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Temperature shock of the growth of *Ulva lactuca* in pangandaran, west java Indonesia

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Abstract
Temperature shock would cause an affected the growth and physiology of *Ulva lactuca*. The study was conducted to determine the effect of global warming on the growth of *Ulva lactuca* in the nature. The study was conducted in Pangandaran, West Java, Indonesia. The results of the study showed that salinity, acidity (pH), dissolved oxygen, concentrations of nitrate and phosphate waters respectively were as follows 29 – 39 ‰; 6,62 – 8,37; 3,3 – 9,8 mg/l; 0,0572 to 1, 012 mg/l ; and 0,03 – 0,27 mg/l. Water temperature ranges from 26-34.4 ºC with temperature fluctuations reaching 8 ºC. The results showed that an increase in sea water temperature and length of receding during October had a negative effect on the growth of *Ulva lactuca*, disruption of the reproductive stages and inhibition of growth and caused in damage to the enzyme and destruction of the biochemical mechanism in the macroalgae thallus.

Keywords: *Ulva lactuca*, sea surface temperature, growth

Introduction

Benthic macroalgae is one of the most important biological resources for shallow water ecosystems (Chang and Tseng 2010) [9]. They mostly live in the sea and need a substrate to grow. Macroalgae tend to be ephlitic, that means they supposed to be stuck on substrate such as rocks, sandstone, sandy soil, wood, and shell of mollusca. Macroalgae can support productivity aquatic, food provider (Prathep 2005) [36], habitat for other organisms, reduce heavy metal pollutants and potentially as pollutants biomonitoring (Dawes 1998) [13]. Along with the growth of the time, activity human continues to increase, including agriculture, urbanization and tourism, which have caused an increase in anthropogenic nutrient loads to the shallow coast and cause disturbance to ecosystems that are vulnerable to change. Nutrient enrichment was found to increase macroalgae biomass (Mc Clanahan *et al*. 2007) [28]. In the case, the direct and indirect effects of overfishing can greatly influence biological interactions between coastal organisms, such as declining marine organisms and blooming of certain organisms and changing structure of populations and distribution of certain species in coral reef ecosystems (Hughes 1994) [22]. Increased of macroalgae biomass occurred inspecies *Ulva lacuca*.

Ulva lactuca came from Brittany (Katsanevakis *et al*. 2014; Davidson *et al*. 2015; Hoffman *et al*. 2014; Stiger-Pouvreau & Thouzeau 2015; Riosmena-Rodríguez *et al.*, 2012; Guiry & Guiry 2016) [23, 12, 21, 41, 37, 17], widespread throughout world (Wald 2010; McReynolds 2017) [43, 29]. It al so one of the invasive species that has a huge ecological impact (Katsanevakis *et al* 2014; Davidson *et al* 2015) [23, 12]. The existence of *Ulva lactuca is* influenced by environmental conditions to grow. One of the thing that causes the disruption of growth *Ulva lactuca* is the phenomenon of global warming and the increasing burden of pollutants in the waters.

Major changes have occurred throughout the marine ecosystem due to global warming (Hobday and Gretta 2014) [20]. In the past few decades, international concerns over the phenomenon of global climate change have been higher, because it has had a negative impact on the sustainability of life on the face of the earth due to rising of temperatures known as global warming. Over the past 100 years, the temperature of the global climate has increased by 0.6 °C, and has doubled for now (Walther *et. al.* 2002) [44]. Changes in global temperatures, the last 112 years have caused sea temperatures to be risen by 1 °C (Haders 2014 *at* Pelayo 2016) [35]. An increase of temperature in the air can occur quickly and can increase the temperature of surface water by two-fold and cause thermal stratification. The impact of climate change in marine systems appears to be greater than in terrestrial systems despite the fact that ocean warming is slower than terrestrial (Burrows *et al.* 2011) [8]. Research by Hobday and Gretta (2014) [20] has stated that there has been an increase in sea temperatures, especially in the deep sea (Cutler *et. al.* 2003) [11], but scientists have differed views about the extent of the effect of temperature changes on marine life.

