Population dynamics of seagrass *Thalassia hemprichii* in Tanjung Tiram waters, Poka, Ambon Island, Indonesia

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Abstract. This study aims to determine the growth of rhizomes, estimated age structure, recruitment rate and mortality rate of the seagrass population *Thalassia hemprichii* using reconstruction techniques. The measurement of seagrass growth is focused on rhizomes. The seagrass' age determination is based on plastochrone interval. The recruitment rate estimated from age structure of the live shoots, while the mortality rate is estimated from the age structure of the died shoots. This research was conducted in late March to early April 2016. Horizontal rhizome elongation rate ranged from 6.92 to 10.67 cm year^{-1}, and the vertical rhizome elongation rate ranged between 1.09 to 1.15 cm year^{-1}. The average age of *T. hemprichii* varied between 1.31 and 1.63 yeas. The youngest shoot found is 0.38 yeas old and the oldest age is 7.36 years. The age distribution is polymodal, which reflecting cohort shoots. The rate of recruitment obtained ranged from 0.29 to 0.72 year^{-1}, and the mortality rate ranged from 0.69 to 0.89 year^{-1}. Population of seagrass *T. hemprichii* in Tanjung Tiram Poka, is in a state of decline which showed with the recruitment that is smaller than the value of mortality.
Key Words: rhizome, age, recruitment, mortality.

Introduction. The coastal area is a quite complex area, especially with the various problems faced by the ecosystem change, environmental degradation and the decline of natural resources (Supriharyono 2007). The coastal area of Ambon island waters are increasingly under pressure which caused by both natural and anthropogenic factors. Natural factors, including erosion and accretion, while anthropogenic factors including waste disposal into the sea either biodegradable waste or non-degradable waste which triggers pollution (Asyiawati 2010).

One of coastal ecosystems that can be found on the Ambon island, especially in the area of Tanjung Tiram, Poka is seagrass. Seagrass ecosystem has one ecological function which is an important habitat for many fish species and marine invertebrates such as mollusks, crustaceans and echinoderms (Dahuri 2003). If there is an environmental degradation, then the productivity of seagrass ecosystems will decrease including all animal populations associated with the seagrass ecosystems.

Irrational management of resources or a particular ecosystem, one of which appeared as a result of the lack of biological information, such as age, growth, recruitment and mortality. Therefore, comprehensive information about the resources needed to undertree to a management without disrupting its continuity and keep it at a productive level. Biological information from seagrass ecosystem is still lacking, especially the dynamics of the population. Therefore a study on the biological aspects of these ecosystems is needed.

The studies on population dynamics have been done on animals, but on plants are still rare. All this time, the study of seagrass growth is done by measuring the length of the leaf. For plants, growth can be determined other than through the length of the leaves, which is through the length of rhizomes (Short & Duarte 2001). Seagrasses can reproduce asexually (vegetative) through elongation of the rhizomes (Tomlinson 1974). Growth measurements in this study focused on the length of vertical and horizontal rhizomes. From the rhizomes we can determine the age and growth, and can estimation of recruitment and mortality rate of seagrass.

The purpose of this study was to determine the population dynamics of seagrass from species *Thalassia hemprichii* which includes rhizome growth, age structure, recruitment and mortality rate.

Material and Method

Sampling methods. This research was conducted in the waters of Tanjung Tiram Poka, Ambon Island, Indonesia, in late March to early April 2016. Sampling was done in two observation stations that represent a mixture of sand and mud substrates (S1) and a mixture of sand and coral rubble substrates (S2) (Figure 1).

