**BIOEDUSCIENCE**
ISSN: 2614-1558
http://journal.uhamka.ac.id/index.php/bioeduscience

# Distribution and Diversity of Macroalgae in Seagrass and Coral Reef Ecosystems on the Coast

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**Abstract**

**Background:** The existence of macroalgae is threatened by various kinds of community activities, such as dumping garbage and household waste on the beach and fishing activities using boats that damage macroalgae habitat. This study aims to determine the distribution and diversity of macroalgae species in seagrass ecosystems and coral reefs on the coast in Samui Island, Surat Thani Province, Thailand. **Methods:** Data collection was carried out using the quadratic linear transect method. The transects used are 5 pieces with a square measuring 1x1 meter, as many as 10 pieces, and are supported by measurements of various physical parameters of aquatic clams. **Results:** There are 12 types of macroalgae found on the coast, of which 5 species are in seagrass ecosystems, and 7 are on coral reefs. The distribution of macroalgae in seagrass ecosystems is by attaching to sand and mud substrates, while on coral reefs, macroalgae are attached and stuck to coral rocks on reef flats. The value of macroalgae species diversity in seagrass ecosystems is low (1,381), while coral reefs are classified as medium (2,806). The value of overall macroalgae species diversity on the coast is low (2,093). The condition of physicochemical factors of waters in the form of temperature (29.20C), current Strength (23.8 cm / second), depth (124 cm), and salinity of seawater (32.9 ppt) is still in a good range for macroalgae growth, while the acidity (pH) of seawater (6.07) is in a range that is not good for macroalgae growth. **Conclusions:** The value of macroalgae species diversity in seagrass ecosystems is low, while coral reef ecosystems on the coast are classified as medium.

***Keywords:*** Distribution; diversity; seagrass; seaweed; coral reef.



**Article history**
Received: 24 Jul 2023
Accepted: 01 Dec 2023
Published: 31 Des 2023

**Publisher's Note:**
BIOEDUSCIENCE stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Citation:** Mayakun & Prathep. (2023). Distribution and Diversity of Macroalgae in Seagrass and Coral Reef Ecosystems on the Coast. *BIOEDUSCIENCE, 7*(3), 326-332. doi: 10.22236/j.bes/12402



## Introduction

Macroalgae are used as biological indicators of ecosystem health (D'Archino & Piazzi, 2021). The European Union recently used macroalgae to develop indices to monitor the ecological quality of coastal systems. Marine coastal areas are highly vulnerable to human pressure and are among the most exploited by human activities (Borja et al., 2010). Macroalgae have a long history of use in ecological assessment (Stevenson, 2014). Neto, J.M., et al (2012), state that macroalgae distribution is widely considered a good ecological indicator for monitoring surveys and impact evaluation studies.

The distribution of macroalgae is strongly influenced by environmental and habitat factors (Krupek & Branco, 2012). If environmental and habitat factors are good, then the distribution and diversity of macroalgae species will also be good. The greater the number of macroalgae species, the higher the diversity value. A good knowledge of the distribution of macroalgae in an area can tell us a lot about the dynamics of ecosystems, their resilience and pollution in the area (Katz et al., 2021). The diversity of macroalgae in estuarine environments is less when compared to that found in coastal waters, as relatively few macroalgae species are tolerant of various salinities. However, the contribution of these species to the biomass and productivity of estuaries and ports may be very significant in certain locations (Neill et al., 2012). Tropical marine ecosystems (TME) have biodiversity and include a variety of habitats, such as coral reefs, mangroves, seagrass beds, and macroalgae grasslands (Alidoost Salimi et al., 2021).

