CHAPTER I

INTRODUCTION

1.1 Background

Seagrass are flowering plants that have fully adapted to submerged aquatic life in the near shore marine environment and are known for their important role in the overall health of the marine environment. Seagrass diversity is relatively low compared to other marine taxa, such as fish and coral, consisting roughly of 72 species worldwide (Short et al., 2011). However, a single seagrass species is capable of forming vast ecosystems that extend for multiple kilometres along the coastline (Leopardas et al., 2014). By lowering wave action, it increases the deposition of organic and inorganic materials, favoring the existence of more invertebrate species, which can lead to greater prey availability for economically significant fishes than surrounding unvegetated areas (Alsaffar et al., 2020). The presence of seagrass in coastal environments increases habitat complexity and ecological niches (Ambo-Rappe, 2016; Smith et al., 2014), making it one of the most productive of the classic marine habitats.

Despite their importance, these ecosystems are constantly being threatened by natural factors such as weather variations and changes in current flow velocity and circulation patterns, and the increasing anthropogenic pressures. Coastal construction, eutrophication, dredging, trawling, sewage discharges, and recreational activities have significantly increased seagrass fragmentation in recent years (Alsaffar et al., 2020; Unsworth et al., 2018; Short & Wyllie-Echeverria, 1996). This fragmentation threatens organisms that have found shelter in seagrass meadows, with associated species being the most negatively affected (McCloskey & Unsworth, 2015). Fragmentation can have far-reaching consequences, reducing ecological connectedness among coastal habitats and food webs, disturbing the ecosystem resilience, functioning, and food security of local people (Alsaffar et al., 2020).

The effect of seagrasses on associated fauna is generally well understood; seagrass beds enhance faunal diversity by providing structural habitat, food, nursery grounds, protection from predators, and a much larger range of available niches than areas devoid of vegetation (Daudi et al., 2023; Ambo-Rappe, 2016). Previous research has investigated the effect of seagrass identity on invertebrates; however, much of this research has been conducted in monospecific seagrass beds (Bostrijm & Bonsdorff, 1997). The tropical Indo-Pacific hosts the highest diversity of seagrasses (24 species), where beds are often multispecific, with as many as 14 species co-occurring in a single
Short et al., 2007). In Indonesia specifically, 18 species of seagrass
evipendunculata and *Halophila spinulosa* have been recorded
2025; Kurniawan et al., 2024; Yasir & Moore, 2021).

dron ciliatum* is a species widely distributed across the Indo-Pacific;
ia, its distribution is very patchy with often sightings in South
nba and Flores Sea but also spotted in Sanger, Rotendao, Small
f-Ohoiwa), Kema, Batanta, Wakatobi and Selayar (Supriyadi et al.,

2024; Rani et al., 2020). *Thalassodendron ciliatum* is a species that has thick-woody rhizomes and forms dense bush-like meadows that increase its structural complexity (den Hartog, 1970). This seagrass is usually found growing in monospecific communities that are dominant on sand, rubble (dead coral fragments), and hard substrates (Priosambodo, 2007), however it has been observed to grow in multispecific beds as well (Johan et al., 2025; Kuriandewa et al., 2003).

Macroinvertebrates are those invertebrates with a body size large enough to be seen by the naked eye, usually referring to fauna retained by a 500-μm mesh (Jacobsen et al., 2008; Hauer & Resh, 2007). Though a general trend among stream ecologists is to use collecting methods employing finer-meshed collecting nets, during this research our collection method based on those organisms that were visible with the naked eye. This group comprise mostly insects as well as crustaceans, mollusks, polychaetes, and other taxa

Current knowledge on whether epibenthic macroinvertebrates are dependent on seagrass species identity as they are to seagrass structural complexity and whether epibenthic invertebrate community structure varies between *Thalassodendron ciliatum*-dominated seagrass beds and beds dominated by other seagrass species is lacking. If the responses of associated invertebrates differ among seagrass species, then seagrass identity within a meadow may directly or indirectly determine the structure of the epibenthic invertebrate communities, and may be a good predictor of invertebrate abundance and biodiversity patterns (Ambo-Rappe et al., 2013).

This study examined effects of *Thalassodendron ciliatum* on associated invertebrates through a quantitative comparative study. We hypothesized that invertebrates living on the surface of the sea floor are affected by the structure of seagrass based on past studies (Nakaoka, 2005; Orth et al., 1984). So, we expected that differences in seagrass species, hence the difference in shape and size of seagrass plants, would influence the community structure of epibenthic invertebrates associated with the seagrass. To test this idea, we compared the epibenthic invertebrates found in seagrass beds with two different dominant seagrass meadow types: *Thalassodendron ciliatum*-dominated seagrass beds and mixed seagrass beds. The study took place in Tomia, Wakatobi National Park (WNP), Indonesia.

