The growth and population dynamics of seagrass Thalassia hemprichii in Suli Waters, Ambon Island

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Abstract. The objectives of the research were to determined growth of rhizome, age structure, recruitment rate, and mortality rate of Thalassia hemprichii. Data were collected by using reconstruction technique which the measurements were based on past growth history. The age of seagrass was based on plastochrone interval. The recruitment rate was estimated by age structure of living shoots while mortality rate was estimated by age structure of dead shoots. The research was conducted on coastal waters of Suli where divided into two stations with different substrates, namely mixed substrates of sand and mud (S1) and mixed substrates of sand and coral fragment (S2). The growth rate of horizontal rhizome ranged from 4.15-8.68 cm.year⁻¹ whereas the growth rate of vertical rhizome was 1.11-1.16 cm.year⁻¹. The average age of T. hemprichii varied between 3.22-4.15 years. The youngest shoots were found at age 0.38 years and the oldest shoots were 7.82 years. Distribution of age was polymodal which reflecting cohort. The recruitment rate ranged from 0.23-0.54 year⁻¹. Otherwise, the mortality rate ranged from 0.21-0.26 year⁻¹. Seagrass population of T. hemprichii in Suli Waters indicated an increasing condition which shown by higher recruitment rate than mortality rate.

1. Introduction

One of the coastal ecosystems that can be found on Ambon island is seagrass ecosystem. The seagrass ecosystem is found to flourish in tidal areas, coastal waters or lagoons that essentially are mud, sand, gravel and dead coral fragments at up to 4 meters depth. In clean waters, seagrass can be found growing up to 8-15 meters even up to 40 meters depth [1]. These ecosystems have important functions as sediment traps, stabilizing basic sediments, reducing wave and current energy (physical functions), and ecological functions such as providing important habitats and shelter for some animal species and habitats that rich in nutrients substances for flora and fauna diversity.

Suli coastal waters which are part of Ambon Island waters have a fairly dense seagrass ecosystem with healthy status [2]. One of the species found abundantly in this waters is Talassia hemprichii. This species is found to grow and spread on muddy, sandy substrates up to coral beds.

Recently, the utilization of coastal area has been higher along with the increasing of establishment. This has resulted in greater changes to the environment and the resources in it. The utilization activities such as solid and liquid waste disposal to the sea, sand and stone mining, boat docking and bameti conducted by people of Suli coastal area are feared could impact on the degradation of seagrass ecosystem. This problem can occur due to lack of public awareness on the role of seagrass ecosystem and the minimum information about the biology of seagrass itself. The biological aspect that still lacks of information is about dynamics population including growth of rhizome, age structure, recruitment...
and mortality. To date, the research on seagrass growth is mostly conducted on the leaves. The growth of seagrass other than from the length of the leaves can also be determined by the length of rhizome [3]. Seagrass can reproduce asexually (vegetative) through rhizome elongation [4]. From rhizome, the growth, age structure, recruitment rate and mortality rate can be determined. Thus, this research was aimed to determine the population dynamics of seagrass T. hemprichii which includes rhyzome growth, age structure, recruitment rate and mortality rate.

2. Method

2.1. Sample collection method
This research was conducted on 2 observation stations based on substrate difference located in Suli Waters. Station 1 represents muddy sand substrate and Station 2 represents sand substrate mixed with coral fragments. Seagrass samples of T. hemprichii were collected in squares of 1 x 1 m size, as many as 10 observation squares covering minimum 200 stands [5]. The seagrass samples were then calculated for dead shoot and live shoot, number of vertical nodes and internodes, number of horizontal nodes and internodes, number of leaves, number of living roots, as well as calculated the length and width of leaves, horizontal length of rhizome between two shoots and vertical length of rhizome.

2.2. Data analysis method
Age estimation is generated in interval plastochrone unit which was then converted into an absolute time unit. Interval plastochrone is defined as the average time interval between the successive growth of two leaves in one shoot [6, 5, 7].

The growth rate of horizontal rhizome was estimated as the slope of linear regression equation between rhizome length between shoot connected along the rhizome cut (y) and the age difference of shoots. Similarly, the growth rate of vertical rhizome was estimated as the slope of linear regression between vertical rhizome length (y) and the age of the shoots.

