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Species Inventory of Epilithic Macroalgae in Padang Unoi Coastal Waters, Simeulue Island

Inventarisasi Makroalga Epilitik di Perairan Padang Unoi, Pulau Simeulue

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ABSTRACT

Epiphytic macroalgae are phototrophic organisms that attach to rigid substrates in the intertidal zone and serve as key components of coastal ecosystem structure due to their roles in providing habitat, stabilizing substrates, and supporting nutrient cycling. This study aimed to inventory the types of epiphytic macroalgae present in the rocky intertidal zone of Padang Unoi Village, Salang District, Simeulue Regency. Observations were conducted in July 2025 along a 150-m transect, dividing the area into two tidal zones: the lower littoral and the mid-littoral. The inventory revealed seven species of epiphytic macroalgae, namely *Turbinaria* sp, *Sargassum* sp, *Padina* sp, *Chaetomorpha aerea, Caulerpa taxifolia, C. racemosa*, and *Amphiroa subcylindrica*. Species from the Phaeophyta division dominated the mid-littoral zone, while Chlorophyta were more abundant in the lower littoral zone, and Rhodophyta were observed on coarse-textured rocky substrates. These three major divisions indicate habitat heterogeneity that supports the growth of various types of epiphytic macroalgae. The results of this study highlight the importance of the rocky intertidal zone of Simeulue as a productive habitat and provide a basis for sustainable coastal resource management.

Keywords: Epiphytic macroalgae, Intertidal zone, Rocky substrate, Simeulue, Coastal ecosystem

ABSTRAK

Makroalga epilitik adalah organisme fototrof yang menempel pada substrat keras di zona intertidal dan berfungsi sebagai komponen kunci dalam struktur ekosistem pesisir karena perannya dalam menyediakan habitat, menstabilkan substrat, dan mendukung siklus nutrien. Penelitian ini bertujuan untuk menginventarisasi jenis-jenis makroalga epilitik yang terdapat di zona intertidal berbatu Desa Padang Unoi, Kecamatan Salang, Kabupaten Simeulue. Pengamatan dilakukan pada bulan Juli 2025 sepanjang transek 150 meter dengan membagi area menjadi dua zona pasang surut, yaitu zona bawah (lower littoral) dan zona tengah (mid littoral). Hasil inventarisasi menunjukkan terdapat tujuh spesies makroalga epilitik, yakni *Turbinaria* sp, *Sargassum* sp, *Padina* sp, *Chaetomorpha aerea, Caulerpa taxifolia, C. racemosa*, dan *Amphiroa subcylindrica*. Spesies dari divisi Phaeophyta mendominasi zona mid-littoral, sementara Chlorophyta lebih banyak dijumpai di zona lower-littoral, serta Rhodophyta teramati pada substrat berbatu dengan tekstur kasar. Keberadaan ketiga divisi utama tersebut menunjukkan heterogenitas habitat yang mendukung pertumbuhan berbagai jenis makroalga epilitik. Hasil penelitian ini menegaskan pentingnya zona intertidal berbatu Simeulue sebagai habitat produktif serta dapat menjadi dasar pengelolaan sumber daya pesisir secara berkelanjutan.

Kata Kunci: Makroalga epilitik, Zona intertidal, Substrat berbatu, Simeulue, Ekosistem pesisir

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INTRODUCTION

Coastal ecosystems are dynamic and complex systems in which macroalgae are crucial in maintaining marine ecological balance. As primary producers, macroalgae contribute significantly to food webs, oxygen supply, and nutrient cycling while providing essential habitats for various aquatic organisms (Basyuni et al., 2024; Suhartini et al., 2024). Beyond their ecological importance, macroalgae have long been utilized for multiple human needs, ranging from food and feed to sources of bioactive compounds with high economic potential (Oktavia et al., 2025). Among these groups, epilithic macroalgae species that grow attached to rigid substrates such as rocks in coastal zones hold a critical ecological function. These communities provide microhabitats for cryptofauna, support coral recruitment, and serve as indicators of aquatic ecosystem health (Tebbett et al., 2024). Their distribution and abundance are strongly influenced by environmental factors such as light intensity, salinity, currents, and wave dynamics (Barros et al., 2024; Suhartini et al., 2024).