1.2 Objectives and Benefits

The aim of this study is to investigate how seagrass habitat characteristics influence the structure and community patterns of epibenthic invertebrates in tropical coastal ecosystems. To address this research aim, the study was designed around the following specific objectives:

1.2.1 To compare the composition, species richness, and abundance of epibenthic
communities between seagrass beds dominated by
dron ciliatum and mixed seagrass beds.
whether seagrass species identity (habitat type) significantly
structure of epibenthic invertebrate communities.
is expected to enrich the knowledge of marine ecology, particularly
al role of specific seagrass species in tropical regions.

CHAPTER II

RESEARCH METHODS

2.1 Study Site

This research was conducted from February 8th to 15th, 2025, along the coasts of Tomia Island, Wakatobi National Park, Indonesia. Four sampling locations were selected based on the presence of extensive seagrass meadows and, specifically, the known occurrence of *Thalassodendron ciliatum* (Figure 1).

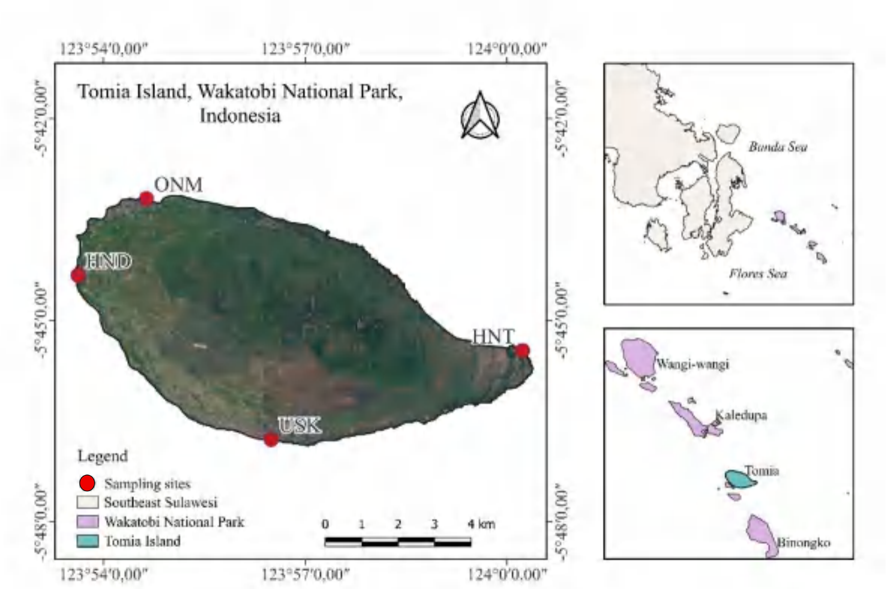

Figure 1. Study area map showing sampling sites on Tomia Island, part of Wakatobi National Park, Southeast Sulawesi, Indonesia. The four sampling locations are ONM (Onemay), HND (Pantai Hondue), USK (Usuku), and HNT (Pantai Hu'untete).

2.1 Materials

To carry out the fieldwork, several tools and materials were used for sampling, measuring, recording data, and identifying species. The complete list of equipment is shown in Table 1.

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e involved a literature review to establish the theoretical framework ith advisors to finalize the research design and methodology. ere selected based on pre-surveys and existing data indicating the presence of both mixed-species seagrass beds and beds dominated by *Thalassodendron ciliatum*.

Table 1. The materials used in this study.

No	Tools and materials	Use
1	Stationery	Documenting data
2	Camera	Taking pictures
3	Thermometer	Measuring temperature
4	Metric tape 100 cm	Measuring depth
5	Waterproof paper	
6	Hand refractometer	Measuring salinity
7	GPS/Phone	Define coordinate points
8	Surveying tape 100 m	Making transects
9	Seagrass Identification Book	Identifying seagrass species
10	Macroinvertebrates Identification Book	Identifying macroinvertebrates
11	Plot 1x1	Sampling
12	Snorkel and fins	Underwater mobility for sampling

2.2.2 Data Collection

Seagrass and macroinvertebrate communities were surveyed at two spatial scales: (1) a small scale, comparing *T. ciliatum*-dominated seagrass beds to mixed seagrass beds within each site, and (2) a large scale, comparing communities among the four different sites: ONM (Onemay), HND (Pantai Hondue), USK (Usuku), and HNT (Pantai Hu'untete) (Figure 2).

Seagrass Data

Seagrass species, cover and shoots were counted within a 1 m x 1 m quadrat (subdivided into four sections for easier counting. Sampling was done by snorkeling along transect lines deployed perpendicular to the shoreline across the seagrass beds (up to a
500 m offshore). Quadrats were placed systematically along each
mber of quadrats depending on the size of each seagrass bed,
ely 10% coverage of the total seagrass bed area in each habitat
on *ciliatum*-dominated seagrass beds and mixed seagrass beds
2). Other parameters such as substrate, depth, and tide stage were
drat.