Seagrasses can grow rapidly in new areas through vege-active propagation, altering seascapes, and turning soft sandy bottoms into submerged areas of aquatic vegetation (Smulders et al., 2017; Alidoost Salimi et al., 2021). Seagrass communities in tropical reef systems are located in different environments than other seagrass beds worldwide: they are exposed to high light intensity and low nutrient concentrations in carbonate sediments (Tussenbroek, 2011). In addition to seagrasses, macroalgae are also commonly found on coral reefs. According to Chaudhury et al. (2019), coral reefs are the main habitat for marine macroalgae or seaweed. Macroalgae represent a key among coral reef communities and are important in areas such as reef structure stabilization, tropical sand production, nutrient retention and recycling, primary productivity, and trophic support.

The role of macroalgae in human economic life and ecosystems is relatively well-known (Mayakun & Prathep, 2005). According to Andral et al. (2006), in the Mediterranean, the most diverse macroalgae communities are found in coastal areas, but these areas are also among the most exposed to fishing (Andral et al., 2006; Katz et al., 2021). The use of macroalgae as food, animal feed, fertilizer, raw material in the production of industrial phycocolloids, and as a natural feed for economically important aquaculture species has received much attention in Thailand and many other countries worldwide.

The study was conducted on Samui Island in Surat Thani Province, Southern Thailand. According to Mayakun & Prathep (2005), the island has many marine habitats, such as rocky beaches, coral reefs, and sandy beaches. Samui Island has one of the richest macroalgae diversity in Southern Thailand. This study aimed to determine the number of macroalgae species attached to substrates in seagrass and coral reef ecosystems. This is because the number of macroalgae types greatly affects the value of diversity and how they attach themselves to the substrate concerning distribution.

## Method

This research was carried out on the beach of Samui Island. The samples in this study are types of macroalgae contained in observation plots on seagrass ecosystems and coral reefs on the coast of Samui Island. The tools used in this study were 1/2inch PVC pipe, 2-way connector, revolts pipe glue, hacksaw, nylon rope, 100-meter meter, sample plastic, label paper, gloves, GPS, mercury thermometer, current ball, scale stick, refractometer, pH meter, and stationery. The materials used are macroalgae samples, 4% formaldehyde, and nice tissue rolls.

Five transects were made in seagrass and coral reef ecosystems with a length of 100 meters and a distance between transects of 25 meters. In each transect, a square with a size of 1x1 meter is placed as many as 10 pieces with a distance between squares of 10 meters.

The macroalgae in each square identified habitat and counted the number of species. Habitat identification data will be used to determine distribution, while species count data will be used to calculate diversity values. Environmental factors measured are seawater temperature using a mercury thermometer, strong seawater currents using ball currents, seawater depth using scale sticks, seawater salinity using a refractometer, and seawater pH using a pH meter. Macroalgae found in seagrass and coral reef ecosystems will be identified using references according to Bhavanath et al. (2009). Distribution analysis is carried out based on the results of macroalgae observations in their habitats (seagrass ecosystems and coral reefs), and then the inventory results are made. The value of macroalgae diversity is calculated using the diversity index according to Ortiz-Burgos (2016) and Shannon-Wiener, namely $H' = -(\sum Pi \ln Pi)$ where $Pi = ni/N$. With the following macroalgae species diversity criteria: if $H'>3.3$, then species diversity is high; if $2.3< H'<3.3$, then the species diversity is moderate; and if $H'<2.3$, then species diversity is low (Li et al., 2022).

## Result

### *Types of mangroves found on the beach of Samui Island*

Based on the research results conducted on each observation plot in seagrass ecosystems, the types of macroalgae obtained can be seen in Table 1.

**Table 1.** Types of macroalgae found in seagrass ecosystems on the coast of Samui Island

| Class | Type |
|---|---|
| Chlorophyceae | *Caulerpa serrulata* (Forsskål) |
| Phaeophyceae | *Dictyopteris acrostichoides* (J. Agardh) |
| | *Padina australis* (Hauck) |
| Rhodophyceae | *Hypnea valentiae* (Turner) |
| | *Liagora viscida* (Forsskål) |

Table 1. shows that there are 5 types of macroalgae found in seagrass ecosystems on the coast of Samui Island, where 1 type is from the Chlorophyceae class, 2 types are from the Phaeophyceae class, and 2 types are from the Rhodophyceae class. The types of macroalgae found in coral reef ecosystems on the coast of Samui Island can be seen in Table 2.