Recruitment rate (in unit per year) was estimated from the total number of shoots (\( \sum_{t=0}^{\infty} N_t \)) and the number of shoots in more than one year (\( \sum_{t=1}^{\infty} N_t \)) contained in the population [8, 5, 7] as follows:

\[
R_{gross} = \ln \sum_{t=0}^{\infty} N_t - \ln \sum_{t=1}^{\infty} N_t
\]

Mortality rate was calculated based on exponential decrease from the number of dead stands with age and allows the estimation of mortality rate of exponential shoots (M, in units per time).

\[
N_t = N_0 e^{-Mt}
\]

\( N_0 \) is the number of dead shoots of the same age as the model, and \( N_t \) is the number of dead shoots at age interval in t time [8]. The growth rate of net population was calculated as the difference between annual recruitment and mortality.

Mortality (M) and recruitment (R) were used to evaluate the seagrass population status and to predict its growth [8].

If \( R > M = \) Population increased
\( R = M = \) Population balanced
\( R < M = \) Population decreased
3. Result and discussion

3.1. Substrate of research station

Seagrass grows almost in all substrate types ranging from muddy substrates to coral fragments. In the Suli waters, seagrass is found to be dominant in muddy sand and mixed muddy with coral fragments. Substrate fraction composition in two observation station can be seen in Table 1. In Table 1, it is seen that in substrate station 1 is dominated by fine sand followed by very fine sand, while station 2 is dominated by medium sand. This type of substrate supports the growth of T. hemprichii seagrass. According to Tomascik et al., [9] that T. hemprichii is an abundant species of seagrass in intertidal areas on coral reefs with sand substrate and coral fragments. Substrates play a role as a protector of plants from ocean currents and as a place of processing and suppliers of nutrients [10].

Table 1. Percentage of substrate fraction size at both Suli waters research stations

| Station | Percentage of substrate fraction size (%) |
|---------|-----------------------------------------|
|         | G (4mm) | VCS (2mm) | CS (1mm) | MS (0.50mm) | FS (0.25mm) | VFS (0.125mm) | S (0.063mm) | C (0.0038mm) |
| 1       | 0       | 0        | 6        | 14         | 44         | 23           | 12          | 0           |
| 2       | 8       | 8        | 11       | 46         | 25         | 0            | 0           | 0           |

Note: G = gravel; VCS = very coarse sand; CS = coarse sand; MS = medium sand; FS = fine sand; VFS = very fine sand; S = silt; C = clay

3.2. Rhizome growth

Rhizome in monocots such as seagrass T. hemprichii is a modification of the stem which also contained two or more vascular bundles and numerous fiber bundles to distribute nutrient needs. Rhizome develops extensively and has a major role in vegetative propagation. This vegetative propagation is more important than generative propagation because it is more profitable for seagrass dispersal. The average length of horizontal rhizome T. hemprichii between two shoots in the Suli waters ranged from 4.51 ± 1.99 - 4.56 ± 1.88 cm, where the longest size was 12.50 cm and the shortest size was 1.00 cm (Table 2). Its growth rate ranges from 4.15 - 8.68 cm.year⁻¹ (Table 2). This value is smaller when compared to the growth rate of horizontal rhizoma T. hemprichii in the waters of Tanjung Tiram, Poka [11]. Also it is also smaller when compared to other species of seagrasses such as Cymodocea nodosa [7]. Morphologically the horizontal rhizome of the genus Cymodocea is smaller but longer than the genus Thalassia [12, 13].

The average length of vertical rhizomes ranges from 1.80 ± 1.72 - 2.43 ± 1.89 cm, where the longest length was 9.90 cm and the shortest size was 0.30 cm (Table 2). The growth rate of vertical rhizomes ranges from 1.11 - 1.16 cm.year⁻¹ (Table 2). The vertical rhizome consists of some nodes and internodes. The longer the vertical rhizome, the more nodes and internodes, which characterize the older or longer life of the seagrass shoot, on the contrary, the shorter the vertical rhizome, the less the nodes and the internodes that characterize the younger or new shoot.

