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WEEDS, EPIPHYTES AND ICE-ICE DISEASE ON GREEN-STRAINED *KAPPAPHYCUS ALVAREZII* (DOTY) IN TAKALAR WATERS, SOUTH SULAWESI IN DIFFERENT SEASONS AND LOCATIONS OF CULTIVATION

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Abstract

Weeds, epiphytes, and ice-ice damage the *Kappaphycus alvarezii* seaweed system is often found at cultivation sites, impacting on yields. The location of cultivation that has a problem of weeds, epiphytes and ice-ice is Takalar District, a production centre in South Sulawesi, often encountered in extreme weather and not in optimal environmental quality. This study was carried out to analyze weed density, epiphytic attachment, and infection of ice-ice disease of green-strained *K. alvarezii* seaweed in different seasons and locations of cultivation. This research was conducted in the waters of Punaga Village, Takalar Regency in two locations, that were inshore and offshore, using the long line method, which was 45 days for each location. Weeds, epiphytes and ice-ice diseases and water quality were observed by season and location and analyzed descriptively. The results showed that the season affected weed density, epiphytic attachment and ice-ice infection. In the transition season from the rainy season to the dry season (May-July), weeds of the *Hypnea* sp type dominated the seaweed cultivation area (137.5g / m), the beginning of the dry season (May-July) *Sargassum* sp. (431.25g / m) and *Ulva* sp. (137.5g / m) appeared on offshore, but none on inshore. Epiphytes Neosiphonia sp. and ice-ice disease infect the thallus at the end of the dry season (September-October) onshore and offshore.

***Keyword*:** Epiphyte; ice-ice; inshore; *Kappaphycus* sp.; offshore; season; weed.

Introduction

Green-strained *Kappaphycus alvarezii* (Doty) is one seaweed type that produces kappa-carrageenan which is widely cultivated and used as the main livelihood in some coastal communities in Indonesia. Seaweed production fluctuates according to season, generally the productive season is from April to October, while the less productive planting season is in January, November, and December. The pattern of seaweed production changes based on climate, where climate influences the condition of local waters (Arisandi *et al.*, 2013; Asni, 2015).

In certain seasons *K. alvarezii* has decreased biomass due to damage to the thallus. This is caused by several factors, and what is commonly found in seaweed farming activities is the presence of weeds, epiphytes, and ice-ice disease. The impact of these three factors varies on seaweed. Weed is a competitor in terms of absorption of nutrients and barrier to sun penetration that can inhibit photosynthesis (Arisandi *et al.*, 2017; Gazali *et al.*, 2018; and Joppy, 2014), but on the other hand, weeds function as shelters from pest attacks.

In addition to weeds, a factor causing the decline in seaweed production is epiphytes, which their presence is influenced by seasons, as occurs in several countries such as Sabah, Malaysia and the Philippines (Vairappan *et al.*, 2008), the emergence of epiphytes that infect *K. alvarezii* in general from the macroalga group like *Neosiphonia spp*. (Vairappan *et al.*, 2008) whose existence is related to changes in water quality such as temperature and salinity.

In contrast to weeds and epiphytes, ice-ice disease infection in seaweed is characterized by a change in the color of the talus to turn pale yellow and eventually turn white and break easily (Maryunus, 2018).

Based on the description above about weed density, epiphytic attachment and infectious diseases in seaweed affected by the season, and the season will affect water quality, then a study was conducted to analyse the presence of weeds, epiphytes, and ice-ice disease of *K. alvarezii* seaweed in green waters in different seasons and locations.

Materials and Methods

The research was carried out for a year in different locations and seasons from April 2018 to March 2019, in Malelaya Hamlet waters, Punaga Kecamatan Mangarabombang Village, Takalar Regency, South Sulawesi Province. To obtain research samples, seaweed planting was carried out on a stretch rope by following the planting pattern according to the season at different cultivation locations. All cultivation periods were carried out for 45 days. Seaweed was cultivated in two different waters locations in waters close to the coast (inshore) and in waters that has a steep slope (offshore). Seaweed cultivation was done by the long line method (Kasim & Mustafa, 2017). The seaweed planting patterns were based on different seasons, that were the transition from the rainy season to the dry season (April-May), the beginning of the dry season (May-June), mid-dry season (July-August), end of the dry season (September-October), transition from the dry season to the rainy season (October-November). In the rainy season (December-March) planting was not carried out because the weather conditions do not allow planting, and even local farmers did not carry out cultivation activities. During the study period, we collected data on weed density, epiphytic attachment, and ice-ice infection in seaweed and recording of water quality parameters according to the seaweed planting period in different seasons and locations.