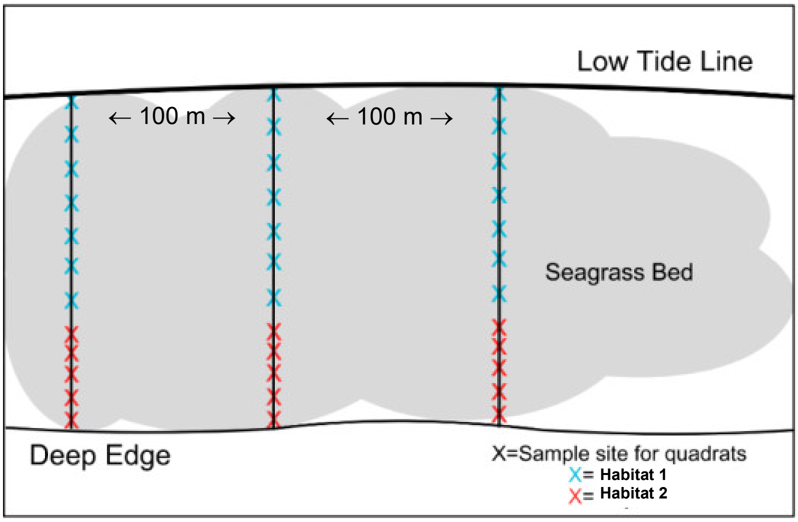

Figure 2. Seagrass and invertebrate data collection model. Habitat 1 stands for mixed seagrass beds and Habitat 2 stands for seagrass beds dominated by *Thalassodendron ciliatum.* The length of the transects depended on the seagrass bed area.

Macroinvertebrate Data

The survey focused on invertebrates living on the surface of seagrass beds. All visible invertebrates within each 4 m² plot were counted (for subsequent analyses, these data were standardized to individuals per meter ind./m2 units), recording only living organisms without the use of a mesh or other collection devices. No data were collected from infauna invertebrates. Every organism was recorded with a code on site and carefully photographed to facilitate further identification. No live samples were taken back to the laboratory due to regulations set by the Wakatobi National Park (WNP).

Environmental data

Environmental data were collected on a daily basis between February 8 and 15, 2025. The characteristics recorded were sea surface temperature, salinity, depth, and tidal conditions. The sea surface temperature was measured in situ with a mercury thermometer, with three replicate measurements made at each sampling point and averaged for analysis. Salinity was determined using a handheld refractometer on surface water samples obtained at each site. Water depth was measured with a calibrated metric tape and measuring rod. Tidal data were gathered as secondary data

ts app and utilized to contextualize field observations.

ere conducted using R v.4.3.3 software (R Core Team, 2024). We

ted in whether *T. ciliatum*-dominated seagrass beds support distinct invertebrate assemblages compared to mixed seagrass bed, and we ensured our sampling was replicated across different sites to capture random spatial variation. For comparisons between samples and sample groups, we utilized several ecological metrics of the invertebrates:

2.4.1. Biodiversity metrics

Species richness, abundance, the Shannon-Wiener Diversity Index (H'), and Pielou's Evenness (J') were calculated for invertebrate communities (Magurran, 2005; Pielou, 1966; Shannon, 1948).

2.4.2. Data modelling

Multivariate

For visualizing patterns in invertebrate epifaunal community structure, a non-metric multidimensional scaling (NMDS) using Bray–Curtis dissimilarities was first attempted (metaMDS in vegan). However, NMDS converged on a configuration with extremely low stress (≈ 0), and the ordination presented plotting artefacts due to many identical/near-identical samples or low multivariate complexity. Therefore, to visually represent multivariate distances we used Principal Coordinates Analysis (PCoA) on Bray–Curtis distances (cmdscale/capscale), which preserves the pairwise distance relationships and produced an interpretable ordination plot. The analysis was conducted in vegan (Oksanen et al., 2013). Rows with zero total abundance were removed prior to analysis because Bray–Curtis cannot be calculated for empty samples. Bray–Curtis dissimilarities were then computed from the community matrix, and PCoA was performed to visualize multivariate dispersion among habitat types (*Thalassodendron ciliatum*-dominated seagrass beds vs. mixed seagrass beds).

To statistically test for differences in community composition, we applied a non-parametric multivariate analysis of variance (PERMANOVA; Anderson, 2001) using adonis2() with the same distance matrix. PERMANOVA can accommodate unbalanced designs and tests whether centroids of groups differ in multivariate space. Multivariate dispersion (homogeneity of variance) was examined using betadisper followed by a permutation test. All analyses were based on 999 permutations.

Univariate

The richness and abundance data were further analyzed with Generalized Linear Mixed Models (GLMMs), as they offer more accuracy and flexibility when working with count
09). Negative Binomial GLMM was employed for abundance due
ersion (dispersion = 2.42, p<0.001), while species richness was
sson GLMM (Gardner et al., 1995). Model selection involved using
) function. This allowed us to compare candidate models based on
es of freedom, and Akaike weights.