The Growth Analysis of *Euchema cottonii* using The Simple Longline Method and Basket Method on The Coast of Kemojan Island

R A Nugroho¹, D Wijayanto²*, F Kurohman², I D Maulina², R E Puspitasari²

¹ Department of Aquaculture, Faculty of Fisheries and Marine Science, Universitas Diponegoro, Tembalang Campus, St. Prof. Soedarto S.H., Semarang, Central Java, Indonesia
² Department of Capture Fisheries, Faculty of Fisheries and Marine Science, Universitas Diponegoro, Tembalang Campus, St. Prof. Soedarto S.H., Semarang, Central Java, Indonesia

Email: ristiwian1976@gmail.com

Abstract. The development of seaweed cultivation method that support marine conservation needs to be done on Kemojan Island. The use of basket to cultivate seaweed can reduce the conflict between seaweed farmers and sea turtle protection compared to the longline method that used by local people on Kemojan Island at the present. The purpose of this study was to analyze the seaweed growth (*E. cottonii*) using the basket method compared to the simple longline method. Seaweed cultivation was conducted for 21 days. We measured the growth variables include biomass growth and daily growth rate. This study proved that the simple longline method produces higher seaweed growth than the basket method. However, the simple longline method is more prone to harvest failure than the basket method. In the absence of disease, the growth of seaweed on the simple longline method was 1.8% per day, while in the basket method was 1.2% per day.

1. Introduction
Aquaculture is a strategic sector for Indonesia because it has a significant contribution to economic growth, food security, poverty alleviation and a source of livelihood for residents in coastal and rural areas, including in Kemojan Island [2,17]. Kemojan Island is a part of the Karimunjawa Islands which has been designated as a marine conservation area. The cultivation of seaweed, especially *Eucheuma cottonii*, has become one of the main livelihoods for the local people of Kemojan Island. Marine conservation need to be supported by the availability of sufficient livelihoods for local residents so as not to behave destructively to mangroves, coral reefs, and other protected marine biota [18,21]. Eucheumoid cultivation (including *E. cottonii* or *Kappaphycus alvarezii*) has become a main source of livelihood for the coastal communities in developing countries [16], including Indonesia. Indonesia is also the main producer of *Eucheuma* sp in the world [5,18].
Kemojan Island people cultivate seaweed on the northwest coast. Seaweed farmers on Kemojan Island use a simple longline method [17,18]. This method is prone to predation by herbivorous animals, including Siganids fish (rabbitfish) and sea-turtles. Sea-turtle is a protected marine biota. There is a potential conflict between seaweed farmers and sea-turtle conservation, because seaweed farmers can disturb or kill sea-turtles if they are found to be eating or destroying the seaweed. Therefore, it is necessary to find a solution to reduce conflicts between seaweed farmers and sea-turtle conservation, including by using the basket method. The use of basket as media cultivation can reduce predation of seaweed by herbivore biota. The use of basket in seaweed cultivation will also reduce the risk of seaweed being lost due to the impact of sea waves. Seaweed farmers on Kemojan Island tend to accept new technology if it is proven successful. Therefore, the experiment using basket in seaweed cultivation on Kemojan Island need to be conducted. The purpose of this study was to analyze the growth of E. cottonii seaweed using the basket method compared to the simple longline method.

2. Material and Method

2.1. The location and time of research.
The research location is on the northwest coast of Kemojan Island with coordinates 5°47'22.326" S and 110°27'25.819" E (Figure 1). The research was conducted in July to September 2020.

![Figure 1. The research location](image)

2.2. Research material
We used E. cottonii with the source of seeds from local farmers. Young thallus seeds were selected from the harvest of seaweed farmers.

2.3. Experimental design
The experiment was conducted for 21 days of cultivation using 2 treatments, namely the simple longline method and the basket method as media cultivation. Each treatment was replicated 4 times. For the simple longline method, a rope with a length of 3 meters per unit was used with a planting distance of seaweed was 25 cm per ties. While the length of the rope for the basket method treatment was also 3 m. We used 6 unit basket per line of basket (as experimental unit) with basket size of 51 x 41 x 26 cm. Seaweed biomass per unit replication was about 3 kg, both for the simple longline method...
and the basket method. Seaweed biomass measurements were conducted at the initial and end of cultivation. The experimental layout can be seen in Figure 2.

