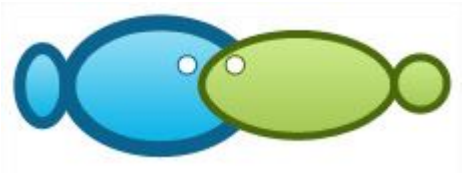

Environmental parameters and specific growth of *Kappaphycus alvarezii* in Saugi Island, South Sulawesi Province, Indonesia

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Abstract. *Kappaphycus alvarezii* is one of superior seaweed. This study was aimed to find the influence of environmental parameters on specific growth of this species. Seaweed were obtained from the farmers in the waters of Saugi Island. Based on this study, the environmental parameters in the rainy season was in the optimum range for growth of seaweed, resulted in a favorable growth rate of seaweed. Specific growth of seaweed in the rainy season was from 33.75 g in the first week to 127.5 g on the 7th week. The increase in nitrate content and the current velocity at stable conditions of temperature and pH enhanced seaweed growth by 3.917 g and 0.08 g, respectively. However, the environmental parameters in the dry season was not ideal, which resulted in reduced growth of the seaweed.
Key Words: environment, growth, *Kappaphycus alvarezii*, Saugi Island, season.

Introduction. Seaweed are known to have many benefits for humans and the environment. In aquaculture production, seaweed are used as a source of carbohydrate in the fish feed (Aslamyah et al 2016). Since the benefits of seaweed have been known, the seaweed demand is continuously increasing (Norambuena et al 2015; Ilias et al 2015; Aslamyah et al 2016). It has impact on the improvement of effort to meet the demand of seaweed. Various studies have been carried out to improve the productivity of seaweed, especially in cultivation techniques (Raven & Geider 1988; Brault & Queguiner 1989; Burfeind & Udy 2009). Seaweed cultivation system in nature is still kept under review to improve the quality and quantity of seaweed produced.

One of superior seaweed is *Kappaphycus alvarezii*. The first commercial cultivation of *K. alvarezii* was performed in the Philippines in 1960 and spread to several countries in Asia and South Africa, including Indonesia (Kotiya et al 2011). Cultivation of this seaweed in the waters is highly dependent on natural factors. The critical success factors of cultivation are adequacy of nutrients and environmental conditions which are in accordance with the living needs of seaweed. Environmental factors can affect physiology and the impact of growth (Hurd 2000).

Environmental parameters that play a role in determining the biomass and productivity of aquaculture activities are nutrients and light (Harrison & Hurd 2001). One of the essential chemical components to the growth of seaweed is nitrate. Nitrate is a dissolved inorganic nitrogen material which is used by the organism for growth, metabolism, and reproduction. Nitrogen is a nutrient that can be a limiting factor for the growth in the waters (Harrison & Hurd 2001). In addition to the chemical components, physical components such as water temperature and current velocity also play a very important role (Hurd 2000). In this study, we attempted to uncover the influence of environmental parameters with specific growth of *K. alvarezii.*

Material and Method

Plant. Test organisms used in this study was *K. alvarezii* collected from seaweed farmers in the Saugi Island, Pangkep Regency, South Sulawesi, Indonesia. Kallus to be used was selected in the section that had many branches using a scalpel. The initial weight of kallus was homogenized to be approximately 10 g. Kallus obtained were washed with seawater and directly attached to a maintenance rope for further observation.

Location and research design. The research was conducted in 2015 during the rainy season (January-February) and during the dry season (October-November) in the Saugi Island, Pangkep Regency, South Sulawesi. The method used was explanatory research to determine the relationship between environmental parameters and specific growth of *K. alvarezii*.

Cultivation method. Seaweed cultivation was conducted using floating method with ropes. Total maintenance area was 40 x 20 m consisting in 20 stretches of which each stretch had a length of 20 m. Plant spacing of seaweed on the rope stretch was 19 cm so that 100 points of planting were consisted in each span. As many as 2 kallus seeds were tied on each point of planting and maintained at a depth of 50 cm below sea level. The data collection of environmental parameters such as nitrate, pH, temperature and current velocity was performed every week. The data obtained in this study were analyzed using descriptive statistic and multiple linear equation.

Results

Environmental parameters. Nitrate concentrations obtained during research ranged from 1.12 to 2.17 ppm in the rainy season and 1.24-1.96 ppm in the dry season (Table 1). Based on observations during the study, the pH level of the water ranged from 7.68 to 8.14 in the rainy season and 8.25 to 8.39 in the dry season. In general, changes in pH levels in waters are related with changes in temperature, dissolved oxygen and phytoplankton production (Chen & Durbin 1994).

Water temperature is one of the environmental factors that determines the success of seaweed farming. The ranges of water temperatures during the study were 29-33°C in the rainy season and 32-34°C in the dry season. Water temperature was positively correlated with light intensity. The more sunlight enters the waters for a long time will impact on the increase in water temperature; therefore, water temperatures tended to be higher in the dry season than in the rainy season.

Current velocity obtained during the study was 5-20 cm min^{-1} in the rainy season and 0-20 cm min^{-1} in the dry season.