**Table 2.** Types of macroalgae found in coral reef ecosystems on the coast of Samui Island

| **Class** | **Type** |
|---|---|
| Chlorophyceae | *Dictyosphaeria cavernosa* (Forsskål) |
| Phaeophyceae | *Sargassum cincitum* (J. Agardh) |
| | *Acantophora specivera* (M. Vahl) |
| | *Gracilaria corticata* (J. Agardh) |
| Rhodophyceae | *Gracilaria dura* (C. Agardh) |
| | *Gracilaria salicornia* (C. Agardh) |
| | *Laurensia papilosa* (C. Agardh) |

Table 2. shows that there are 7 types of macroalgae found in coral reef ecosystems on the coast of Samui Island, where 1 type is from the Chlorophyceae class, 1 type is from the Phaeophyceae class, and 5 types are from the Rhodophyceae class.

### *Distribution of macroalgae in seagrass ecosystems and coral reefs on the coast of Samui Island*

Based on the research results conducted on each observation plot in seagrass and coral reef ecosystems, the distribution of macroalgae can be seen in Table 3.

**Table 3.** Distribution of macroalgae in seagrass ecosystems and coral reefs on the coast of Samui Island

| **Type** | **Ecosystem** | | **Habitat Distribution** |
|---|---|---|---|
| | **Seagrass** | **Coral Reefs** | |
| *Caulerpa serrulata* | √ | - | Attached to the sand in seagrass beds |
| *Dictyosphaeria cavernosa* | - | √ | Attached to coral fragments on reef flattening |
| *Dictyopteris acrostichoides* | √ | - | Clinging to sand and mud in seagrass beds |
| *Padina australis* | √ | - | Attached to the sand in seagrass beds |
| *Sargassum cincitum* | - | √ | Sticking to rocks on flattened reefs |
| *Acantophora specivera* | - | √ | Attached to rocks on reef flats |
| *Gracilaria corticata* | - | √ | Attached to rocks on reef flats |
| *Gracilaria dura* | - | √ | Attached to rocks on reef flats |
| *Gracilaria salicornia* | - | √ | Attached to rocks on reef flats |
| *Hypnea valentiae* | √ | - | Attached to the sand in seagrass beds |
| *Laurensia papilosa* | - | √ | Attached to rocks on reef flats |
| *Liagora viscida* | √ | - | Attached to the sand in seagrass beds |

Table 3 shows that the distribution of macroalgae in seagrass ecosystems in the coastal waters of Samui Island is carried out by attachment to sand and mud in seagrass beds. Meanwhile, the distribution of macroalgae in coral reef ecosystems in the coastal waters of

Samui Island is carried out by attaching to coral fragments corals and sticking to rocks on the reef flat.

### *Diversity of macroalgae species in seagrass ecosystems and coral reefs on the coast of Samui Island*

Based on the calculation results, the value of macroalgae species diversity in seagrass ecosystems and coral reefs in the coastal waters of Samui Island can be seen in Figure 1.

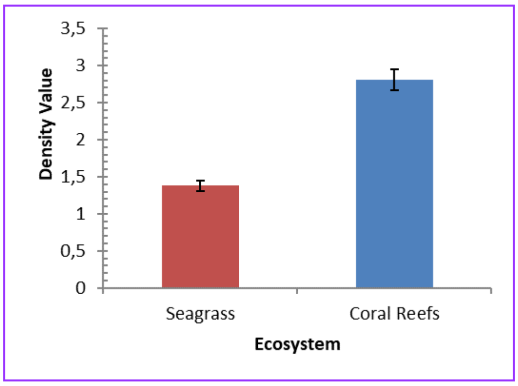


**Figure 1.** Histogram of Macroalgae Species Diversity Value in Seagrass Ecosystems and Karag Reefs on Samui Island Beach

Figure 1. shows that the value of macroalgae species diversity in seagrass ecosystems is 1.381. The value of macroalgae species diversity in coral reef ecosystems is 2,806.