Weed density calculation was done at the end of maintenance along with the seaweed harvest time. Weeds that grow on a stretch of rope along with seaweed were separated by type, then weighed as a whole. Determination of weed density is calculated by the formula cited in (Hendrawati, 2018) as follows: K = *ni* / A, where, K is weed species density (ind/m), *ni* is the number of species (individuals) and A is the length of the stretch (m). Meanwhile, to find out the epiphyte and ice-ice disease on seaweed thallus, its samples were randomly taken, put in sterile plastic bags, placed in a coolbox at a temperature of less than 4 degrees Celsius, then taken to the laboratory for analysis.

The water quality parameters observed in situ are physical parameters including temperature measured with a thermometer, salinity with a refractometer, and a flow meter to measure the speed of the current. While the chemical parameters measured are parameters that support the growth of seaweed such as NO_3, PO_4, CO_2, Ca and Mg analyzed in the laboratory by spectrophotometry based on the method (Parsoons, 1972).

Statistical Analysis

Data on the density of weeds that grow on the stretch of seaweed culture, epiphytic attachment to the seaweed thallus, and ice-ice disease that infects seaweed were analysed descriptively. While the water quality data measured both insitu and in the laboratory were also analyzed descriptively.

Results

Weeds in the cultivation of green-strained seaweed K. Alvarezii on Inshore and Offshore at Different Seasons

There are 4 (four) species weeds that dominate the green-strained K. Alvarezii seaweed, that are Ulva sp., Sargassum sp., Gracillaria sp., And Hypnea sp. (Figure 1). Weeds attached to the seaweed thallus vary according to season and location of cultivation, both density, and species (Figure 1).

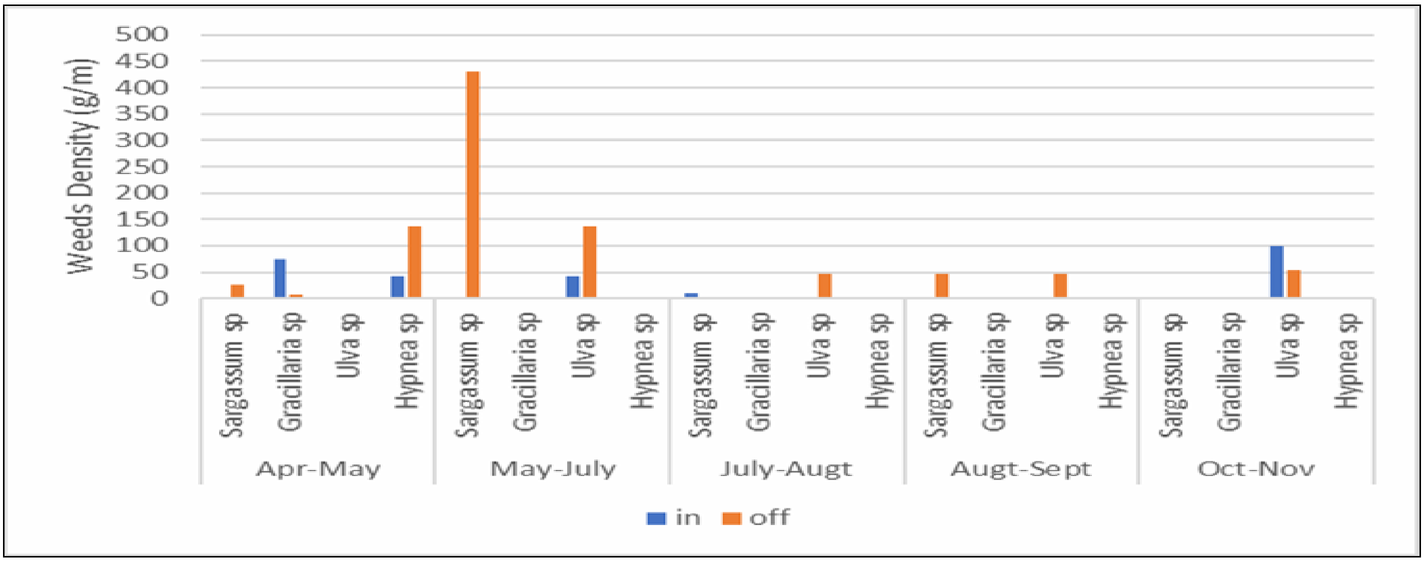

Fig. 1 : Density of weeds on *K. Alvarezii* seaweed at different locations and seasons