Several studies in tropical regions of Indonesia have demonstrated that macroalgal community variation is closely linked to local ecological conditions. Research in East Lombok and Gunungkidul revealed that substrate type and local factors are key determinants of macroalgal diversity (Rasyid et al., 2025). Seasonal changes in community structure were reported in West Kalimantan waters (Safitri et al., 2023), while research in Merana Village, Sindue District, showed that macroalgal abundance and distribution are shaped by environmental drivers (Hidayanti et al., 2025). Nevertheless, studies addressing epilithic macroalgal communities in remote coastal areas remain limited. One underexplored region is the Simeulue District, Aceh Province, where previous research primarily focused on post-tsunami ecosystems and coral reef conditions. Nevertheless, this district possesses rocky coastlines with high potential as habitats for diverse macroalgal species. In particular, Padang Unoi Village in Salang District is of special interest due to its relatively pristine environment and minimal human disturbance.

In light of this knowledge gap, the present study aims to identify and inventory epilithic macroalgal species in the coastal waters of Padang Unoi Village, Salang District, Simeulue, and to describe their composition and diversity. The findings are expected to provide a scientific basis for sustainable management and utilization of coastal resources in this region.

MATERIALS AND METHODS

This study was conducted in July 2025 at Padang Unoi Village, Salang District, Simeulue Regency. Observations of epilithic macroalgae were carried out in the intertidal zone within a single day of fieldwork. The research site was located along a rocky shore, where predetermined sampling points had been established. Sampling was conducted along a 150-m stretch of coastline, and macroalgae were identified based on morphological differences. The observation area was divided into two tidal zones: lower littoral and mid-littoral (Lisdayanti et al., 2025). Epilithic macroalgae attached to rocky substrates were directly observed, documented through photographs, and subsequently identified using the website https://www.algaebase.org/ and macroalgae identification and taxonomy manuals (Al-Yamani et al., 2014).

RESULT AND DISCUSSION

The inventory results revealed that seven species of epilithic macroalgae were identified in the rocky waters of Padang Unoi, Simeulue. These included *Turbinaria* sp, *Sargassum* sp, *Padina* sp, *Chaetomorpha aerea*, *Caulerpa taxifolia*, *C. racemosa*, and *Amphiroa subcylindrica*. Three genera belonging to the division Phaeophyta (*Turbinaria*, *Sargassum*, and *Padina*) dominated the observation area in the mid-littoral zone, where rocky substrates were more stable and better supported thallus attachment. In contrast, the genera *Caulerpa* (*C. taxifolia* and *C. racemosa*) and *C. aerea* (Chlorophyta) were more commonly found in the lower-littoral zone, which remains submerged and nutrient-rich.

Meanwhile, *A. subcylindrica* (Rhodophyta) was observed firmly attached to coarse-textured rocky substrates, facilitating the growth of its calcified thallus. The presence of the three major macroalgal divisions, Phaeophyta, Chlorophyta, and Rhodophyta, indicates that the waters of Padang Unoi provide a relatively heterogeneous habitat, allowing various species of epilithic macroalgae to grow and adapt. Moreover, the dominance of brown macroalgae (Phaeophyta) suggests that the area is characterized by relatively high light intensity and stable substrates that favor colonization, consistent with the natural habitat preferences of this group.

***Turbinaria* sp**

The specimen of *Turbinaria* sp. found in the intertidal zone exhibited a dark brown thallus with irregular branching. The holdfast was disc-shaped and small, anchoring firmly onto rocky substrates. The cylindrical, branched stipe produced blades ranging from spatula-shaped to small circular forms with broadened tips and finely serrated margins. Small spherical air vesicles on the blade surface kept the thallus upright in the water column. Reproductive structures in the form of conceptacles were observed on the lateral parts of the branches.

Figure 1. Morphology of *Turbinaria* sp.