Methods

This Research was conducted in September-November 2018 in the shallow waters of Pangandaran. Sampling of *Ulva lactuca was* taken during low tide conditions in 3 locations, namely Karapyak Beach, Pasir Putih Beach and Madasari Beach (figure 1) and each location was divided into 3 stations namely west, east and center. The research location was determined by purposive sampling by considering the location of macroalgae habitat. Each station was taken three repetitions using the line transect method. Macroalgae sampling was carried out in tidal areas using a 1x1 m plot^2 transect. The macroalgae that has been sampled were put into a plastic label, photographed and identified in the laboratory. Identification of macroalgae by using Marine Biology books (Romimohtarto and Juwana 2009) was verified using the Algaebase.org website.

Parameters of water quality used in this research were temperatures, dissolved oxygen (DO), acidity levels (pH), salinity, and phosphate and nitrate concentrations. The parameters of the macroalgae observed were density (Brower *et al.* 1998) [7] and cover of macroalgae (English *et al.* 1994) [15].

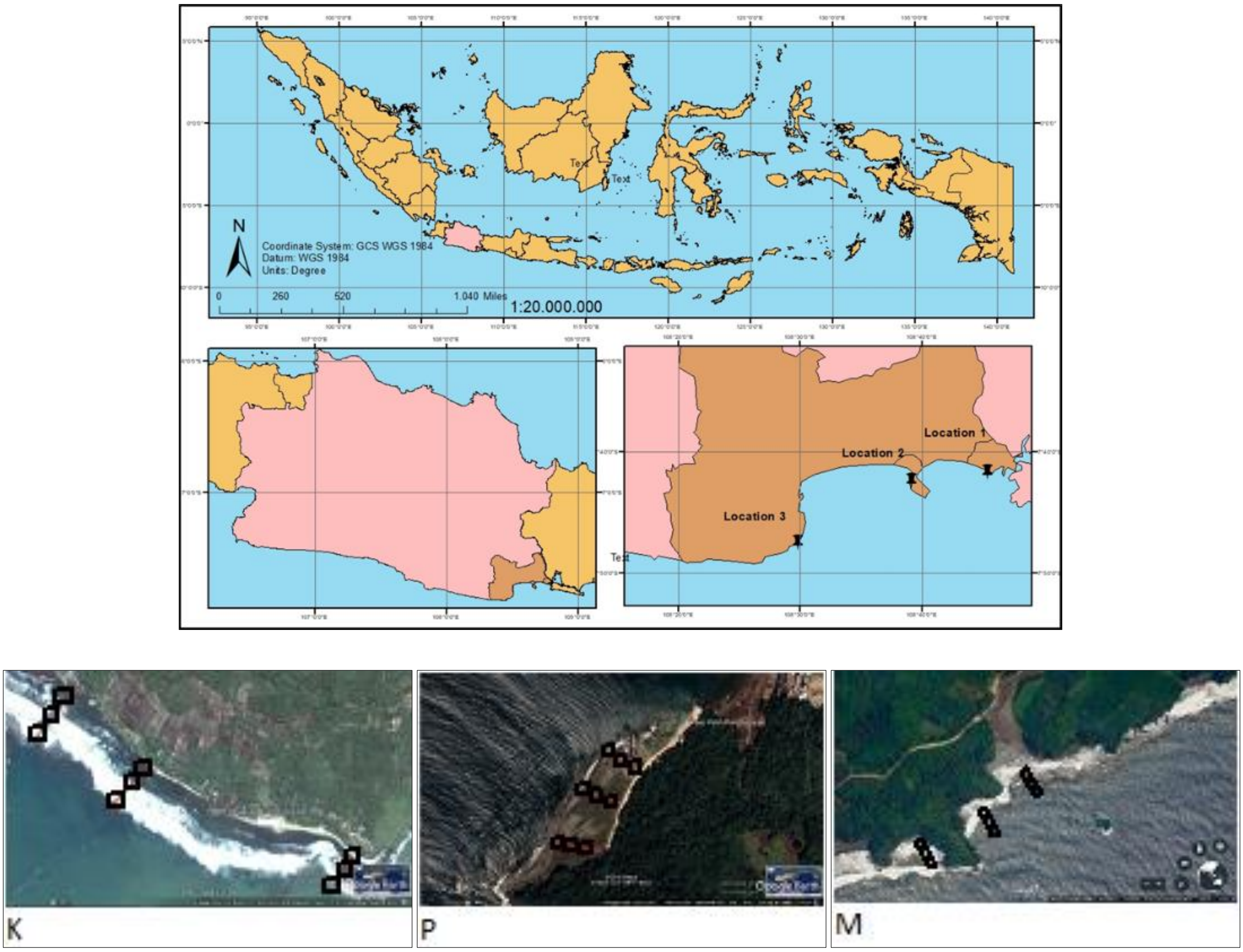


Fig 1: Research Location Map Note: (K) Karapyak Beach, (P) Pasir Putih Beach, (M) Madasari Beach