In one shoot consist of 2 - 5 leaves with an average length of 12.45 ± 4.82 - 13.87 ± 5.31cm, where the longest size was 28.30 cm and the shortest size was 1.20 cm (Table 2). The average leaf width was 0.76 ± 0.18 - 0.91 ± 0.18 cm, the largest leaf width was 2.60 cm, and the smallest leaf width was 0.30 cm. The size of this seagrass leaves was much larger than the T. hemprichii seagrass found in Tanjung Tiram, Poka with an average length of 5.68 ± 2.17 and the average width of 0.59 ± 0.12 [11]. The average production of leaves of both stations was the same, that is 13.04 leaves.year⁻¹ (Table 2.). Production of this leaf was also greater than the production of T. hemprichii leaves in the waters of Tanjung Tiram, Poka as much as 12.71 [11]. If the results of this study were compared with the results of the study on the species C. nodosa, then the species of C. nodosa has more varied leaf production in one year as many as 12-14 leaves.year⁻¹ [5].
Table 2. Summary of rhizome growth and morphometric of *T. hemprichii* (Mean ± standard errors) at the two stations

|                           | St 1          | St 2          |
|---------------------------|---------------|---------------|
| Average length of horizontal rhizomes (cm) | 4.56±1.88     | 4.51±1.99     |
| Longest horizontal rhizome (cm)          | 12.50         | 12.00         |
| Shortest horizontal rhizome (cm)         | 1.20          | 1.00          |
| Horizontal rhizome elongation cm.year⁻¹   | 4.15          | 8.68          |
| Average length of vertical rhizomes (cm) | 2.43±1.89     | 1.80±1.72     |
| Longest vertical rhizome (cm)            | 9.90          | 9.60          |
| Shortest vertical rhizome (cm)           | 0.30          | 0.30          |
| Vertical rhizome elongation (cm.year⁻¹)  | 1.16          | 1.11          |
| Average production of leaf (leaves.year⁻¹)| 13.04         | 13.04         |
| Average leaf length (cm)                | 12.45±4.82    | 13.87±5.31    |
| Longest leaf (cm)                      | 24.00         | 28.30         |
| Shortest leaf (cm)                     | 1.20          | 3.00          |
| Average leaf width (cm)                | 0.91±0.18     | 0.76±0.18     |
| Biggest leaf width (cm)               | 2.60          | 2.40          |
| Smallest leaf width (cm)               | 0.30          | 0.40          |
| Average number of leaves (shoots⁻¹)     | 2.86±0.83     | 3.10±0.69     |

3.3. Age Estimation
The seagrass age structure of the Suli Coastal Waters is shown in Table 3 and Figure 1. The age of *T. hemprichii* ranges from 0.38 to 7.82 years. *T. hemprichii* in Suli Coastal Waters is mostly concentrated at the age of 0.50 -1.99 years, that is 12 - 39%. This indicates that most *T. hemprichii* population at the two stations in the Suli Coastal Waters are new shoot or a young shoot. New shoot or young shoots are characterized with shorter vertical rhizomes, fewer vertical internodes, fewer leaves and more life roots. The average age of *T.hemprichii* ranges from 3.22 to 4.15 years (Table 3). The youngest shoots were found to be 0.38 years old and the oldest was 7.82 years old (Table 3). Tupan *et al.* [11] found *T. hemprichii* on the Tanjung Tiram, Poka having an age range of 0.38 - 7.36 years. Compared to this research, *T. hemprichii* of Suli waters have a slightly longer lifetime than seagrass of Tanjung Tiram Poka. Cunha and Duarte [5] found the oldest *C. nodosa* in Ria Formosa, southern Portugal with the oldest age of 7.6 years, and not much different from this study. The old seagrass is characterized by more vertical internodes, longer vertical rhizome length and more leaves.

3.4. Mortality and Recruitment
Figure 1. shows the distribution of shoots age is polymodal which reflects the presence of cohort, and looks very oblique indicating a high mortality rate. This annual cohort is due to an annual cycle in the rhizomes growth [7]. This figure also shows the more the age; the less *T. hemprichii* shoots survive, which indicating high mortality rates of shoot.

The age structure of dead shoots shows the number of dead shoots ranging from 0.00 – 4.99 years old, and most shoots die at less than 2 years old (Figure 3). This condition indicates the high mortality occurred in the first years (Figure 3). The mortality rate found ranging between 0.21 – 0.26 year⁻¹ (Table 4). The mortality rate in this research was smaller than the mortality rate in Tanjung Tiram Waters, Poka which found between 0.69 – 0.89 years⁻¹ [11], and also smaller that mortality rate of *C. nodosa* which ranging between 0.99 – 3.70 year⁻¹ [5].