Brown macroalgae of the genus *Turbinaria* are recognized as common epilithic algae in tropical waters with rigid substrates, particularly in the intertidal to shallow subtidal zones (Tamara et al., 2025). Their morphological adaptations, such as strong holdfasts and air vesicles, support their ability to withstand moderate to strong wave conditions. Ecologically, *Turbinaria* is a primary producer, contributing to coastal ecosystem productivity and providing habitat for small organisms, including invertebrates and juvenile fishes (Riry et al., 2022). In addition, this genus is known to produce bioactive compounds, particularly polyphenols and fucoidan, which exhibit potential as natural antioxidants, antimicrobials, and immunostimulants (Handayani et al., 2025). These characteristics make *Turbinaria* ecologically important and promising for pharmaceutical, food, and marine biotechnology applications.

***Sargassum* sp**

Field observations showed that *Sargassum* sp. was the most abundant brown macroalga (Phaeophyceae) in the rocky intertidal zone. The thallus was golden brown to dark brown, with a small disc-shaped holdfast firmly attached to hard substrates. The cylindrical stipe branched irregularly and supported flat to oval blades with smooth margins. Small spherical air vesicles were scattered among the branches, helping the thallus remain upright in the water column. Reproductive structures in the form of conceptacles were observed on the lateral branches (Fauzi, 2021).

Figure 2. Morphology of *Sargassum* sp

The dominance of *Sargassum* sp at the study site reflects its high adaptability to water conditions with moderate to intense wave action. The strong holdfast and presence of air vesicles provide ecological advantages in maintaining an upright position and enhancing photosynthetic efficiency. Ecologically, *Sargassum* functions as a significant primary producer and provides habitat for various small organisms, including invertebrates and juvenile fish, thereby supporting the structure of coastal ecosystems (Adderley et al., 2023).

Beyond its ecological role, *Sargassum* also has considerable economic value due to its secondary metabolites. Bioactive compounds such as polysaccharides (alginate, fucoidan), phenolics, and terpenoids have been reported to possess antioxidant, antibacterial, and anticancer activities, offering potential applications in the pharmaceutical and food industries (Gazali et al., 2024; Riwanti et al., 2024). Thus, the presence of *Sargassum* sp is ecologically important and promising in supporting the development of a marine-based bioeconomy.

***Padina* sp**

Specimens of *Padina* sp. found in the rocky intertidal zone had a fan-shaped thallus of relatively small size, light brown to golden in color. The thallus was attached to the substrate by a small disc-shaped holdfast. Its surface was thin, transparent to semi-transparent, with darker concentric bands. The thallus margin was rolled upward. Calcium carbonate deposits were visible in certain parts, giving the surface a stiffer and more rigid texture (Rizki, 2023).

Figure 3. Morphology of *Padina* sp

Padina is the only genus in the family Dictyotaceae that undergoes calcification, characterized by calcium carbonate deposition on the thallus surface, which often causes the thallus to appear pale (Arianti et al., 2024). This adaptation protects against herbivory and enhances resilience to fluctuating intertidal conditions. Ecologically, *Padina* is an important epilithic macroalga that stabilizes substrates, provides microhabitats, and contributes biomass to the food web (Septria et al., 2025). Moreover, this genus is known to produce bioactive compounds, particularly alkaloids, saponins, steroids, phenols, polyphenols, and terpenoids, which show potential as antifungal, antibacterial, antioxidant, and anticancer agents (Hidayah et al., 2024; Wahdaniyah, 2024). Recent studies also highlight the significant antimicrobial activity of *Padina* extracts against both marine and human pathogens, making it of interest in marine biotechnology (Asharo et al., 2024).