Table 1: Analysis of Water Quality

Parameters Environmental	Unit	Data Obtaining
Nitrate and Phosphate	mg/l	Exitu
Temperature	° C	Insitu
Salinity	‰	Insitu
Dissolved oxygen (DO)	mg/l	Insitu
Degree of Acidity (pH)	mg/l	Insitu

Water Quality Parameters

Water quality results in each sample zones are presented in Table 1. water quality parameters such as temperature, pH, dissolved oxygen (DO), the salinity and concentration of nitrate and phosphate were found between zoning and values that were not significantly different. Water quality measurement results can be seen in table 2 below.

Results and Discussion

Results

Table 2: Water Quality Measurement Results of

	Research Location								
	Karapyak Beach			Pasir Putih Beach			Madasari Beach		
Environmental Parameters	K.1	K.2	K.3	P.1	P.2	P.3	M.1	M.2	M.3
Temperature (^{O}C)	26 - 30,8	26 – 31	26,9 -31	27 – 32,2	27,4 – 34,3	26,6 – 32,9	27,5 – 32	26,7 – 29,5	26 – 29,6
Salinity (‰)	34 - 37	32 - 38	33 - 37	34 - 38	33 - 38	34 - 39	33 - 36	29 - 37	35 - 38
DO (mg / l)	4,2 – 8,5	5,9 – 8,8	3,3 – 7,5	4,1 – 8,3	5,8 – 9,5	5,7 – 9,8	6,9 – 7,9	5,9 – 8.8	4,2 – 8,8
Degree of Acidity (pH)	7,18 - 8,33	6,62 – 8,45	7,11 – 9,34	7,11 – 8,22	6,86 – 8,18	6,79 – 8,15	6,94 – 8,37	7,5 – 8,17	6,88 – 8,33
Nitrate (mg/l)	0,088 - 0,19	0,088 - 0,15	0,088 - 0,15	0,11 - 0,132	0,0572 - 0,12	0,088 - 0,23	0,19 - 0,968	0,11 - 1,012	0,176 - 0,2
Phosphate (mg/l)	0,08 - 0,23	0,093 - 0,17	0,096 - 0,22	0,03 - 0,22	0,06 - 0,19	0,05 - 0,19	0,05 - 0,21	0,06 - 0,16	0,084 - 0,27

Based on the results of temperature measurements in the Karapyak Waters region, it 26 - 31 °C, in the region the waters of Pasir Putih between 26.9 - 34.3 °C and in the Madasari Waters region 26.7 - 32 °C. Salinity in the Karapyak waters area 32-38 ‰, in the waters the Pasir Putih 33-39 ‰, and in the waters the Madasari 29-38 ‰. The concentration of dissolved oxygen (DO) in the Karapyak Waters region showed that dissolved oxygen (DO) of waters

3.3-8.5 mg/l, in the waters of Pasir Putih 4.1-9.8 mg/l, and in the Madasari waters 4.2-8.84 mg/l. The degree of acidity (pH) in the Karapyak waters region is obtained the pH of the waters ranging 6.62 to 9.34, in the waters of the Pasir Putih between 6.79-8.22, and in the Madasari Waters region 6.88-8,37. The results of testing nitrate concentrations in the Karapyak Waters region 0.088-0.18 mg/l, in the waters of Pasir Putih 0.0572 to 0.23 mg/l, and in the Madasari Waters region ranged from 0.11-1.012 mg/l. The measurement results of phosphate concentration in the Karapyak waters region ranged from 0.088-0.23 mg/l, in the waters of Pasir Putih ranged from 0.03 to 0.22 mg/l and in the Madasari Waters region ranged from 0.05-0.27 mg/l.

Density and Covered of *Ulva lactuca*

Density is a comparison between the number of individual types and the total number of type individuals (Fachrul 2006). The purpose of the density calculation is to find out the total number of vegetation types of the total of all individuals types. Based on the result of the study about density of *Ulva lactuca* at the study site can be seen in Figure 2.