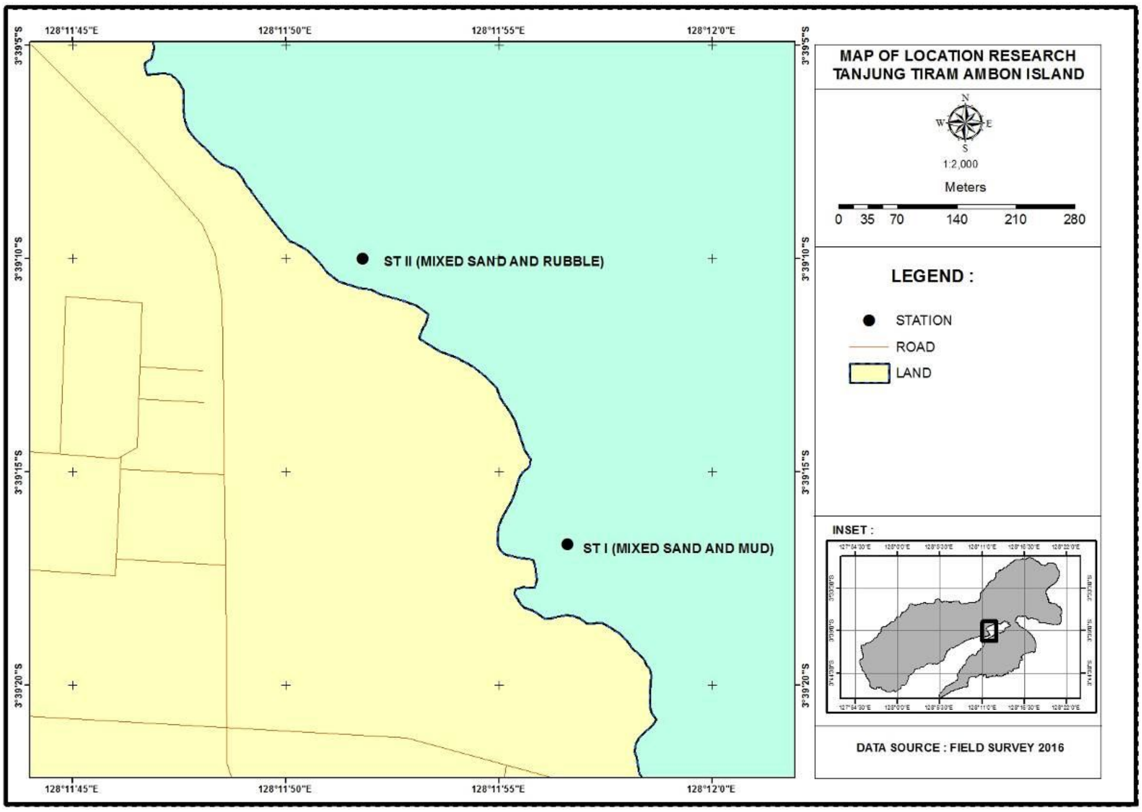

Figure 1. Map of location research.

The samples collection carried out in quadrate of 1 x 1 m. Seagrass is sampled in 8 to 10 quadrate of the observations depending on the deployment and the density of *T. hemprichii*, which includes at least 200 shoots from each population (Cunha & Duarte 2005). Seagrass was carefully separated from the sediment to prevent a loss of roots and horizontal rhizomes between one shoot to another. Samples of seagrass then calculated on the number of life shoot (i.e. bearing green leaves) and dead shoot (i.e. devoid of green leaves), the number of vertical nodes and internodes and the number of horizontal nodes and internodes, the amount of leaves, the amount of flowers (if any), the amount of live and dead roots and measure the length and width of leaves, length of horizontal rhizome between the shoots and the length of rhizome vertically (Figure 2).

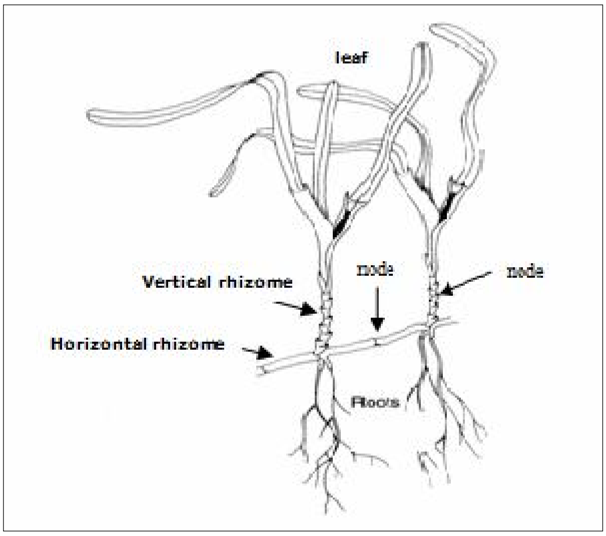

Figure 2. Measurement of *T. hemprichii* (modification of English et al 1997).

Data analysis method. The use of age units associated with average time interval between two leaves growth sequentially on the shoot and called interval plastochrone (Brouns 1985; Cunha & Duarte 2005; Cabaço et al 2010). Age estimation generated in the interval plastochrone unit then converted into absolute time units.

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

The shoot recruitment rate (in units year^{-1}) was estimated from the total number of shoots ($\sum_{t=0}^{\infty} N_t$) and the number of shoot of more than one year ($\sum_{t=1}^{\infty} N_t$) in the shoot population (Duarte et al 1994; Cunha & Duarte 2005; Cabaço et al 2010) as follows:

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

The mortality rate is calculated based on the exponential decrease of the amount of dead shoots with age, and allowed the estimation of mortality rate of the exponential shoot (M, in units time^{-1}):

$$N_t = N_0 e^{-Mt}$$

where: N_0 is the number of dead shoots with an age equal to the mode, and N_t is the number of dead shoots older than the modal shoots by time t (Duarte et al 1994). Net population growth rate is calculated as the difference between the annual recruitment and mortality.

