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PRELIMINARY STUDY: DISTRIBUTION OF SEA GRAPES (*Caulerpa*) IN SOPURA BAY, KOLAKA REGENCY

Kajian Awal Sebaran Anggur Laut (*Caulerpa* sp.) di Teluk Sopura, Kabupaten Kolaka

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ABSTRACT

This study explored the distribution and morphotypes of sea grapes (*Caulerpa*) in Sopura Bay, Kolaka Regency. Observations were conducted across fine sand, muddy sand, a combination of fine and muddy sand, and dead coral substrates, including morphotype identification and in situ environmental measurements. Two main morphotypes were recorded, *C. racemosa* and *C. lentillifera*. Sea grapes (*C. racemosa*) occurring on fine, muddy, and mixed sand, characterized by cylindrical stolons with grape-like vesicles, although it was not dominant on muddy sand. In contrast, *C. lentillifera* was predominantly found on dead coral, forming dense mats of spherical vesicles. Environmental parameters supported the growth of these species, with water temperatures ranging from 27–30 °C, salinity 30–33 ppt, pH 7.7–8.1, dissolved oxygen 6.3–7.5 mg/L, and light penetration between 72–83%. These findings provide baseline data on the distribution, morphotypes, and ecological conditions of *Caulerpa* sp., serving as a reference for sustainable coastal resource management in Sopura Bay.

Keywords: *Caulerpa*, Distribution, Sopura Bay, Kolaka

ABSTRAK

Penelitian ini mengeksplorasi sebaran dan morfotipe anggur laut (*Caulerpa*) di Teluk Sopura, Kabupaten Kolaka. Observasi dilakukan pada substrat pasir halus, pasir berlumpur, kombinasi pasir halus dan berlumpur, serta karang mati, termasuk identifikasi morfotipe dan pengukuran parameter lingkungan secara in situ. Dua morfotipe utama tercatat, yaitu *C. racemosa* dan *C. lentillifera*. Anggur laut (*C. racemosa*) ditemukan pada pasir halus, pasir berlumpur, dan kombinasi keduanya, ditandai oleh stolon silindris dengan vesikel menyerupai anggur, meskipun tidak dominan pada pasir berlumpur. Sebaliknya, *C. lentillifera* didominasi tumbuh pada karang mati, membentuk lapisan padat vesikel berbentuk bulat. Kondisi lingkungan mendukung pertumbuhan kedua morfotipe ini, dengan suhu air 27–30 °C, salinitas 30–33 ppt, pH 7,7–8,1, oksigen terlarut 6,3–7,5 mg/L, dan penetrasi cahaya 70–83%. Temuan ini menyediakan data dasar mengenai sebaran, morfotipe, dan kondisi ekologis *Caulerpa*, serta menjadi referensi untuk pengelolaan sumber daya pesisir berkelanjutan di Teluk Sopura.

Kata Kunci: *Caulerpa*, Distribusi, Teluk Sopura, Kolaka

INTRODUCTION

Kolaka Regency, located in Southeast Sulawesi Province, has a coastline of approximately 293.25 km with waters rich in biodiversity. One of the potential commodities found in this region is sea grapes (*Caulerpa*), a type of green macroalgae (Asriani *et al*., 2024). Despite their significant ecological and economic value, sea grapes remain underutilized compared to red (*Rhodophyta*) and brown (*Phaeophyta*) macroalgae (Stuthmann *et al*., 2023). This is due to limited cultivation standards and relatively low acceptance in the global market (Windarto *et al*., 2025). In fact, this species plays an important role in the production of functional foods and natural cosmetic products (Rushdi *et al*., 2020).

Caulerpa grows naturally in tropical waters, including Sopura Bay, Kolaka. This alga is rich in fiber, minerals, and vitamins, and contains bioactive compounds with potential applications in food and cosmeceutical products (Rushdi *et al*., 2020: Pangestuti *et al*., 2021). Its economic value has increased in line with the growing public awareness of healthy and environmentally friendly food consumption (Machdi *et al*. 2022 : Rimmer *et al*. 2021). Moreover, the cultivation and development of sea grapes have the potential to support food diversification and enhance the income of coastal communities (Jagtap & Meena, 2021). Research conducted in Indonesia highlights that sea grapes play a vital role in coastal dietary traditions and hold promising prospects for development, especially in improving food security and supporting local economic sustainability (Pangestuti *et al*., 2025).