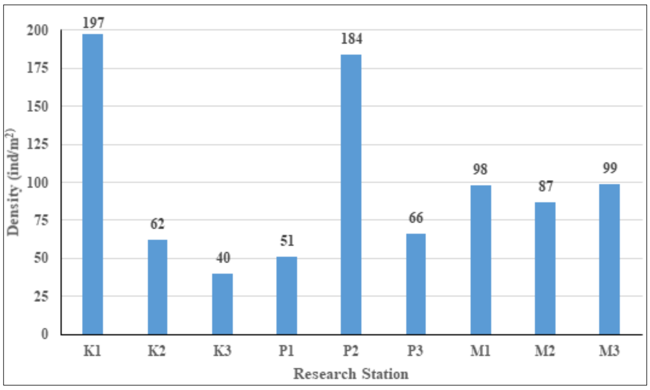


Fig 2: Density of the Type of *Ulva lactuca* in Pangandaran.
Note : K = Karapyak Beach; P = Pasir Putih Beach; M = Madasari Beach

Nappe is the covered area of *Ulva lactuca*. Nappe is used to determine the concentration and spread of dominant types. Based on the results of the study, the value of type nappe *Ulva lactuca* at the study site can be seen in Figure 3.

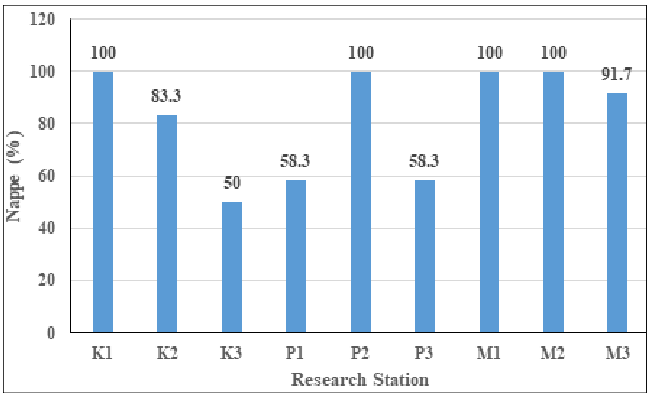


Fig 3: Nappe of the Type of *Ulva lactuca* in Pangandaran.
Note : K = Karapyak Beach; P = Pasir Putih Beach; M = Madasari Beach

Discussion

Ulva lactuca is one of Chlorophyta division which has a wide thallus shape like lettuce leaves, that's why it is also called sea lettuce. Thallus length *of Ulva lactuca* up to 1 m (Ms Breure 2014) [30] besides the thallus of *Ulva lactuca* is only up to 30 cm (Wald 2010) [43] especially in the eutrophic aquatic conditions, *Ulva lactuca* can be freelie growth.

The low of macroalgae nappe in stations 1 and 3 of Pasir Putih waters is because at station 1 is the center of tourism activity and there are MV Viking Lagos wrecks, while at station 3 is the place for surrounding communities to fish so the macroalgae can possible stomped on and off. The low *Ulva lactuca* nappe at station 3 of Madasari waters do to the native habit that ussualy consume the macroalgae like *Ulva lactuca*. Based on the observation of all stations, the highest frequency and macroalgae nappe found in Madasari waters, this is because the madasari waters has not been visited by many tourists so that they experience lower ecological pressure compared to Karapyak and Pasir Putih. These people Activities can affected the existence of macroalgae, because macroalgae are very vulnerable to ecological pressure and environmental changes that occur around them (Atmadja 1999) [3].

The high nappe of *Ulva lactuca* must be continuously controlled and get better attention from the government and from the community it self. *Ulva lactuca* is the only macroalgae that can cause blooms (*Green tides*) (Malta *et al.* 1999; Wald 2010) [27, 43]. The occurrence of green tides is caused by *Ulva lactuca* having strong physiological plasticity and competitiveness (Handayani 2014) [19] it also can maximize nutrient absorption and its to do the fregnentation easily to vegetable (Gravier 2012) [16].