Recruitment rate describes the population growth rate obtained ranging between 0.23 – 0.54 year⁻¹ (Table 4). This value is smaller than the recruitment rate of *T. hemprichii* population in Tanjung Tiram Poka with range value of 0.29 – 0.72 year⁻¹ [11] and *C. nodosa* seagrass population with range of 0.7 –
3.6. year\(^{-1}\) [5]. The net growth rate of population varies considerably from non-growth to growth in the range of 0.02 – 0.33 years\(^{-1}\) (Table 4). The low net growth rate of population is in line with the low growth of rhizomes. This limited growth of rhizomes reduces the recruitment of the seagrass shoots.

### Table 3. Age shoots of *T. hemprichii* at the two stations

| No | Age range (year) | percentage of life shoots | percentage of dead shoots |
|----|------------------|---------------------------|---------------------------|
|    |                  | St 1 | St 2 | St 1 | St 2 |
| 1  | 0.00 - 0.49      | 0.97 | 1.93 | 15.63 | 31.25 |
| 2  | 0.50 - 0.99      | 19.81 | 39.61 | 31.25 | 50.00 |
| 3  | 1.00 - 1.49      | 23.67 | 26.57 | 21.88 | 6.25 |
| 4  | 1.50 - 1.99      | 18.84 | 12.08 | 3.13 | 3.13 |
| 5  | 2.00 - 2.49      | 8.70 | 3.86 | 3.13 | 0.00 |
| 6  | 2.50 - 2.99      | 6.76 | 3.86 | 6.25 | 3.13 |
| 7  | 3.00 - 3.49      | 7.73 | 2.90 | 3.13 | 0.00 |
| 8  | 3.50 - 3.99      | 5.80 | 2.90 | 9.38 | 3.13 |
| 9  | 4.00 - 4.49      | 1.93 | 0.97 | 0.00 | 3.13 |
| 10 | 4.50 - 4.99      | 1.45 | 0.97 | 6.25 | 0.00 |
| 11 | 5.00 - 5.49      | 0.48 | 0.97 | 0.00 | 0.00 |
| 12 | 5.50 - 5.99      | 0.48 | 1.45 | 0.00 | 0.00 |
| 13 | 6.00 - 6.49      | 0.48 | 0.48 | 0.00 | 0.00 |
| 14 | 6.50 - 6.99      | 0.48 | 0.48 | 0.00 | 0.00 |
| 15 | 7.00 - 7.49      | 0.48 | 0.48 | 0.00 | 0.00 |
| 16 | 7.50 - 7.99      | 1.93 | 0.48 | 0.00 | 0.00 |
|    | Total            | 100.00 | 100.00 | 100.00 | 100.00 |

#### 3.5. Population Status.
To evaluate the population status of *T. hemprichii* seagrass in Suli coastal waters, both of recruitment and mortality value analysis were conducted. Based on this analysis, the average recruitment value of both stations were 0.38 year\(^{-1}\) and the average mortality value was 0.23 year\(^{-1}\). With reference to these values, it is concluded that the *T. hemprichii* population in Suli waters has increased because the recruitment value was higher than mortality value. The results obtained in this research were different from the research results in Tanjung Tiram, Poka. The population status of *T. hemprichii* in Tanjung Tiram, Poka waters are decreasing [11]. Although the growth value of horizontal rhizomes and the recruitment rate of *T. hemprichii* in the Suli waters is smaller than Tanjung Tiram, Poka, however its population status is increasing. This is supported by a smaller mortality rate. This condition is different from the waters of Tanjung Tiram Poka which has high growth rate of horizontal rhizome, high recruitment rate but also high mortality rate causing the population to decline.