Chaetomorpha aerea

Chaetomorpha aerea, one of the most significant green algae with global distribution, commonly grows abundantly in rocky intertidal zones, especially in areas submerged at high tide and remaining moist at low tide (Qin et al., 2023). It attaches directly to rigid substrates through simple rhizoids, often forming dense clumps resembling green fibrous balls easily recognized in the field. The thallus consists of long, stiff, unbranched filaments, bright green to dark green depending on light intensity. The filaments appear coarse, composed of large cylindrical cells arranged in straight chains resembling thick threads. The thallus tips may be straight or slightly curved with water movement, while the colony typically forms a compact mass, firm but easily detached during heavy wave action. Its texture is somewhat rigid to the touch, distinguishing it from softer filamentous green algae.

Figure 4. Morphology of *Chaetomorpha aerea*

As an epilithic green alga, *C. aerea* plays a key role in intertidal ecosystems by providing oxygen through photosynthesis and serving as a food source for herbivorous invertebrates and small fishes. Its colonies can trap sediment particles, helping stabilize substrates. Its abundance often serves as an environmental indicator, reflecting nutrient-rich waters (mild eutrophication) with sufficient water flow to supply nutrients, linked to its strong bioremediation capacity. Extracts of *C. aerea* contain high chlorophyll, valued as a functional additive due to antioxidant, antibacterial, antifungal, hepatoprotective, anticancer, and immunomodulatory activities (Wahyuni et al., 2022). The extract enhances mucosal immunity, with lysozyme activity, myeloperoxidase activity, total

immunoglobulin levels, and alternative complement activity (Wahyuni et al., 2024; Govindharajan et al., 2024). Sulphated polysaccharides from *C. aerea* represent a promising natural anticoagulant source for promoting health and treating thrombotic diseases (Qin et al., 2023).

Genus Caulerpa

Caulerpa species were found in the rocky intertidal zone: *C. taxifolia* and *C. racemosa*. *C. taxifolia* exhibited bright to dark green stolons creeping across the substrate, with erect lateral branches resembling feather-like flattened leaves arranged regularly along the central axis (Rueda & Alberto, 2025). In contrast, *C. racemosa* was characterized by creeping stolons producing erect branches with spherical vesicles resembling bright green grape clusters, densely arranged along the branch, forming a typical grape-like appearance. Both species attached firmly to rigid substrates with simple rhizoids and showed adaptive capacity to form extensive mats over rocky habitats.

A B

Figure 5. Morphology of *C. taxifolia* (A) and *C. racemosa* (B)

Both species belong to the Ulvophyceae (Chlorophyta) class and are unique for their siphonous thallus structure (multinucleate without cross-walls). Ecologically, *Caulerpa* plays a significant role in stabilizing substrates, preventing erosion, and providing habitats for small invertebrates and juvenile fishes (Rahareng, 2020). Dense mats of *Caulerpa* may also affect benthic community dynamics by competing for space and light (Septiyaningrum et al., 2020). From a bioactive perspective, *C. taxifolia* is known to produce secondary metabolites such as caulerpenyne, which functions as a chemical defence against herbivores and has been reported to have antibacterial, anticancer, and anti-diabetic activities (Bayro et al., 2021; Liu et al., 2025). Meanwhile, *C. racemosa*, commonly consumed as local food (sea grapes/latoh), is rich in fiber, vitamins, minerals, and bioactive compounds with antioxidant and anti-diabetic properties (Rasyid, 2017). This alga also contains bioactive pigments such as chlorophylls and xanthophylls with demonstrated in vitro biological activities, including anti-diabetic, anti-obesity, antioxidant, anti-inflammatory, and cytotoxic effects (Kurniawan et al., 2023). The occurrence of both species in Padang Unoi highlights the high diversity of epilithic green macroalgae, which are ecologically significant and economically and pharmaceutically valuable for developing a sustainable marine bioindustry.

Amphiroa subcylindrica

Specimens of *A. subcylindrica* were found firmly attached to rocks in the intertidal zone exposed to moderate to strong waves. This alga grew in colonies, forming small bushes easily recognized due to their hard texture and dense branching. The thallus structure consisted of rigid cylindrical segments with dichotomous branching, making miniature shrubs appear. The surface of the thallus appeared smooth but brittle when pressed, indicating calcium carbonate deposition that makes it more complicated than non-calcified red algae (Hamad, 2024). Each branch was relatively small in diameter but densely arranged, forming compact colonies.