The presence of weeds at the study site was detected in the transition season from the rainy season to the dry season (April-May), dominated by *Gracillaria sp*. (75g/m) inshore and *Hypnea sp.* (137.5 g/m) offshore, at the beginning of the dry season (May-July) was dominated by *Sargassum sp.* (431.25g/m) and followed by *Ulva sp* (137.5g/m) offshore. Furthermore, in the middle of the dry season (July-Aug) until the end of the dry season, *Ulva sp.* appeared attached to the stretch of seaweed cultivation only offshore, and entered the transition season or transition season from the dry season to the rainy season (Oct-Nov), the existence of *Ulva* sp. was seen both onshore and offshore.

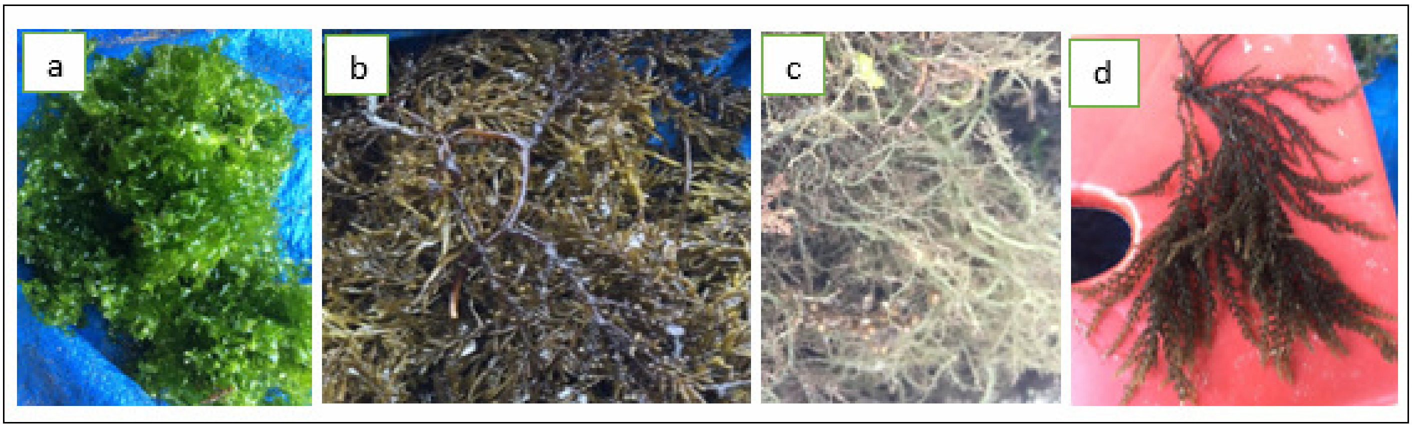

Fig. 2 : Types of weeds in seaweed, (a) *Ulva* sp., (b) *Sargassum* sp., (c) *Gracillaria* sp., and (d) *Hypnea* sp

Epiphytes on seaweed Green-Strained Kappaphycus alvarezii on Inshore and Offshore at Different Seasons

Epiphytes attached to seaweed during the study were seen at the end of the dry season (Sept-Oct), both onshore and offshore. The epiphytes were found from the *Neosiphonia sp.* type which attached to the surface of the seaweed species *K. Alvarezii*. The observation of several thallus taken at random shows small black spots that gather in a circle, a thallus surface that contains a lot of mucus, and fine threads (Figure 3).

Fig. 3 : Epiphytes attached to the seaweed thallus, (a) black spots, (b) Mucus and (c) Fine threads

Infection of Ice-Ice Disease in Green-Strained Kappaphycus alvarezii on Inshore and Offshore at Different Season

The infection of Ice-ice disease during the study occurred at the end of the dry season (Sept-Oct), both onshore and offshore. Seaweed infected with ice-ice has a change in the color of its thallus from green to yellowish and eventually turned to white and destroyed. This change starts from the epical part towards the basal part of the seaweed thallus (Figure 4).