The research on the population dynamics of the seagrass based on past historical growth that is reflected in the current morphological structure. The morphological structure of seagrass is influenced by the environmental quality of the surrounding waters. According Ambo Rappe [13], heavy metal pollution can affect the morphological structure of the seagrass such as shortening the rhizomes and reduce the number of nodes and change the size structure of seagrass *Halophila ovalis*. Although the current population status of *T. hemprichii* is increasing, it is necessary to monitor the condition of waters regularly due to the discovery of various utilization activities around the Suli Coastal waters. Various utilization activities can produce waste that potentially polluting waters, so it is feared to affect the growth and population dynamics of seagrass *T. hemprichii* population in these waters.
Figure 1. Age distribution of *T. hemprichii* life shoots

Figure 2. Age distribution of *T. hemprichii* dead shoots
Table 4. Summary of population dynamic of *T. hemprichii*

|                        | St 1 | St 2 |
|------------------------|------|------|
| Average shoot age (years) | 4.15 | 3.22 |
| Youngest shoot (years)   | 0.38 | 0.46 |
| Oldest shoot (Years)     | 7.82 | 7.52 |
| Recruitment rate(years⁻¹)| 0.23 | 0.54 |
| Mortality rate (years⁻¹) | 0.26 | 0.21 |
| Net population growth rate (years⁻¹) | -0.02 | 0.33 |

4. Conclusion
The population of *T. hemprichii* in Suli waters have limited rhizomes growth, but have higher recruitment rate than the mortality rate which causes the seagrass population to increase.

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References
[1] Erftemeijer P A L 1993 *Factors Limiting Growth and Production of Tropical Seagrass: Nutrients Dynamics in Indonesia Seagrass Bed* Thes (Nijmegen Catholic University: Nijmegen the Netherland)
[2] Sinmiasa V C 2015 *Status keberlanjutan komunitas lamun di perairan pesisir Negeri Suli, Kecamatan Salahutu, Maluku Tengah*, Thes (PS Manajemen Sumberdaya Kelautan dan PP Kecil, Pascasarjana Unpatti: Ambon) 123 p
[3] Short F T and Coles R G 2001 *Global Seagrass Research Methods* (Amsterdam: Elsevier Science B V)
[4] Tomlinson P B 1974 *Vegetative morphology and meristem dependence: the foundation of productivity in seagrass*. *Aquat. Bot.* 4 107-130
[5] Cunha A H and Duarte C M 2005 Population age structure and rhizome growth of *Cymodocea nodosa* in the Ria Formosa (southern Portugal) *Mar. Biol.* 146 841 – 47
[6] Brouns J M 1985 *The plastochrone interval method for study of the productivity of seagrass: possibilities and limitation*. *Aquat. Bot.* 21 71 – 88
[7] Cabaco S, Ferrira O and Santos R 2010 Population dynamics of the seagrass *Cymodocea nodosa* in Ria Formosa Lagoon following inlet artificial relocation. *Estu. Coast and Shelf Sci* 87 510 – 16
[8] Duarte C M, Marbà N, Cébrian J, Enriquez S, Fortes M D, Gallegos M E, Merino M, Olesen B, San-Jensen K, Uri J and Vermaat J 1994 Reconstruction of seagrass dynamics: age determination and associated tools for the seagrass ecologist. *Mar. Ecol. Prog. Ser.* 107 195 – 209
[9] Tomascik T A J, Nontji M A and Moosa M K 1997 *The ecology of the Indonesian seas* (Periplus Eds: Singapore)
[10] Dahuri R 2003 *Keane Karagaman Hayati Laut. Aset Pembangunan Berkelanjutan Indonesia*. (Gramedia Pustaka Utama: Jakarta) pp 38-52
[11] Tupan C I, Pentury R and Uneputty Pr A 2016 Population dynamics of seagrass *Thalassia hemprichii* in Tanjung Tiram Waters, Poka, Ambon Island, Indonesia *AACL Bio* 9(6) 1286 – 93
[12] Lanyon J 1986 *Guide to the identification of seagrass in the Great Barrier Reef Region* (Great Barrier Reef Marine Park Authority Special Publication Series/ Townsville, Queensland) 54p

[13] Kuo J den Hartog C 2001 Seagrass taxonomy and identification key In Global *seagrass research methods*. Short F T and Coles R G (eds) (Amsterdam: Elsevier Science B. V) pp 31-58

[14] Ambo Rappe R, Lajus D L and Schreider M J 2011 Heavy metal impact on growth and leaf asymmetry of seagrass, *Halophila ovalis* *J. of Environ Chem and Ecotox* 3(6) 149-159