![Figure 2. The experimental layout](image)

2.4. Data analysis.
We make analysis especially seaweed biomass growth (W) and specific growth rate (SGR) for 21 days of cultivation. Statistical test were performed using analysis of variance (ANOVA) with P=0.05, both for W and SGR variables. The formula used to calculate W and SGR are as follows [14,17]:

\[
W = W_t - Wo \tag{1}
\]

\[
SGR = \frac{\ln W_t - \ln Wo}{t} \tag{2}
\]

Notes:
- \(W\) = the absolute biomass growth of seaweed (kg);
- \(W_t\) = the weight of seaweed at the time of \(t\) (kg);
- \(Wo\) = the initial weight of seaweed (kg);
- \(t\) = time of cultivation (days);
- \(SGR\) = specific growth rate (% per day);
- \(\ln\) = the logarithm of natural.

3. Results and Discussion

3.1. The Results.
Field experiment were conducted with controlled of ‘ice-ice’ disease, epiphyte plants attack and preying by herbivorous fish during the experiment. The ‘ice-ice’ disease is non-infectious disease that could be triggered by unfavourable environmental conditions including extreme temperature, salinity and opportunistic bacterial pathogens [1,16]. The growth of macro-epiphyte is depend on enviromental factors, including current velocity, water transparency and dissolved oxygen. Epiphytic plants are also need sunlight for photosynthesis. Low current velocity could trigger macro-epiphyte growth [9].

The experimental unit in \(L_3\) experienced predation by herbivore animals compared to other experimental units, so that the growth of seaweed was lower than the other experimental units in the longline method (Table 1).
Table 1. The growth of seaweed in the experiment.

| Treatments | Basket | Longline |
|------------|--------|----------|
| Replication | B₁ | B₂ | B₃ | B₄ | L₁ | L₂ | L₃ | L₄ |
| W₀ (kg)     | 3.06 | 3.01 | 3.01 | 3.18 | 3.06 | 3.09 | 2.97 | 3.01 |
| W₁ (kg)     | 3.81 | 3.88 | 3.88 | 4.24 | 4.94 | 4.69 | 3.64 | 4.81 |
| W (kg)      | 0.75 | 0.87 | 0.87 | 1.06 | 1.88 | 1.60 | 0.67 | 1.81 |
| SGR (% per day) | 1.04 | 1.21 | 1.21 | 1.36 | 2.28 | 1.98 | 0.98 | 2.25 |
| Average SGR | 1.21 % per day | 1.87 % per day |

The results of statistical analysis showed that there is no significant difference between the treatment of the basket method and the simple longline method, both in W (sig. value 0.079; F count 4.46) and SGR (sig. value 0.076; F count 4.58) at α = 0.05. However, if L₃ is removed because it is considered outlier data, the results of statistical analysis showed that there is a significant difference between the basket method and the simple longline method, both from the variable of W (sig. value 0.0004; F count 70.66) and SGR (sig. value 0.0003; F count 75.37). In our experiment in 2019, the average growth of seaweed using the longline method was 2.72% per day [16], while the experiment in 2020 resulted the specific growth rate of 1.87% per day. There are various factors that influence the growth of seaweed, including seed quality, sea-water quality, presence of disease and predators [6,13,17,19,20]. Season is also play crucial role in seaweed production. In the case of Rote Island (Indonesia), the dry season has a negative impact on seaweed production [12].

Water quality during the study can be seen in Table 2. Water surface temperature, pH, salinity, and TDS did not change significantly. While the sea-waves and current velocity fluctuate and subsequently affect the clarity of the waters. At the research location, sunlight can penetrate to the bottom of the sea-water (2 m). DO was above 5 ppm and relatively supports the life and growth of E. cottonii.

Table 2. Water quality during research.

| Parameters       | Min  | Average | Max  | Standard & References |
|------------------|------|---------|------|-----------------------|
| DO (ppm)         | 5.5  | 7.1     | 8.6  | >5 [8]                |
| Temperature (°C) | 27.1 | 28.3    | 29.5 | 24 – 30 [8]           |
| pH               | 7.28 | 7.37    | 7.54 | 7 – 8.5 [3]           |
| Salinity (‰/oo) | 35.1 | 35.9    | 37.1 | 23 to 38 [4]          |
| TDS (ppm)        | 28.4 | 29.2    | 29.8 | < 80 [19]             |
| Current velocity (m per second) | 0.010 | 0.081 | 0.167 | 0.2 – 0.4 [3] |
|                  |      |         |      | 0.04-0.06 [8]         |