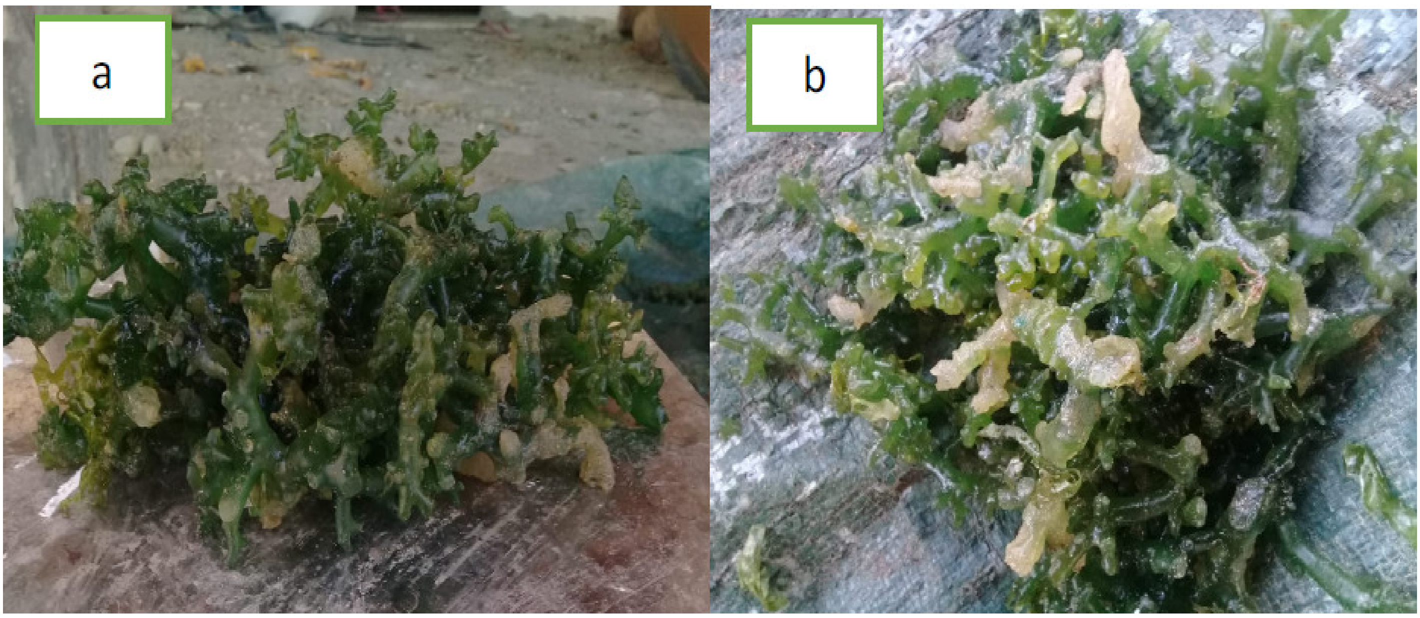

Fig. 4 : Ice-Ice Disease on seaweed thallus, (a) inshore, (b) offshore

Water Quality

Water quality parameters observed during the study were temperature, salinity, pH, brightness, current speed, PO_4, NO_3, CO_2, Ca and Mg. Each concentration value of the parameter shows a different state of concentrations, depending on the season and location of cultivation and has an impact on the presence of weeds, epiphytic attachment or infection with ice-disease (Tables 1 and 2).

Table 1 : Concentrations of Temperature, Salinity, Brightness, pH and Flow Speed in Different

Parameters	Units	Locations	Seasons					Optimum ranges	Reference
			I	II	III	IV	V		
Temperature	°C	inshore	28.5-30.5	30.0-31.0	30.0-31.5	30.0-31.0	29.0-30.5	20 – 28	Parenrengi, 2012.
								24-27	Radiarta, 2016.
		offshore	29.0-31.0	30.0-31.5	30.1-31.5	30.5-31.1	30.0-31.1	24-30	Largo, 2020
salinity	ppt	inshore	33.9-35.1	34.5-35.0	33.5-35.5	33.0-34.0	31.1-33.0	28-34	Largo, 2017
		offshore	33.5-35.5	35.0-35.5	33.9-35.0	33.0-34.5	31.5-33.0	30-33	Hurtado, 2017
Brightness	%	inshore	100	100	100	100	100	100	Lideman, 2013
		offshore	100	100	100	100	100		
pH	-	inshore	7.53-7.64	7.53-8.3	7.65-8.2	7.9-8.0	7.53-8.1	06-Sep	Zitta, 2012
		offshore	7.83-7.97	7.89-7.97	7.89-8.1	7.5-7.9	7.53-7.9		
Current speed	cm/det	inshore	5.8-6.5	4.5-6.5	4.5-5.5	4.0-5.5	5.5-6.46	6-46.9	Sulistiawati, 2020
		offshore	6.5-7.5	5.0-6.5	5.4-6.8	6.5-7.5	7.8-8.5		