### *Conditions of physical factors of aquatic chemistry on the coast of Samui Island*

Based on the results of measurements made on each observation plot, the average value of the physical-chemical factors of the waters on the coast of Samui Island can be seen in Table 4.

**Table 4.** The average value of physical and chemical factors of waters on the coast of Samui Island

| Environmental Parameters | Ecosystem | |
|---|---|---|
| | Seagrass | Coral Reefs |
| Temperature ($^0$C) | 28,9 | 29,6 |
| Current strength (cm/second) | 22,8 | 24,8 |
| Depth (cm) | 111,9 | 136,1 |
| Salinity (ppt) | 32,8 | 33,1 |
| pH | 6,35 | 5,79 |

Table 4 shows that the average seawater temperature in seagrass ecosystems is 28.9$^0$C, and in coral reef ecosystems, it is 29.6$^0$C. The average strong current of sea water in seagrass ecosystems is 22.8 cm/second, and in prohibitive reef ecosystems, it is 24.8 cm/second. The average depth of seawater in seagrass ecosystems is 111.9 cm, and coral reefs are 136.1 cm. The average salinity of seawater in seagrass ecosystems is 32.8 ppt, and that of coral reef ecosystems is 33.1 ppt. The average pH of seawater in seagrass ecosystems is 6.35, and that of coral reef ecosystems is 5.79.

## Discussion

### *Types of mangroves found on the beach of Samui Island*

The large number of macroalgae species from the Rhodophyceae class in seagrass ecosystems and coral reefs on the coast of Samui Island is because the Rhodophyceae class has a larger number of species distributed. This is supported by Lyra et al. (2015), who state that macroalgae of the class Rhodophyceae occupy the largest order of the number of species distributed. The growth and spread of macroalgae are strongly influenced by environmental factors such as waves and light, which are strongly influenced by water depth (Bi et al., 2014). In addition, the large number of macroalgae species from the Rhodophyceae class due to the physical-chemical conditions of the waters in seagrass ecosystems and coral reefs on the coast of Samui Island is still in the optimum range. Rhodophyceae, as mangrove associations mainly in South Africa and elsewhere, include Gelidium, Polysiphonia, Catenella, and Murrayella species (Prinsloo, 2012).

Also, the large number of macroalgae species of the Rhodophyceae class is due to the types of the Rhodophyceae class that were found to have the ability to adapt to changes in the Ph of seawater in Samui Island so that the number of species found (5 types) is more than the types of the Phaeophyceae class (3 types), and the types of the Chlorophyceae class (2 types). Macroalgae are found most abundantly in northern regions, although this may be due to the higher sampling frequency and greater number of sampling locations in these areas (Peerapornpisal et al., 2006).

### *Distribution of macroalgae in seagrass ecosystems and coral reefs on the coast of Samui Island*

The distribution of macroalgae in coral reef ecosystems is carried out by attaching and sticking their holdfast in coral rocks. Coral reefs, as buffer zones, absorb most of the impacts of waves and tropical storms, reducing the force of the oceans when they reach the shores of natural and artificial communities. Coral reefs protect beaches from flooding and erosion and provide some ecosystem services (Mumby & Steneck, 2008). While some coral reefs are found in deeper waters, most occur in the shallower tropics in subtropical waters between 30°N and 30°S (Liu, 2018).

The distribution of macroalgae in coral reef ecosystems is carried out by attaching and sticking their holdfast in coral rocks. Coral reefs are the most diverse marine ecosystems and the largest biogenic structures on Earth (Liu, 2018). Diaz-Pulido & McCook (2008), species variation is also determined from the combination of substrate structures.