The high growth of *Ulva lactuca* causes a loss for recreational activities and the environment itself, namely the decline in macroalgae diversity in the area. In addition, almost all cases of *green tides* have a quantitative increase in these benthic algae. Algae biomass that experiences this bloom will reduce light penetration so that photosynthetic lower organism will experience inhibition of growth and development, which in turn will cause a decrease in the wealth and diversity of biota (Gravier 2012) [16]. In some areas *Ulva lactuca* has been used for high antioxidant activity and can inhibit the rate of oxidation of fish oil (Arbi *et al.* 2016) [1], being cooked vegetables and chips ulvain Gunung Kidul (Nurmiyai 2013), as organic fertilizer in the Netherlands (Ms Breure 2014) [30], as a natural antioxidant (Mahmud *et al* 2014) [26], contains anti-inflation (Awad 2000; Blackwell 2012) [4, 5], Biogas in Denmark (Horn *et al.* 2000), as a cosmetic ingredient (Mc Reynolds 2017, as bioethanol and biogas (Saqib *et. al.* 2013) [39] and in Pangandaran own community to use it to be made of vegetables or seaweed chips.

The salinity in the study site ranged from 32-39 ‰. The salinity in the study site within tolerances *Ulva lactuca*. Salinity can affect the release of spores by influencing turgor pressure and pore diameter of sporangia (Han *et al.* 2008) [18]. Ulva's spores and growth are affected by salinity. Growth will be significantly impaired at salinity under 5 ppt (Sousa *et al*. 2007) [40]. Ulva can grow optimally with salinity more than 20 ppt and the most effective growth is at 35 ppt. The degree of acidity (pH) at the study site ranged from 6.62-9.34. The pH range at the study site is still within the growth tolerance limit of *Ulva lactuca*. According to Nordby (1977) [31] the optimum pH for inducing sporulation in *Ulva mutabilis* ranged from 8-8.5 and according to Han *et al.* (2008) [18] The optimum pH for spore formation *Ulva pertusa* ranged from 7-9.

Dissolved oxygen (DO) at the study site ranged from 3.3 - 9.8

mg / l. According to Brotowidjoyo *et al*. (1995) [6] in open water conditions oxygen waters are in a natural condition, so it is rarely found in oxygen-poor open water conditions. Novotny and Olem (1994) [32] state that, the source of dissolved oxygen in water comes from the diffusion of oxygen from air, flow of water through rainfall and photosynthetic activity by aquatic plants and phytoplankton.

Nitrate concentrations at the study site ranged from 0.088-1.012mg / l. The concentration of nitrate was still relatively high above the nitrate content which is usually present in marine waters. Normal nitrate concentrations in marine waters generally range from 0.001-0.007 mg / l (Brotowidjoyo *et al*. 1995) [6]. The threshold value of a waters determined by US-EPA (1973) *in* Arfah and Patty (2016) [2] for nitrate is 0.07 mg / l. But these concentrations can still be tolerated by macroalgae, as Moos (1986) *in* Palallo (2013) states wich the nitrate content that describes good water conditions for macroalgae growth is 0.09 to 3.5 mg / l. While Chu in Wardoyo (1982) [45] suggests that the range of nitrate concentration 0.3-0.9 mg / l is sufficient for the growth of organisms and> 3.5 mg / l can endanger the waters. Thus the range of nitrate content in these waters is still within the safe limits of a waters fertility.

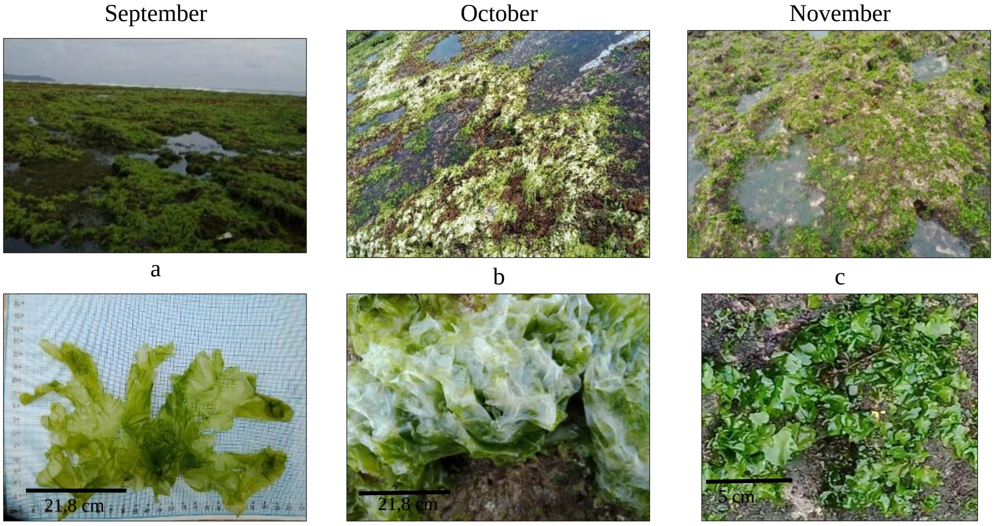
Phosphate concentrations in the study sites ranged from 0.05 to 0.27 mg / l.. The phosphate concentration can still be tolerated by macroalgae growth. Djafar (2011) states that the need of phosphate for algal growth will be lower if nitrogen is in the form ofsalt ammonium and vice versa if nitrogen is in the form of nitrate, the required phosphate concentration is higher. The phosphate concentration need for algal growth ranges from 0.018-0.090 mg / l and the highest limit is 8.90-17.8 mg / l (P-PO4) if nitrogen is in the form of nitrate.