Notes:
I = Transition season from the rainy season to the dry season (April-May)
II = Beginning of the Dry season (May-July)
III = Mid-Dry Season (July-August)
IV = End of the Dry Season (September-October)
V = Transition Season from Dry Season to Rainy Season (October-November)

Observation of water temperature shows that the temperature in the dry season is higher than the temperature in the transition season, both on land and offshore. Temperatures in the transition season from the wet season to the dry season on land and offshore (29-31°C and 30-31.1°C), the dry season (30-31°C and 30-31.5°C) and in the transition season from the dry season to the rainy season (28.5-30.5°C and 29-30.5°C). The suitable temperature for the cultivation of *K. alvarezii* according to (Radiarta *et al*., 2016; Syamsuddin and Rahman, 2014) is 24-27°C and 25-26°C, if an increase in temperature occurs, it will affect on the discoloration of thallus seaweed, becoming yellowish, not growing optimally, and will provide opportunities for epiphytes to grow.

For salinity parameters, in all seasons both inshore and offshore shows an appropriate value of salinity for seaweed cultivation (Hurtado *et al*., 2017). Brightness parameter is a requirement for the continuation of the photosynthesis process and in this study in different seasons and locations, the brightness at all the cultivation site supports the photosynthesis process, which is at 100%, while the pH and current speed are all in accordance with the growing needs of *K. alvaezii* (Zitta *et al*., 2012 and Sulistiawati *et al*., 2020).

Table 2 : Concentrations of PO_4, NO_3, CO_2, Ca and Mg in Different Seasons and Locations

Parameters	Units	Locations	Seasons					Optimum ranges	Parameters
			I	II	III	IV	V		
PO_4	ppm	inshore	0.5-0.71	0.2-0.4	0.4-0.49	0.49-0.60	0.5-0.72	0.37-0.5	Pariakan *et al*., 2019
		offshore	0.6-0.72	0.2-0.4	0.4-0.69	0.69-0.72	0.71-0.78		Akmal *et al*., 2017 Gunalan *et al*., 2010
NO_3	ppm	inshore	0.4-0.46	0.19-0.25	0.15-0.25	0.15-0.27	0.43-0.5	0.6 – 0.37	Mustafa *et al*., 2017
		offshore	0.2-0.58	0.1-0.2	0.1-0.2	0.15-0.2	0.35-0.41		
CO_2	ppm	inshore	15.34-22.76	22.76-29.97	27-95-29.97	25-96-27.95	22.50-25.96	23-25	Triyulianti *et al*., 2018
		offshore	23.95-28.45	21.97-28.45	21.97-31.96	31.95-31.96	28.45-31.95	34-58	Akmal *et al*., 2017b
Ca	ppm	inshore	920-1023	920-1041	1041-1282	1281-2403	1023-2403	422	Tucker, 1998
		offshore	920-1024	920-1041	1041-1401	1401-2121	1024-2121		
Mg	ppm	inshore	4861-4909	4861-5637	3020-5637	3020-3911	3911-4681	1324	
		offshore	4822-4884	4822-5504	2634-5504	2634-3707	3707-4822		

Notes:
I = Transition season from the rainy season to the dry season (April-May)
II = Beginning of the Dry season (May-July)
III = Mid-Dry Season (July-August)
IV = End of the Dry Season (September-October)
V = Transition Season from Dry Season to Rainy Season (October-November)

Chemical parameters, such as PO_4, show higher concentrations offshore at the end of the dry season and in the transition season from the dry season to the rainy season, which are 0.69 to 0.72 and 0.71 to 0.78 ppm, while the feasibility value for seaweed are 0.37-0.5 (Pariakan *et al*., 2019) and 0.064-0.599 ppm (Akmal *et al*., 2017). For NO_3 parameters, waters that support seaweed growth are waters that has NO_3 content of 0.6 -3.7 ppm (Mustafa *et al*., 2017), while the results of NO_3 measurements at the study sites in different seasons both inshore and offshore respectively 0.15-0.46 ppm and 0.1-0.58 ppm respectively. The CO_2 parameter shows that the concentration in the offshore is in a reasonable range except at the end of the dry season and the transition to the dry season during the rainy season, the concentration is higher than the feasibility limit according to (Triyulianti *et al*., 2018). CO_2 with a range of 29.2-39.3 ppm is an appropriate range for the cultivation of *E. cottonii* (Akmal *et al*., 2017). While the parameters of Ca and Mg are in a range that is suitable for the growth of *K. alvarezii* seaweed (Tucker, 1998).

