formula (Odum, 1993), as follows:

$$C = \sum (ni/N)^2$$

Where C is the dominance index, ni is the number of individuals of the genus-i (ind), and N is the individual total abundance of the genus (ind).

Table 1. Dominance index category

Value	Category
< 0,5	Rendah
0,5 - 0,75	Sedang
> 0.75	Tinggi

3. Result and Discussion

3.1. Seaweed Composition

Seaweed composition in the waters of Pantai Tanjung Api, Paloh, West Kalimantan consisted of 4 orders, 4 families, 2 classes, and 4 genera (Table 2). Among the identified species, *Ulvophyceae* (50%) and *Phaeophyceae* (50%) have the same contribution percentage. In the aquatic environment, *Phaeophyceae* is one of the largest classes and has a wide distribution. In addition, this class is euryhaline and has a high tolerance for

changes in water conditions (Guiry & Guiry, 2020). Previous studies reported that in West Kalimantan, *Padina* and *Sargassum* grow abundantly in the waters of Lemukutan Island (Sofiana et al., 2022), Kabung Island (Sofiana et al., 2021; Sumarni et al., 2022; Agustina et al., 2023), and Temajuk Village (Aswandi et al., 2023). *Ulvophyceae* are also widely reported to have a high level of diversity of more than 1900 species (Guiry & Guiry, 2020). This class is found mainly in tropical and sub-tropical areas (Huisman & Saunders, 2007), and in fresh, brackish, and marine waters (Škaloud et al., 2018). According to Gaillande et al. (2017), most Ulvophyceae species have significant economic worth and contain bioactive substances frequently used in the pharmaceutical industry (Smith, 2004; Güven et al., 2010), and also play an important role in bioremediation (Bolton et al., 2016; Roleda & Hurd, 2019) of various types of pollutants in waters.

Table 2. Seaweed composition in the water of Pantai Tanjung Api

Order	Family	Class	Genus
Dasycladales	Polyphysaceae	Ulvophyceae	*Acetabularia*
Ulvales	Ulvaceae		*Ulva*
Dictyotales	Dictyotaceae	Phaeophyceae	*Padina*
Fucales	Sargassaceae		*Sargassum*

3.1.1. Acetabularia

The identification and classification of *Acetabularia* are as follows (Guiry & Guiry, 2022): Kingdom Plantae, Phylum Chlorophyta, Class Ulvophyceae, Order Dasycladales, Family Polyphysaceae, and Genus *Acetabularia* (Figure 3).

Figure 3. *Acetabularia* from the waters of Pantai Tanjung Api Paloh, Sambas Regency

Acetabularia from the waters of Pantai Tanjung Api, Paloh District has a green thallus with a height ranging from 5-7 cm. The thallus consists of three parts, such as the lower part in the form of rhizoids with a short holdfast, the middle part in the form of a long stalk, and the upper part in the form of an umbrella a canopy.

3.1.2. Ulva

The identification and classification of *Ulva* are as follows (Guiry & Guiry, 2022): Kingdom Plantae, Phylum Chlorophyta, Class Ulvophyceae, Order Ulvales, Family Ulvaceae, and Genus *Ulva* (Figure 4).

Figure 4. *Ulva* from the waters of Pantai Tanjung Api Paloh, Sambas Regency

The genus *Ulva* is cosmopolitan with more than 100 species (Guiry & Guiry 2007). It is extensively distributed in fresh, brackish, and seawaters (Ichihara et al., 2009; O'Kelly et al., 2010; Horimoto et al., 2011; Wolf et al., 2012), as the main benthic group in the estuary (Hiraoka & Higa, 2016). This genus has a green thallus of various sizes, thin, smooth, and slick. The length of the thallus reaches 30 cm, while the width can reach 15-20 cm. Holdfasts are small, bright to dark green (Lee et al., 2019; Ismail and Mohamed, 2017; Utama et al., 2021), and blades are green to olive green. *Ulva* can grow abundantly to form "green tides" (Kang et al., 2014; Zhong et al., 2020) in sub-tropical waters with relatively lower temperatures (Wolf et al, 2012; Husni & Budhiyanti, 2021). In the aquatic environment, diversity and species composition are related to ecological characteristics, such as survival, habitat, growth rate, and adaptability to changes in the aquatic environment (Gao et al., 2011; Luo & Liu, 2011). In addition, the species composition of *Ulva* also varies with time and place

(Kang et al., 2019). In East Asian countries, *Ulva* species have been used as an important source of commercial food ingredients (Liu et al., 2013).

3.1.3. Padina

The identification and classification of *Padina* are as follows (Guiry & Guiry, 2022): Kingdom Plantae Phylum Ochrophyta, Class Phaeophyceae, Order Dictyocales, Family Dictyotaceae, and Genus *Padina* (Figure 5).

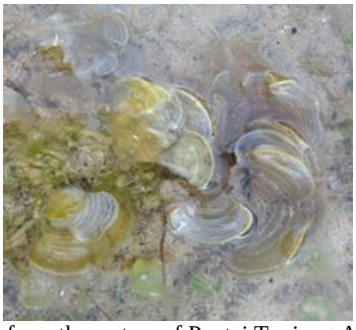

Figure 5. *Padina* from the waters of Pantai Tanjung Api Paloh, Sambas Regency

Padina from the waters of Pantai Tanjung Api has a smooth and bunch thallus-like fan shape with rounded edges, composed of thin lines, and brown. According to Subagio & Kasim (2019), the genus *Padina* is found mostly in intertidal waters with coral and rocky substrate characteristics. In West Kalimantan, *Padina* is widely distributed in the waters of Lemukutan Island (Sofiana et al., 2022), Kabung Island (Hidayat et al., 2021; Agustina et al., 2023), and Desa Temajuk (Aswandi et al., 2023). Previous studies showed that *Padina* from Kabung Island waters was reported to have antibacterial (Warsidah et al., 2022) and antioxidant activities (Sofiana et al., 2021).