Specific growth of seaweed. Specific growth of seaweed in the rainy season showed a significant increase, that was from 33.75 g in the first week to 127.5 g on the 7th week (Figure 1). However, different result was found in the specific growth of seaweed maintained in the dry season that was 34 g in the first week and increased to 87.5 g at week 3 then declined to 39.75 g in week 7. It was assumed to be caused by changes in environmental parameters which was not in accordance with the optimum conditions for seaweed growth. In the dry season, changes in chart patterns were assumed to be caused by changes in environmental parameters which were not in accordance with the optimum conditions for seaweed growth. So it also affects the physiology (Harrison & Hurd 2001).

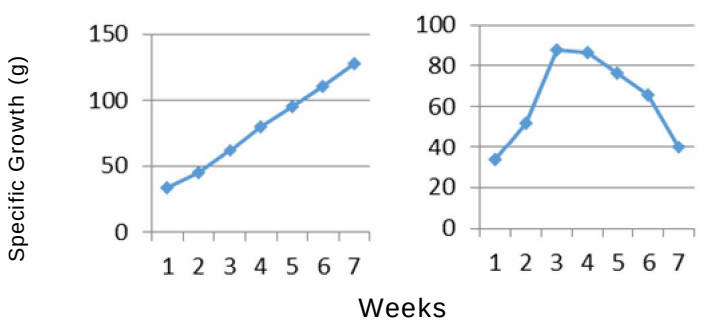

Figure 1. Specific growth of *Kappaphycus alvarezii* (in the rainy season - left; in the dry season - right).

The effect of environmental parameters. Based on data obtained in the field which later were processed by multiple linear equations resulted a positive correlation between the specific growth of seaweed and the increased nitrate and current velocity to the optimum limit. These results were inversely proportional to the temperature and pH parameters which had a negative correlation with the specific growth of seaweed.

Specific growth of seaweed increased along with an increase in nitrate content and the current velocity but decreased with an increase in temperature and pH. The increase in nitrate content and the current velocity at stable conditions of temperature and pH enhanced seaweed growth by 3.917 g and 0.08 g, respectively. These results were inversely proportional to the increase in pH and temperature variables which caused a decrease in seaweed growth by 5.267 g and 0.618 g, respectively.

Discussion. Each environmental parameter is related and affected each other. Physical, chemical and biological factors may affect the absorption rate of nutrients (Harrison & Hurd 2001). Therefore, a synergy of all parameters to ensure the seaweed growth at the optimum condition is needed in order to obtain maximum results. Environmental parameters throughout the study, especially during the rainy season, were in the optimum range for seaweed growth. This was indicated by good growth rate of seaweed. Meanwhile, conditions of environmental parameter in the dry season were not so good that caused seaweed growth declined.

Increase in seaweed growth in the rainy season was alleged because physical and chemical conditions of the waters are always in the optimal range. Nitrate contents during the rainy season continued to increase until the end of the observation and the conditions of water pH were always in the optimum range so that the absorption of nutrients by the seaweed could be maximum. The conditions guaranteed the availability of nitrate during maintenance so as to fulfill the needs of seaweed to growth. The results obtained were relevant to Menendes et al (2002) research which found an increase in biomass in *Chaetomorpha linum* enriched by nitrogen. A different condition occurred during the dry season where nitrate concentrations were lower and tended to decrease until the end of the study. Nitrate concentrations were in maximum ranges during fall and rainy seasons and in minimum ranges during spring and drought seasons (Harrison & Hurd 2001).

The situation was exacerbated by the increasing pH. The unsuitable pH level for the growth of seaweed might affect the growth rate and at higher levels it could cause death for seaweed. pH could change the distribution of carbon dioxide and carbon availability, change the availability of essential nutrients and could potentially affect physiological systems directly at extreme pH levels (Chen & Durbin 1994). It was expected to be one cause of the decline in growth due to insufficient nitrate for seaweed growth. Loss of nitrogen might lead to a decrease in the ability to sustain growth (Brault & Queguiner 1989).

In addition to chemical factors, physical factors of waters also determined the level of seaweed growth. Aquatic physical parameters that greatly affected the growth of seaweed were light, temperature and current velocity. Temperature and current velocity

obtained in the dry season showed excellent conditions for seaweed growth. While in the dry season, temperatures had increased and current velocity decreased. This was presumably because the irradiation intensity in the dry season had increased in the terms of the number and time. Increased high temperatures could affect the absorption of nutrients in the metabolism of the algae (Raven & Geider 1988).

Current velocity is extremely important because it determines the speed and diffusion boundary layer around the thallus, and regulates the movement of ions and gasses to and from thallus surface (Hurd 2000). Observation results of current velocity during the study showed a good condition in the rainy season. The movement of water currents delivered nutrients and ions needed for seaweed growth. While in the dry season, current movement had continued to decline even became undetectable in the last week of observation. It was alleged to cause a decrease in seaweed growth due to lack of water flow that drove nutrients and ions.

Conclusions. Environmental parameters affected on seaweed growth. The ideal range for seaweed growth was in rainy season in the Saugi Island, resulted in the best seaweed growth. Physical and chemical conditions in Saugi Island water were contributed to increase of seaweed growth in the rainy season. However the growth was found to decrease in the dry season.

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