Figure 6. Morphology of *A. subcylindrica*

The presence of seven identified macroalgal species in the rocky intertidal zone demonstrates high marine vegetation diversity at the study site, with each species exhibiting unique morphology and adaptive strategies to survive dynamic environmental conditions such as temperature, light, and wave pressure fluctuations. Collectively, these seven species reflect complementary ecological functions in the intertidal system, including habitat provision (*Sargassum*, *Caulerpa*), substrate stabilization (*Padina*, *Amphiroa*), rapid nutrient absorption (*Chaetomorpha*), and carbonate sediment production (*Amphiroa*). This makes macroalgal communities fundamental to the balance of coastal ecosystems. Their presence can also serve as ecological indicators, as variations in abundance and dominance often correlate with changes in water quality, anthropogenic pressures, and local oceanographic dynamics.

CONCLUSION

The inventory of epilithic macroalgae in the rocky waters of Padang Unoi Village, Salang District, Simeulue Regency, successfully identified seven species, namely *Turbinaria* sp, *Sargassum* sp, *Padina* sp, *Chaetomorpha aerea*, *Caulerpa taxifolia*, *C. racemosa*, and *Amphiroa subcylindrica*. These seven species represent the diversity of macroalgae from three major groups: Phaeophyceae (brown algae), Chlorophyta (green algae), and Rhodophyta (red algae). The presence of these species indicates that the rocky intertidal ecosystem at the study site provides a suitable substrate and supports the growth of various macroalgal taxa. Ecologically, these findings highlight the important role of the intertidal zone as a productive habitat that contributes to the structure of coastal communities. From a practical perspective, the occurrence of macroalgae such as *Sargassum*, *Turbinaria*, and *Caulerpa* demonstrates potential applications in food, health, and biotechnology industries, while *Amphiroa* contributes to substrate stabilization and the carbon cycle. Therefore, this inventory provides a baseline for conservation efforts, sustainable management, and the development of the economic potential of macroalgae in the Simeulue region.

REFERENCES

Adderley, A., Wallace, S., Stubbs, D. *et al.*, 2023. *Sargassum* sp as a biofertilizer: is it really a key towards sustainable agriculture for the Bahamas?. *Bull Natl Res Cent*., 47: 112.

Al-Yamani, F.Y., Polikarpov, I., Al-Ghunaim, A., Mikhaylova, T., 2014. *Field guide of marine macroalgae (Chlorophyta, Rhodophyta, Phaeophyceae) of Kuwait (First Edition).* Kuwait Institute for Scientific Research (Publisher).

Anggadiredja, J.T., Zatnika, A., Purwoto, H., Istini, S., 2006. *Rumput laut: Pembudidayaan, pengolahan dan pemasaran komoditas perikanan potensial*. Penebar Swadaya.

Arianti, A., Pazila, B.D.A.P., Ramdhiani, A., Kurniawan, A., Kholidah, B.M., Royani, B.N., Ghazali, M., 2024. Diversity of macroalgae in Sire Beach, North Lombok. *Jurnal Biologi Tropis*, 24(2): 315–326.

Asharo, R.K., Wardana, N.A., Yusup, A.L., Cahyati, N.L., Pratama, F.A., Luthfiyah, H., 2024. Potential of macroalgae as antifungal, antibacterial, and antioxidant substances in supporting the utilization of marine resources. *LenteraBio: Berkala Ilmiah Biologi,* 13(2): 270–278.

Barros, G.S.F., Cesar, A.M.M., Cordeiro, C., Carlos, E.L., Ferreira, F., 2024. Structuring patterns of the epilithic algal matrix cryptofauna in a tropical oceanic reef. *Regional Studies in Marine Science*, 69:103292.