The temperature of the study results ranged from 26-34,3 ºC. In tropical areas *Ulva lactuca* grows well in conditions of temperatures of 15-30ºC (Luning 1990) [25] with an optimum temperature of 28-30ºC (Handayani 2014) [19] but macroalgae have a temperature tolerance of <2 ºC from natural temperatures (KMLH 2004). *Ulva lactuca* in September has a wide and green thallus (figure 4d). This is because in September the environmental conditions supported the growth of *Ulva lactuca* even though the water temperature in September ranged from 26-32.5 ºC but the receding time in September was not too long which ranged from 13.00 to 16.00 WIB. The highest temperature is found in October, which ranges from 29.5 - 34.4ºC, causing the thallus of *Ulva lactuca to* experience dryness and pale white color and cause algal death in October (figure 4e). Rapid temperature changes, especially during high tides, cause *Ulva lactuca to be* more susceptible to temperature changes, causing algae death in the heat and *Ulva lactuca* has no tolerance that large enough to survive in the environment when temperature fluctuations are high (Alstyne 2014 *in* Pelayo 2016) [35].

The death of *Ulva lactuca* in October because the temperature was too high and receding at the study site was longer, from 09.00 - 18.00 WIB, causing the growth of *Ulva lactuca to be* disturbed due to too long exposure to the sun's heat and less exposure to seawater. *Ulva lactuca* in November has a thallus that was not wide enough because was estimated that the thallus was just growing (figure 4f). This is because in November the sea surface temperature has decreased, which was around 26.6 - 32 ºC, the receding time in the research location is not too long, namely at 08.00 - 11.00 WIB and at 15.00 - 18.00 WIB and in November was the beginning of the falls season so that it allows macroalgae to regrowth because the environmental conditions already support macroalgae growth.

Temperature that is too high will cause damage to the enzyme and the destruction of the biochemical mechanism in the macroalgae thallus so that the macroalgae cannot grow properly (Luning 1990) [25]. According to Chapman (1997) [10], extreme temperature changes will cause in death for macroalgae, disruption of the reproductive stages and inhibition of growth. Furthermore, according to Luning (1990) [25], physiologically, low temperatures cause biochemical activity in the thallus body to stop, while too high a temperature will cause damage to the enzyme and the destruction of the biochemical mechanism in the macroalgae thallus.

Based on the results of the study, *Ulva lactuca* at the study site had quite high density and type nappe. *Ulva lactuca* was nutrients-absorbable. That means it can optimally absorb the nutrient to allow faster growth. The higher nutrient content, the greener color thallus of *Ulva lactuca* will be (Robertson-Anderson *et al*. 2009) [38].



Note: (a)site field study *Ulva lactuca* in September; (b) The Field site study *Ulva lactuca* in October; (c)field site study *Ulva lactuca* in November; (d) *Ulva lactuca* in September; (e) *Ulva lactuca* in October; and (f) *Ulva lactuca* in November

Fig 4: Condition of *Ulva lactuca* during the study

Conclusion

Global warming will cause an increase in sea surface temperature so that it will cause disruption of the reproductive stages and inhibition of growth, it also cause damage to the enzyme and destruction of the biochemical mechanism in the macroalgae thallus. Overall factors that greatly influence the occurrence of bleaching macroalgae during the study were the increase in water temperature and duration of tides.

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