Nevertheless, the utilization of sea grapes in Sopura Bay remains limited. Harvesting still depends largely on wild populations, and there is minimal scientific information on their distribution, biomass, habitat, and the environmental factors influencing their growth. To date, no systematic studies have mapped *Caulerpa* locally or assessed the environmental determinants of its growth especially in Sopura Bay, Kolaka Regency.

Therefore, this study was conducted to investigate the presence, distribution, and habitat conditions of *Caulerpa* in Sopura Bay, providing essential baseline data. The findings are expected to serve as a scientific reference for the sustainable management and development of sea grapes as a local commodity.

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METHODS

TIME AND LOCATION

This study was conducted from October to November 2025 in Sopura Bay, Kolaka Regency, Southeast Sulawesi, at five observation stations with the following coordinates specifically Station 1 (4°13'59.69"S, 121°34'43.54"E), Station 2 (4°14'46.35"S, 121°33'40.78"E), Station 3 (4°15'47.81"S, 121°32'56.06"E), Station 4 (4°15'14.24"S, 121°32'29.06"E), and Station 5 (4°14'31.65"S, 121°33'59.34"E).

SAMPLING METHOD

This study employed a descriptive exploratory approach to examine the occurrence and distribution of *Caulerpa* Observation sites were selected purposively based on the density of natural sea grape populations. Data were collected using a belt transect method along 50 m transect lines. Quadrats measuring 0.5 × 0.5 m were placed sequentially along the transect at 5 m intervals. Each *Caulerpa* individual found in the field was first cleaned to remove attached dirt or debris and identified visually using a Sea Grapes Identification Sheet. Samples were then placed in labeled bags and transported to the laboratory in a cool box to preserve their biological quality. In the laboratory, samples were further identified to the genus or species level using the online database AlgaeBase (www.algaebase.com), with careful attention to their

morphological characteristics. Each specimen was placed on a tray with a ruler or scale to indicate size, photographed for documentation, and temporarily stored in a cool box. For long-term preservation, samples were placed in sealed containers containing 70% ethanol.

In addition to population observations, environmental parameters were measured *in situ*, including temperature, salinity, pH, dissolved oxygen, light penetration, water depth, and current. Substrate conditions were also recorded visually, including fine sand, coral rubble, or a combination of both as the growth medium for *Caulerpa* This approach allowed for documenting the distribution and morphological variation of *Caulerpa*, while providing information on the environmental conditions supporting its natural growth in Sopura Bay.

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RESULT

The survey of *Caulerpa* in Sopura Bay identified two main morphotypes, *Caulerpa racemosa* and *Caulerpa lentillifera*. Both species were recorded across multiple observation stations, predominantly inhabiting fine sand and dead coral substrates, which provide stable surfaces conducive to growth (Table 1). At Station I, although *C. racemosa* was present on muddy sand, it was not dominant, with individuals occurring sporadically compared to other stations. In contrast, Stations II to V showed higher abundance of one or both morphotypes, particularly on fine sand or dead coral. Morphologically, *C. racemosa* exhibited cylindrical stolons with grape-like or clustered vesicles, while *C. lentillifera* displayed small, spherical vesicles forming dense mats. Mixed morphologies were observed in areas with combined sand and coral substrates. Environmental parameters measured in situ indicated conditions favorable for macroalgal growth (Table 2). Temperature ranged from 27–30 °C, salinity 30–33 ppt, pH 7.7–8.1, dissolved oxygen 6.3–7.5 mg/L, and light penetration exceeded 5 m.

Table 1. Distribution and Morphotypes of *Caulerpa* sp. in Sopura Bay

Station	Substrate Type	Morthotype	Characteristics
I	Muddy sand	*C. racemosa* (not dominant)	Cylindrical stolons, grape-like vesicles
II	Fine sand + muddy sand	*C. racemosa*	Cylindrical stolons, clustered vesicles
III	Fine sand + dead coral	*C. racemosa* & *C. lentillifera*	Mixed morphology, vesicle clusters
IV	Fine sand	*C. racemosa*	Cylindrical stolons, clustered vesicles
V	Dead coral	*C. lentillifera*	Spherical vesicles, dense mats

Table 2. Environmental Parameters at Observation Stations in Sopura Bay

Parameter	Average value					Optimal range
	I	II	III	IV	V	
Salinity (ppt)	30	33	32	32	31	28 – 35 [1]
pH	7,7	8,0	7,9	8,1	8,0	7,5 – 8,5 [2]
Temperature (°C)	28	28	27	30	29	26 – 30 [3]
Dissolved Oxygen (mg/L)	6,3	6,5	7,0	7,5	6,8	>5
Light penetration (%)	70	72	80	83	80	>70

Notes: [1] (Sudrajat, 2015), [2] (Campbell, 2019), [3] (Torres, 2019).