Basyuni, M., Puspita, M., Rahmania, R., Albasri, H., Pratama, I., Purbani, D., Aznawi, A.A., Mubaraq, A., Mustaniroh, S.S.A., Menne, F., Rahmila, Y.I., Salmo, S.G., Susilowati, A., Larekeng, S.H., Ardli, E., Kajita, T., 2024. Current biodiversity status, distribution, and prospects of seaweed in Indonesia: A systematic review. *Heliyon*, 10(10): e31073.

Bayro, A.M., Manlusoc, J.K., Alonte, R., Caniel, C., Conde, P., Embralino, C., 2021. Preliminary characterization, antioxidant and antiproliferative properties of polysaccharide from *Caulerpa taxifolia*. *Pharmaceutical Sciences and Research*, 8(1).

Fauzi, Z., 2021. *Studi keanekaragaman makroalga di Pantai Teluk Asmara Desa Tambakrejo Kecamatan Sumbermanjing Kabupaten Malang.* Universitas Islam Negeri Maulana Malik Ibrahim.

Gazali, M., Effendi, I., Husni, A., Nurjanah, N., Wahyuni, S., Kurniawan, R., 2024. *Sargassum* sp. extract improve hematological profile of tilapia fish (*Oreochromis niloticus*). *F1000Research*, *12*(293).

Govindharajan, S., Balasubramanian, B., Thapo, V., Venkatalakshmi, S., Liu, W.-C., 2024. Enhancement of skin mucus immunity, carotenoid content, sexual parameters, and growth response in guppy fish (*Poecilia reticulata*) fed with green algae (*Chaetomorpha aerea*) diets. *Fishes*, 9(3): 101.

Hamad, M.M., 2024. Geniculate coralline algae from the Pliocene Shagra formation at Wadi Abu Dabbab, Marsa,

alam area, Red Sea coastal plain, Egypt. *Geopersia*, 14(2): 249-270.

Handayani, E., Frediansyah, A., Prasedya, E.S., Sunarwidhi, A.L., 2025. The effect of different solvents and methods on brown seaweed *Turbinaria* sp. metabolite profile. *Jurnal Biologi Tropis*, *24*(2): 422–432.

Hidayah, N., Sumandiarsa, I.K., Alqadiri, W.M., 2024. Screening of phytochemical compounds and antifungal activity of *Padina* sp. extracted by ultrasound assisted extraction against *Aspergillus flavus*. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *27*(4): 297-308.

Hidayanti, N., Nurdin, M., Isnainar, I., Febriawan, A., Alibasyah, L., Lilies, L., 2025. Jenis-jenis makroalga di permandian air panas Desa Marana Kecamatan Sindue. *Bioscientist: Jurnal Ilmiah Biologi*, *13*(2): 1229–1235.

Kurniawan, R., Nurkolis, F., Taslim, N.A., Subali, D., Surya, R., Gunawan, W.B., Alisaputra, D., Mayulu, N., Salindeho, N., Kim, B., 2023. Carotenoids composition of green algae *Caulerpa racemosa* and their anti-diabetic, anti-obesity, antioxidant, and anti-inflammatory properties. *Molecules*, *28*(7): 3267.

Lisdayanti, E., Najmi, N., Rahmawati, R., Lubis, F., Marliana, N., 2025. Inventarisasi dan karakteristik makroalga pada substrat berbatu di Pulau Reusam, Aceh Jaya. *Jurnal Laot Ilmu Kelautan,* 7(1): 1-9.

Liu, S., Qin, L., Li, D., Lu, F., Liang, M., Hao, J., 2025. A sulphated polysaccharide from the green alga *Caulerpa taxifolia*: Characteristics of its structure and anti-diabetic activity. *Marine Drugs*, *23*(10): 374.

Oktavia R., Nurlaila, A.S., Sari, R.W.P., Hidayah, A.N., Alfito, M.A., Kurniawan, I.A., Kaloka, V.N.R.L., Chasani, A.R., 2025. Keanekaragaman makroalga di zona intertidal Pantai Mbuluk, Gunungkidul, Indonesia. *Aquacoastmarine: Journal of Aquatic and Fisheries Sciences*, *4*(1): 17–29.