### *Diversity of macroalgae species in seagrass ecosystems and coral reefs on the coast of Samui Island*

Macroalgae are widespread and can grow intensively on the surface of reefs in the ocean's intertidal zone and form intertidal seaweed beds that are important for nearshore marine ecosystems. Intertidal macroalgae communities have crucial ecosystem functions in maintaining biodiversity water quality and as primary productivity locations (Li et al., 2022). Li et al. (2022) explain that if $H'>3.3$, then species diversity is high; if $2.3< H'<3.3$, then the species diversity is moderate; and if $H'<2.3$, then species diversity is low. Based on these criteria, it can be concluded that the diversity of macroalgae species in coral reef ecosystems is moderate (2,806). The diversity of macroalgae species in seagrass ecosystems is low (1,381).

The value of macroalgae species diversity at coral reef ecosystem stations is moderate because coral reef ecosystems are dominated by hard substrates such as rocks and corals, where these substrates are needed by macroalgae to plug and attach themselves so that they are not released when hit by currents, and protected from strong waves. This is the opinion of Nyabakken (1992), who explained that rocky substrates in intertidal areas are the most densely populated and have the greatest diversity for both animal and plant species, while the diversity is small for sandy substrates. Some of the services provided are that of a local and global food resource, the potential to aid in scientific advances in drug development, the support of local economies, and the important part they play in many coastal cultural activities and practices (Mumby & Steneck 2008).

The value of macroalgae species diversity in seagrass ecosystems is low because it has substrates in the form of sand and mud. This causes the limitation of hard substrate for macroalgae to attach and stick themselves so that when large waves occur, many macroalgae are found released and washed up along the shore. This follows the opinion of Melsasail (2016) which explains that in waters with sand and mud substrates, macroalgae are usually found in small quantities due to the limited hard objects that are sturdy and strong enough to be used as a place to attach themselves.

The overall value of macroalgae species diversity in the coastal waters of Samui Island is low (Table 4.). The low value of macroalgae diversity is due to the small number of species found. It was further explained that a community will have high diversity if it is composed of many types; otherwise, it will have low diversity if it is composed of few types. In addition, the low value of macroalgae species diversity is influenced by unclean water conditions. This is shown by the amount of garbage scattered on the beach, causing seawater to become acidic (Table 4.), thus affecting macroalgae life. The density of macroalgae is affected by seasonal changes, unstable substrate conditions, and coral exposure, leading to low species distribution and dominant individuals (Bruckner & Dempsey, 2015).

### *Conditions of physical factors of aquatic chemistry on the coast of Samui Island*

The average temperature is still within the optimum range for macroalgae growth. The average current strength is still within the optimum range for macroalgae growth. The average depth of seawater is still within the optimum range for macroalgae growth. The average salinity of seawater is still within the optimum range for macroalgae growth. A good salinity range for macroalgae growth (Xiang & Ruan, 2002; Li et al., 2021).

The cause of the pH condition of seawater is not for the growth of macroalgae due to unclean water conditions. This is shown by the amount of garbage scattered on the beach, causing seawater to become acidic or pH>7 (Table 4.). This is consistent with the statement of Doney et al. (2009); Cornwall et al. (2013) that changes in the pH of seawater are caused by increasing atmospheric carbon dioxide ($CO_2$) by burning human fossil fuels, reducing ocean pH and causing major shifts in seawater carbonate chemistry.

## Conclusions

There are five types of macroalgae found in seagrass ecosystems. In comparison, there are seven types and distributions of macroalgae in coral reef ecosystems in seagrass ecosystems. They attach to sand and mud substrates; on coral reefs, they attach and stick to rocks on reef flats. Then, the value of macroalgae species diversity in seagrass ecosystems is low, while it is classified as medium in coral reef ecosystems. In addition, the condition of physical-chemical factors in the form of temperature, current strength, depth, and salinity of seawater is still within the optimal range for macroalgae growth.

## Declaration statement

The authors reported no potential conflict of interest.



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