DISCUSSION

DISTRIBUTION AND MORPHOTYPES OF *Caulerpa* sp.

The presence of *Caulerpa racemosa* and *Caulerpa lentillifera* in Sopura Bay indicates that both morphotypes are well adapted to local environmental conditions. At Station I, *C. racemosa* was not dominant, suggesting that the muddy sand substrate provides a less favorable habitat compared to fine sand or dead coral. In contrast, Stations II–V, which consist of more stable and suitable substrates such as fine sand and coral rubble, exhibited higher abundance and clearer morphological development. The mixed morphologies observed at Station III further suggest co-occurrence and adaptability of both species to heterogeneous substrate conditions.

Several *Caulerpa* species have been reported to inhabit a wide range of substrates, including fine sand, coral rubble, and mixed sediments throughout the Indo-Pacific region (Ciasico, 2023; Apriliyanti *et al*. 2024); Jayusri *et al*., 2023). Ciasico (2023) documented that *Caulerpa* populations in Eastern Samar, Philippines, commonly occur on sandy-coralline rubbles to sandy-muddy bottoms. Similarly, Apriliyanti *et al*. (2024) reported that *C. lentillifera* attaches to various substrates such as coral fragments, sand, and mud under cultivation conditions. Laboratory observations by Jayusri *et al*. (2023) demonstrated that *C. racemosa* grows best on sand substrates compared to coral or volcanic rock, suggesting that substrate type strongly influences growth performance.

In Indonesian waters, *Caulerpa* communities are typically associated with sandy and coral-rubble substrates, where light penetration and substrate stability support their vegetative propagation (Rifa'i *et al*., 2025). Mixed or moderately coarse substrates tend to sustain denser and healthier thalli than soft muddy bottoms, which may restrict anchorage and nutrient diffusion (Yanti *et al*., 2024). These findings align with the present observations in Sopura Bay, where the abundance and morphology of *Caulerpa* species appear closely linked to substrate type and stability.

The co-occurrence of *C. racemosa* and *C. lentillifera* in Sopura Bay demonstrates the ecological plasticity and adaptability of both morphotypes to varying environmental conditions. Similar findings were reported by Ciasico (2023), who documented that *Caulerpa* species inhabit diverse substrate types and mixed sediments. This adaptability enables *Caulerpa* species to colonize a wide range of benthic habitats, where substrate texture and stability play a critical role in determining their distribution patterns.

At Station I, the limited presence of *C. racemosa* suggests that muddy sand is a less favorable substrate due to its unstable and low-oxygen characteristics. This pattern is consistent with the findings of Azis *et al*. (2019) who observed that *C. lentillifera* exhibited reduced growth performance on muddy or clay-rich substrates due to low light penetration, poor sediment stability, and limited water circulation. Conversely, fine sand and coral rubble provide more stable and oxygenated conditions that facilitate stronger holdfast attachment and enhanced nutrient uptake (Jayusri *et al*., 2023). Laboratory studies further confirm that substrate texture significantly affects growth and morphology. For example, *C. racemosa* cultured on sand substrates shows higher survival and growth rates compared to those grown on coral fragments or rocky surfaces (Windarto *et al*., 2025). Collectively, these results emphasize that substrate properties particularly grain size, porosity, and stability are essential determinants of natural *Caulerpa* population success.

Stations II–V in Sopura Bay, characterized by fine sand and coral rubble substrates, supported higher species abundance and more distinct morphological development. Comparable results were reported by Rifa'i *et al*. (2025), who found that green macroalgae, including *C. racemosa*, were more abundant on sandy and coral-rubble substrates than on muddy bottoms. Stable substrates enhance *Caulerpa* establishment by minimizing sediment resuspension and mechanical stress on assimilators, thereby promoting more robust population structures.