3.2. Discussion.

The highest market demand for K. alvarezii or E. cottonii cultivation comes from the hydrocolloid industry [10]. According to Wijayanto et al. [18], seaweed cultivation on Kemojan Island produces the RC ratio of 6.04. This means that every IDR 1 spent by seaweed farmers (as cost) generates IDR 6.04 (as revenue.) The research by Wakibia et al. [16] proved that K. alvarezii cultivation can produce a payback period of 0.3 years (very short time) and Return on investment (ROI) of 380%. The investment capital needed by the seaweed farmers from Kemojan Island is also relatively small. It is very attractive for local people of Kemojan Island who have relatively few alternative livelihoods. According to FAO [5], Indonesia is the major contributor to growth in aquatic plant production (including E. cottonii) in the world where seaweeds production has increased more than 10 times,
from less than one million tons in 2005 to 10 million tons in 2014. The seaweed production share of Indonesia in the world increased significantly from 6.7% in 2005 to 36.9% in 2014.

The cultivation of seaweed using the basket method can reduce the risk of predation of seaweed by herbivorous biota, including siganids fish and sea-turtles [17,19]. There is still a risk of preying seaweed by siganids fish in the basket method, although the risk is much smaller than using the simple longline method. In some baskets, it was found that very small siganids fish were still able to enter the basket. Then the siganids fish grows big, gets caught in the basket and cannot out from the basket. In that basket, the growth of seaweed was not optimal, due to the influence of predation from the siganids fish trapped in the basket.

In the simple longline method, sea-water circulation is smoother than the basket method [17]. The sunlight is also more optimal for the planted seaweed in the longline method. The basket surface can reduce the penetration of sunlight. Sunlight is needed for photosynthesis [11,20]. As a result, the growth of seaweed in the basket method is less rapidly than seaweed in the longline method.

According to research by Munoz et al. [14], the highest average growth rate of K. alvarezii was obtained 6.5% per day for red strain, 7.1% per day for brown strain, and 8.1% per day for green strain during June. The lowest growth rates were obtained during August and September for green strain (2.0% per day). This shows that the season and strain of seaweed affect the growth rate of seaweed. Seaweed farmers from Kemojan Island usually get seaweed seeds vegetatively, namely cutting young thallus as seeds. This method is prone to cause degradation of seed quality so that growth slows down. Seaweed farmers from Kemojan Island usually replace the seeds by bringing in new seeds from the seaweed hatchery center every 3 years due to cost considerations.

The development of seaweed cultivation technology is needed to strengthen the family economy of coastal communities. It is important to diversify the livelihood of coastal communities to improve the welfare of coastal communities. In Indonesia, marine cultivation actors (including seaweed farmers) have other livelihoods, including capture fisheries and traders [2]. Likewise on Kemojan Island, seaweed farmers also have other professions, including: fishermen, wood craftsmen, traders, teachers, construction workers, and land farmers. The research of Larson et al. [10] showed that seaweed cultivation in Indonesia is proven to improve the welfare of seaweed farmers, namely to fulfill basic needs and secondary needs, including for housing, transportation and education.

Based on the field observations, there is an increase in the area of seaweed cultivation on the coast of Kemojan Island compared to 2019. The interview results with several management of the seaweed farmer association show that the people of Kemojan Island think that seaweed cultivation can improve the welfare of local communities. Increasing the welfare of local communities through the development of seaweed cultivation on Kemojan Island can also support the conservation of the Karimunjawa Islands waters [7,18]. But, the increase in seaweed cultivation in Kemojan Island needs to be anticipated to reduce the risk of conflict of interest between local communities and to take into account the carrying capacity of environment.

If too many farmers plant seaweed, it can increase the intensity of 'ice-ice' disease attacks and epiphytic plant booming. Seaweed that is attacked by 'ice-ice’ will break more easily and break loose from its longline when exposed to waves. Epiphytes are attached to seaweed and can cause disturbance photosynthesis process and the growth of seaweed. Several types of macroepiphytes can attach to Eucheuma sp in Indonesia waters including Acanthophora spicifera, A. muscoides, Acrosorium ciliolatum, Ceratium sp, Chondrophyccus papillosus, Chaetomorpha crassa, Dictyota dichotoma, Gracilaria brevis, Hypnea nidulans, Jania longifucra, Neosiphonia sp., Pomatoceros triqueter, Polysiphonia sp., Sargassum cristaefolium, Ulva lactuca, U. clathrata and Turbinaria ornata [9]. Therefore, research on the carrying capacity of environment needs to be conducted as a follow-up to the result of this study.
4. Conclusions
This research proved that the simple longline method produces higher seaweed growth than the basket method. However, the simple longline method is more prone to harvest failure than the basket method. In the absence of disease, the growth of seaweed on the simple longline method was 1.8% per day, while in the basket method it was 1.2% per day.

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