Mortality and recruitment used to evaluate the status of seagrass meadows and to forecast their development (Duarte et al 1994):

If: R > M = the population increased;
R = M = the population balanced;
R < M = the population declined.

Results and Discussion

Rhizome growth. The average length of horizontal rhizomes *T. hemprichii* for the two stations is 5.30±1.82 cm, which the shortest size is 1.50 cm and the longest is 12.50 cm (Table 1). Horizontal rhizome elongation rates ranged between 6.92-10.67 cm year^{-1} (Table 1). This value is smaller than the horizontal rhizomes elongation rates of

Cymodocea nodosa which ranged between 15.8-35.7 cm year^{-1} in the area of southern Portugal (Cabaço et al 2010). Morphologically, horizontal rhizome genus of *Cymodocea* is smaller and longer than *Thalassia*. *Cymodocea* had only 1 internode between two shoots of the horizontal rhizomes. This is different from *Thalassia* which has some internodes between two shoot on horizontal rhizome (Lanyon 1986; Kuo & den Hartog 2001).

The average length of vertical rhizomes range between 0.52±1.03 – 0.77±1.25 cm, where the shortest size is 0.20 cm and the longest is 9.30 cm (Table 1). Vertical rhizome elongation rates of *T. hemprichii* ranged from 1.09 to 1.15 cm year^{-1} (Table 1). This value is smaller than the vertical rhizome elongation rate of *C. nodosa* of South Portugal which was ranging from 2.44 to 5.79 cm year^{-1} (Cabaço et al 2010). The length of vertical rhizome consists of a number of internode and node. The longer the vertical rhizome, then the more vertical internode, which in turns characterizes the older or the longer life of the shoot.

In one shoot, it is found 2-5 leaves with an average length of 5.68±2.17 - 6.64±2.11 cm, where the shortest length is 1.10 cm and the longest length is 15 cm (Table 1). The average width of the leaves is 0.57±0.12 to 0.59±0.12 cm, the widest width is 1 cm. The leaves average production on both stations is 13.04 leaves year^{-1} (Table 1). This value is still in the range of *C. nodosa* leaf production which is 12-14 leaves year^{-1} (Cunha & Duarte 2005).

Table 1

Summary of rhizome growth and morphometric of *T. hemprichii* (Mean ± standard errors) at the two stations (St 1 mixed sand and mud; St 2 mixed sand and rubble)

Rhizome growth and morphometric of *T. hemprichii*	*St 1*	*St2*
Average length of horizontal rhizomes (cm)	5.30±1.82	5.26±1.64
Longest horizontal rhizome (cm)	12.50	11.50
Shortest horizontal rhizome (cm)	2.00	1.50
Horizontal rhizome elongation cm year^{-1}	6.92	10.67
Average length of vertical rhizomes (cm)	0.77±1.25	0.52±1.03
Longest vertical rhizome (cm)	8.60	9.30
Shortest vertical rhizome (cm)	0.30	0.20
Vertical rhizome elongation (cm year^{-1})	1.51	1.09
Average production of leaf (leaves year^{-1})	12.71	12.71
Average leaf length (cm)	5.68±2.17	6.64±2.11
Longest leaf (cm)	14.70	15.00
Shortest leaf (cm)	1.10	2.00
Average leaf width (cm)	0.57±0.12	0.59±0.12
Biggest leaf width (cm)	1.00	0.90
Smallest leaf width (cm)	0.30	0.30
Average number of leaves (shoots^{-1})	2.51±0.74	2.83±0.76

Age estimation*.* The estimation of the seagrass shoot age *T. hemprichii* at Tanjung Tiram, Poka is shown in Table 2. The majority of *T. hemprichii* shoot in the population is at a young age in the range of 0.5-2 years. Young shoots or new shoot are marked with shorter vertical rhizomes length, fewer amount of vertical internodes, less number of leaves and more number of live roots. The average age of *T. hemprichii* varies between 1.31-1.63 years (Table 3). The youngest shoots found to be 0.38 years old and the oldest is 7.36 years old (Table 3). The oldest seagrass *C. nodosa* found is 7.6 years in Ria Formosa, South Portugal (Cunha & Duarte 2005) and it is not much different from this study. The old age seagrass is characterized by the more amount of vertical internodes, the longer vertical rhizome length and the more number of leaves.