Discussion

Weeds

Weeds or disruptive plants (seaweed) are often found on stretch cords and cover seaweed thallus, and seaweed farmers have difficulty coping so that impacts on the quality and quantity of the harvest. Weeds that covered the seaweed talus during the study of *Ulva sp*., *Sargassum sp*., *Gracillaria sp*., and *Hypnea sp*., and seen *Sargassum sp* dominate with density (431.25g/m) at the beginning of the dry season in May-July offshore. Besides the prolonged high temperatures (30-31.5^{o}C), the high density of *Sargassum sp.* in early summer is caused by *Sargassum sp.* being perennial or its presence based on the season, that is in the west and east seasons (Kadi, 2005). Furthermore, it is said that *Sargassum sp.* grows well in coastal areas with large waves and heavy currents depth of 0.5-10 m, and offshore is a suitable habitat for *Sargassum sp.* (Rama *et al*., 2018)

Epiphyte

The existence of epiphytes is strongly influenced by the lack of availability of nutrients and extreme weather phenomena that have an impact on drastic changes in water quality parameters (Maryunus, 2018). The low nitrate content at the peak and the end of the dry season (0.1-0.2 ppm) and the high temperature and salinity (30-31.5^{o}C and 33-35%) are the cause of the decline in seaweed immunity. Another impact of extreme weather on seaweed is the release of spores from cystocarp (Harwinda *et al*., 2018). This cystocarp hole will be covered by mucus as a form of self-defense of seaweed, on the other hand, mucus, and this is a good growing medium for epiphytes and bacteria that cause ice-ice disease (Maryunus, 2018).

The type of epiphytes attached to the seaweed thallus is *Neosiphonia sp.,* characterized by the presence of small black spots on the surface of the thallus, which indicate the occurrence of tetrasporeling embedded in the seaweed cortex layer (Vairappan *et al*., 2008). It is this process that begins the solitary growth of epiphytic plants which will leave a dark hole in cortical swelling. The highest level of epiphytic attachment in this study occurred in the middle of the dry season (July-Aug), where in that month the water temperature was 30-31.5^{o}C, salinity 33-35 ppt (Largo *et al*., 2017), flow velocity 4.5-6,8cm/sec (Sulistiawati *et al*. 2020) and nitrate concentrations of 0.1-0.25ppm (Mustafa *et al*., 2017), are less than optimal conditions for seaweed growth, so seaweed is brittle, slimy and easy a fracture that is likely to develop epiphyte infection.

Ice-Ice Disease

After epiphytic attachment occurs, another phenomenon that arises is the emergence of ice-ice infection in the seaweed thallus. This disease is a seasonal disease in seaweed, which is a disease that appears in certain seasons. During the study, it was noted that the presence of this disease was seen in the dry season in September-October. In contrast to weeds and epiphytes, ice-ice disease infection in seaweed is characterized by a change in the color of the talus to turn pale yellow and eventually turn white and break easily (Maryunus, 2018). The cause of ice-ice disease in seaweed is also caused by extreme conditions, such as increased temperatures and high sunlight intensity (Danilo B. Largo, 2020).

This ice-ice disease attacks both seaweed that is cultivated onshore and offshore. According to (Beveridge, 2008; Maryunus, 2018), the existence of ice-ice disease occurs when seaweed is under pressure due to drastic environmental changes. As a form of self-defense in the event of environmental changes, the seaweed will emit organic substances in the form of mucus. In addition, the things that cause ice-ice epiphytic infections include the occurrence of high temperature and salinity fluctuations, extreme seasonal changes, high levels of macroalgae density in the seaweed thallus and the lack of nutrients in the marine waters environment (Syamsuddin and Rahman, 2014; Rama *et al*., 2018), and the seaweed photosynthesis process was not optimal (Erbabley *et al*., 2018).

Conclusion

From this study, it can be concluded that there is relation between weed density, epiphyte attachment, and infection of ice-ice disease with seasons and locations. The peak of weed density in the seaweed cultivation area occurs at the beginning of the dry season, which is May-July which is dominated by *Sargassum sp.* (431.25g/m) and followed by *Ulva sp.* (137.5g/m) offshore. While epiphytic attachment and ice-ice infection occur at the end of the dry season from September to October.

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