In Stasiun V, where the substrate is dead coral and the morphotype is *C. lentillifera* characterised by spherical vesicles forming dense mats, this morphology aligns with descriptions of *C. lentillifera* having globose tip ramuli and inhabiting sandy or muddy substrates in shallow protected tropical areas (Faradilla *et al*., 2022). The observed cylindrical stolons and grape-like vesicles of *C. racemosa* on fine sand/muddy sand substrata (Stations II & IV) are consistent with reports that *C. racemosa* possesses creeping stolons anchored to sandy bottoms and numerous spherical or oval lateral buds (sea grapes) (Ahmed *et al*. 2022); Salehi Balashahri *et al*. 2024).

Interestingly, mixed morphologies observed at Station III where substrate heterogeneity was greatest indicate morphological plasticity as an adaptive response to small-scale environmental variation. demonstrated that variability in substrate composition, hydrodynamic conditions, and light intensity drives morphological diversification in *C. racemosa* populations across different island typologies in Indonesia. Morphological traits such as stolon thickness, frond density, and assimilator size often reflect phenotypic plasticity that enhances species resilience and competitiveness in heterogeneous environments (Park *et al*., 2023). This flexibility enables *Caulerpa* species to maintain population stability across fluctuating benthic conditions.

Overall, the findings from Sopura Bay corroborate previous research highlighting substrate type as a critical ecological factor influencing *Caulerpa* distribution, abundance, and morphological variation. The sparse occurrence of *C. racemosa* on muddy sand underscores the importance of substrate stability for sustainable population development, while the higher abundance and clearer morphological expression observed on fine sand and coral rubble emphasize the ecological significance of stable and well-oxygenated substrates in supporting natural *Caulerpa* assemblages.

ENVIRONMENTAL CONDITIONS *Caulerpa* sp.

Environmental measurements (Table 2) indicated favorable conditions across Sopura Bay with temperature, salinity, pH, dissolved oxygen, and light penetration all within the optimal ranges for tropical macroalgal growth. Similar findings were reported by Hui *et al*. (2015) and Eviana *et al*. (2024), who demonstrated that *Caulerpa lentillifera* grows best at temperatures between 28–30 °C, salinity levels around 33–35 ppt, dissolved oxygen concentrations of 5.9–6.7 ppm, and pH values between 7.5–7.8. These parameters are consistent with optimal conditions reported for other tropical *Caulerpa* species (Fakhrulddin *et al*., 2021).

The combination of adequate environmental parameters and suitable substrate composition explains the stable presence of *C. racemosa* and *C. lentillifera* in most sampling stations. According to Ahmed *et al*. (2022), *C. racemosa* typically thrives on fine sand, coral rubble, and sandy coralline sediments, whereas muddy or silty substrates may hinder thallus attachment and reduce nutrient exchange. This is consistent with the limited abundance observed at Station I, where the substrate consisted mainly of muddy sand, providing less favorable anchorage and reduce d light penetration compared to stations with sandy or mixed substrates. Similarly, Yanti *et al*. (2024) reported that substrate type significantly affects *Caulerpa* growth performance, with coarse sandy beds supporting faster thallus expansion than silty environments.

The broad distribution of both *C. racemosa* and *C. lentillifera* across stations demonstrates their ecological adaptability to local environmental gradients. Ciasico (2023) described *Caulerpa* species as cosmopolitan macroalgae capable of colonizing sandy to sandy–muddy substrates in shallow tropical waters, while maintaining high tolerance to moderate fluctuations in salinity and light availability. Such adaptability allows these species to occupy diverse benthic habitats throughout the Indo-Pacific region.

Beyond their physiological tolerance, *Caulerpa* species contribute substantially to habitat complexity and coastal ecosystem health. Piazzi *et al*. (2001) noted that dense *Caulerpa* meadows provide structural refuge and feeding grounds for small invertebrates and juvenile fish, enhancing local biodiversity and serving as indicators of well-balanced coastal ecosystems. Therefore, the stable occurrence of *C. racemosa* and *C. lentillifera* throughout most of Sopura Bay stations reflects a favorable and resilient coastal environment capable of supporting macroalgal populations and associated biota.

CONCLUSION

This study indicates that *Caulerpa racemosa* and *Caulerpa lentillifera* are the dominant morphotypes in Sopura Bay. The distribution of these species is influenced by environmental conditions and substrate types, such as fine sand and dead coral, which provide suitable support for vegetative growth. These results suggest that Sopura Bay maintains a healthy coastal ecosystem capable of sustaining natural populations of sea grapes. The findings serve as a scientific reference for the sustainable management and potential utilization of *Caulerpa* species in the area.

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