Table 2

Age shoots of seagrass *T. hemprichii* at the two stations (St 1 mixed sand and mud; St 2 mixed sand and rubble)

No	Age range (year)	Total percentage (%)			
		St 1		St 2	
		Life shoots	Dead shoots	Life shoots	Dead shoots
1	0.000 - 0.499	3.43	5.45	1.47	23.21
2	0.500 - 0.999	23.04	29.09	50.00	48.21
3	1.000 - 1.499	28.43	29.09	25.49	14.29
4	1.500 - 1.999	20.10	10.91	10.29	3.57
5	2.000 - 2.499	9.80	14.55	5.39	7.14
6	2.500 - 2.999	6.86	5.45	2.45	3.57
7	3.000 - 3.499	2.94	0.00	1.47	0.00
8	3.500 - 3.999	1.96	3.64	0.49	0.00
9	4.000 - 4.499	0.98	1.82	0.98	0.00
10	4.500 - 4.999	0.98	0.00	0.00	0.00
11	5.000 - 5.499	0.00	0.00	0.49	0.00
12	5.500 - 5.999	0.49	0.00	0.00	0.00
13	6.000 - 6.499	0.49	0.00	0.98	0.00
14	6.500 - 6.999	0.49	0.00	0.00	0.00
15	7.000 - 7.499	0.00	0.00	0.49	0.00
	Total	100.00	100.00	100.00	100.00

Table 2 shows that the number of shoots decline with age. This indicates a high mortality shoots. This age data then created into the age distribution and it's obtained that the *T. hemprichii* shoots age distribution is polymodal (Figure 3), which reflects the cohort shoots, and very oblique which indicates a high mortality rate (Duarte et al 1994; Cunha & Duarte 2005). The annual cohort is due to the annual cycle in the growth of the rhizomes (Cunha & Duarte 2005).

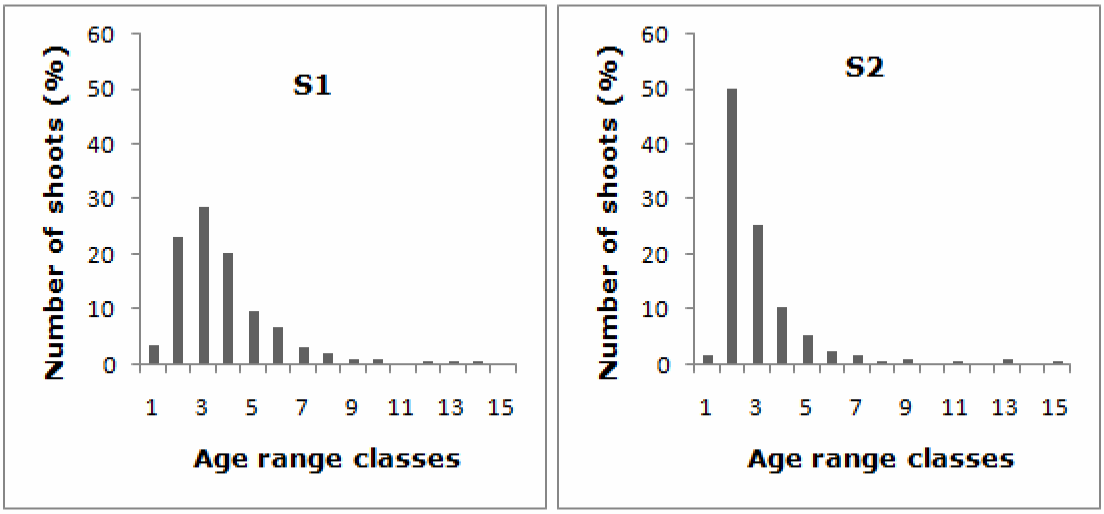

Figure 3. *T. hemprichii* age distribution of life shoots at each station in the Tanjung Tiram Poka, Ambon.

Death shoots age structure shows the number of dead shoots are mostly at young ages both on station 1 and station 2 (Table 2) or in other words, the high mortality rate occurred in the first years of life shoots (Figure 4). The mortality rate was found ranging between 0.69 and 0.89 year^{-1} (Table 3). This value is still lower than the mortality of *C. nodosa* which ranging from 3.15 to 12.35 year^{-1} (Cabaço et al 2010).