Qin, L., Yang, Y., Mao, W., 2023. Anticoagulant property of a sulphated polysaccharide with unique structural characteristics from the green alga *Chaetomorpha aerea*. *Marine Drugs*, *21*(2): 88.

Rahareng, A.J., 2020. *Kandungan nutrient substrat dengan kerapatan tumbuhan anggur laut (Caulerpa sp) di Perairan Pantai Tayando Kota Tual*. Institut Agama Islam Negeri Ambon

Rasyid, A., Putra, M.Y., Handayani, W., Yasman, Y., 2025. Macroalgal community structure and beta diversity in the coastal waters of East Lombok, Indonesia. *Biodiversitas*, 26(7): 3115–3124.

Riry, M., Sinay, H., Karuwal, R.L., 2022. Morphological characterization of brown algae *Turbinaria* sp from the coastal water of Aboru Village, Central Maluku. *Jurnal Biologi Tropis*, *22*(2): 449–454.

Riwanti, P., Mahmiah, M., Juniar, K., 2024. Antioxidant activity of brown algae extract (*Sargassum* sp): A review. *Science Midwifery*, 11(6): 962-970.

Rizki, F., 2023. *Inventarisasi makroalga di Perairan Pantai Selatan Kabupaten Aceh Selatan sebagai media pembelajaran biologi.* UIN Ar-Raniry Fakultas Tarbiyah dan Keguruan.

Rueda, B., Alberto, C., 2025. *Morphological and genetic analysis of the green alga Caulerpa taxifolia (Vahl) C. Agardh (Bryopsidales) in New South Wales, Australia.* Open Research Newcastle.

Safitri, I., Warsidah, W., Sofiana, M.S.J., Gusmalawati, D., Rousdy, D.W., Aswandi, A., 2023. Community structure of macroalgae in Temajuk Waters, Paloh District, West Kalimantan. *JFMR (Journal of Fisheries and Marine Research)*, *7*(1): 59–72.

Septiyaningrum, I., Utami, M.A.F., Johan, Y., 2020. Identification of (*Caulerpa* sp.) Sepang Bay at Bengkulu City. *Jurnal Perikanan Unram*, *10*(2): 195–204.

Septria, A., Alghifari, M.N., Lawoliyo, J., 2025. Review of evolution, global distribution, and ecological roles of macroalgae in tropical and subtropical marine ecosystems. *Indonesian Journal of Tropical Biology*, *1*(1): 9–18.

Suhartini, S., Pangestuti, M.B., Elviliana, E., Rohma, N.A., Junaidi, M.A., Paul, R., Melville, L., 2024. Valorisation of macroalgae for biofuels in Indonesia: an integrated biorefinery approach. *Environmental Technology Reviews*, *13*(1): 269–304.

Tamara, G.M.A.J., Kepel, R.C., Lumingas, L.J.L., Wantasen, A.S., Lasabuda, R., Lohoo, A.V., 2025. Community structure of macroalgae in the coastal waters of Bahowo. *Jurnal Ilmiah PLATAX*, *13*(2): 220–252.

Tebbett, S.B., et al., 2024. Structuring patterns of the epilithic algal matrix cryptofauna in a tropical oceanic reef. *Regional Studies in Marine Science*, 69: 103292.

Wahdaniyah, M., 2023. *Isolasi dan karakterisasi senyawa dari ekstrak kombinasi alga cokelat (Padina sp.) dengan Jeruk Nipis (Citrus aurantifolia), serta uji bioaktivitasnya sebagai antioksidan.* Universitas Hasanuddin.

Wahyuni, S., Gazali, M., Kurniawan, R., 2022. Inhibition zone test of *Chaetomorpha* sp. extract against *Aeromonas hydrophila* and *Vibrio* sp. bacteria. *Jurnal Natur Indonesia*, 20(2).

Wahyuni, S., Nufus, H., Mursawal, A., Kurniawan, R., 2024. Addition of *Chaetomorpha* sp extract on the growth and hematology of tilapia (*Oreochromis niloticus*). *Jurnal Natur Indonesia*, 22(1): 7–11