3.1.4. Sargassum

The identification and classification of *Sargassum* are as follows (Guiry & Guiry, 2022): Kingdom Plantae, Phylum Ochrophyta, Class Phaeophyceae, Order Fucales, Family Sargassaceae, and Genus *Sargassum* (Figure 6).

Figure 6. *Sargassum* from the waters of Pantai Tanjung Api Paloh, Sambas Regency

Sargassum found in the waters of Pantai Tanjung Api has multi-branches of thallus and brown. The blade has spiny margins, disc-shaped holdfast, and is equipped with an air bladder. *Sargassum* species are found in many tropical waters, including Indonesia, such as Karimunjawa (Kadi et al., 2005), Flores and Sumba (Kasanah et al., 2020), the Seribu Islands (Susila et al., 2017), Madura (Kasitowati et al., 2021), Natuna (Tarigas et al., 2020). Meanwhile, in West Kalimantan, *Sargassum* is commonly found in the waters of Lemukutan Island (Sofiana et al., 2022), Kabung Island (Safitri et al., 2021; Sumarni et al., 2022; Agustina et al., 2023), Singkawang (Kamisyah et al., 2020), and Temajuk Village (Aswandi et al., 2023). Saragassum from Kabung Island showed antibacterial activity against *Escherichia coli* (Jumlia et al., 2023). In addition, *Sargassum* has been reported for several biological activities, such as antiviral (Lomartire and Gonçalves, 2022), antibacterial (Warsidah et al., 2022), and antioxidant (Lekameera et al., 2008; Safitri et al., 2021).

3.2. Abundance of Seaweed

According to the results, the seaweed abundance ranged from 1.04-26.75 ind/m^2, while *Padina* has the highest value (Figure 7). *Padina* belongs to the brown microalgae group and is commonly found in aquatic environments, including Paloh. In addition, *Padina* has been widely reported as a species with annual dominance (Kokabi et al., 2016; Srimariana et al., 2020). *Padina* is widely distributed in intertidal waters and grows abundantly on rocky substrates. Mostly, Paloh has many rocky beaches, such as Batu Maludin, Batu

Pipih, and Teluk Atong Bahari (BPS, 2018). Therefore, these substrate characteristics can support the distribution and growth of seaweed, especially *Padina*.

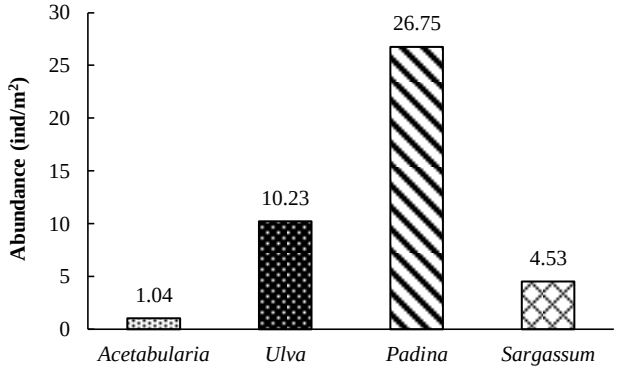

Figure 7. The abundance of seaweed from the waters of Pantai Tanjung Api Paloh, Sambas Regency

3.3. Biological Index of Seaweed

In this study, the seaweed diversity index (H') value is 0.96 and classified into the low diversity category (Odum, 1993). Aquatic environmental factors are considered to affect the level of diversity. Because of this condition, only a few seaweed species can adapt to the aquatic world. The uniformity indicator (E) value indicates that Paloh waters had a high level of seaweed uniformity. This described that each individual had the same distribution and there was no particular species that dominated the population as indicated by the low category of dominance index value.

Table 3. Diversity, Uniformity, and Dominance Index of Seaweed from Pantai Tanjung Api Paloh, Sambas Regency

Indeks	value	criteria
H’	0,96	High
E	0,70	High
C	0,47	Low

Note: H’ = Diversity; E = Uniformity; C = Dominance.

The dissolved oxygen content during this study was good enough for cherax growth, namely the lowest was 4.2 mg/L and the highest was 5.8 mg/L or an average of 5 mg/L. Following the opinion of Boyd *in* Faiz et al. (2021) the optimum range of dissolved oxygen values for crustacean growth is above 5 mg/L, thereby providing good growth and survival.

4. Conclusions

The study found four genera of seaweed from the waters of Pantai Tanjung Api, Paloh District, West Kalimantan, such as *Acetabularia*, *Ulva*, *Padina*, and *Sargassum*. Among the identified species, *Ulvophyceae* and *Phaeophyceae* had the same percentage contribution. The abundance of seaweed species varied from 1.04 - 26.75 ind/m^2, where *Padina* had the highest value. The waters of Pantai Tanjung Api had a low seaweed diversity, high uniformity, and low dominance level.

5. Suggestion

It is needed for further study on the exploration of bioactive compounds and nutritional content of seaweed from the waters of Pantai Tanjung Api, Paloh District, Sambas Regency, West Kalimantan.

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