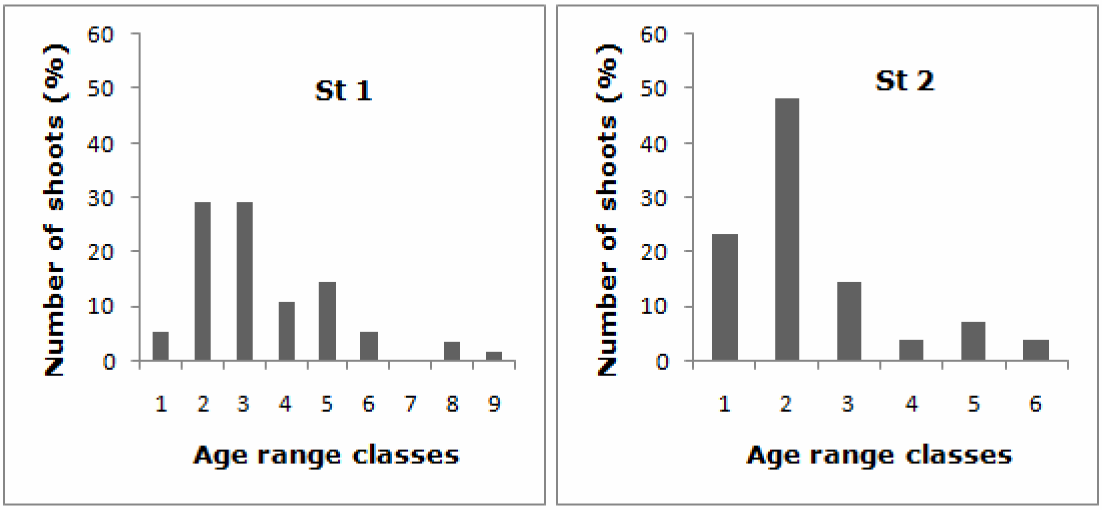

Figure 4. *T. hemprichii* age distribution of dead shoots at each station in the Tanjung Tiram, Poka, Ambon.

Table 3

Age structure and population dinamics of seagrass *T. hemprichii* at the two stations (St 1 mixed sand and mud; St 2 mixed sand and rubble)

Age structure, recruitment rate, mortality rate and population growth rate	*St 1*	*St 2*
Average age shoot age (years)	1.63	1.31
Youngest shoot (years)	0.38	0.38
Oldest shoot (years)	6.83	7.36
Recruitment rate ($year^{-1}$)	0.29	0.72
Mortality rate ($year^{-1}$)	0.89	0.69
Net population growth rate ($year^{-1}$)	-0.60	0.03

The recruitment rate obtained is ranged from 0.29 to 0.72 $year^{-1}$. This value is smaller than the recruitment rate of *C. nodosa* population that ranges between 0.7 and 3.6.$year^{-1}$ (Cunha & Duarte 2005). The rate of recruitment illustrates the growth rate of population in this study is lower than the population growth rate of *C. nodosa*. Spatial variability in net rate of population growth was considerable, ranging from no growth to 0.03 $year^{-1}$ (Table 3). The net growth rate population is low due to the low growth rate of the rhizomes. Recruitment value and mortality used to estimate the population status of *T. hemprichii* obtained an average recruitment value of 0.70 $year^{-1}$ and the average mortality value is 1.20 $year^{-1}$. This indicates that the population of *T. hemprichii* is in a state of decline.

The result of this study indicates that *T. hemprichii* in Tanjung Tiram, Poka has a limited rhizome growth, thus reducing the recruitment of shoots of the seagrass. It is necessary to study the factors that affect the growth of seagrass, given the location of Tanjung Tiram, Poka occurred utilization activities suspected to affect the growth. Tupan et al (2014) obtained the content of lead (Pb) in the waters of Tanjung Tiram, Poka is quite high in the range of 0.04 to 0.05 ppm in the water and 5.25-6.97 ppm in the sediment. It is suspected that the metal content is one cause of the declining population of seagrass *T. hemprichii*. According to Ambo Rappe et al (2011) the heavy metal pollution of Pb and Cu may affect the morphology structure of seagrass such as shortening the rhizomes and reduce the number of nodes and changing the size structure of *Halophila ovalis* seagrass leaf. Additionally Pb metal content can also inhibit the growth of seagrass *T. hemprichii* by reducing the total content of chlorophyll in the leaves (Purnama et al 2015). The results of the research by Tupan & Azrianingsih (2016) also reported that the Pb content may interfere with the anatomical structures of seagrass *T. hemprichii*.

Conclusions. *T. hemprichii* rhizome growth varies on two research stations both vertically and horizontally. This rhizome growth can be used to predict the population dynamics. Rhizome growth obtained is limited resulting in lower recruitment rates ranged between 0:29-0.72 year^{-1} and the mortality rate is high, ranging from 0.69-0.89 year^{-1}. This fact indicates the status of the population of *T. hemprichii* Tanjung Tiram, Poka in a state of decline.

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