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CLUSTERING LOCATION CRITERIA FOR SEAWEED (KAPPAPHYCUS ALVAREZII) CULTIVATION BASED ON OCEANOGRAPHIC CHARACTERS

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ABSTRACT
Aquatic oceanographic characters are a special feature of a waters, where these characters will support the quality of seaweed produced. Oceanographic characters that are closely related to K. alvarezii include geographical position, type of water substrate, temperature, current, pH, salinity, Disolved Oxygen (DO), nitrate and phosphate and sociological characteristics of the community. Therefore, a study is needed to determine the criteria for oceanographic characters that are suitable for the location of K. alvarezii so that it can be used as a reference for farmers K. alvarezii to pay more attention to oceanographic characters in cultivating K. alvarezii. This study begins with observations and measurements of oceanographic characters directly at the location of the study as well as taking water samples. This study uses secondary data to be included, namely a map of the current pattern and that obtained by using the arcGIS application. According to the results of the analysis that has been carried out, S1 group (highly suitable) in Padike waters with a weight of 16, S2 group (suitable) in Tonduk waters with a weight of <16, and group N (not suitable) in Lobuk and Palasa waters with a weight of <10.

KEYWORDS: *Clustering, Kappaphycus alvarezii, Oceanographic characters*

1 INTRODUCTION

Kappaphycus alvarezzi is seaweed with high carrageenan content which can be utilized as sources of food industry raw materials such as thickener, gelling agent, and food stabilizer (Mustapha et al., 2011; Van de Velde et al., 2002; Campo et al., 2009; Neish, 2005; Hurtado, 2000). Thus, in Indonesian waters, K. alvarezii becomes one of favorite seaweed to be cultivated (Kementerian Kelautan dan Perikanan, 2010; Prasetyowati et al., 2008; Sahabudin and Tangko, 2008). Therefore, the production of K. alvarezii in Indonesian waters is still fluctuating. It occurs because season changes, susceptibility to diseases, pests, and infections (Hurtado, et al., 2008; Wilson, 2013). thus, it decreases a decrease in the quality of carrageenan and even leads to crop failure (Tokan, 2009; Mendoza et al., 2002).

In Madura, Sumenep District especially in villages of Lobuk, Padik and Tonduk, the waters is utilized as cultivation area of K. alvarezii. Type of K. alvarezii cultivated in those villages is green K. alvarezii. Cultivation of K. alvarezii in those four locations is one of the source of income of the local people. Planting K. alvarezii in the villages of Lobuk, Padike, Palasa and Tonduk doesn't depend on seasons so it is conducted every month and the resulting quality is different. (Kementerian Kelautan dan Perikanan, 2010).

The quality of seaweed depends on some factors namely ecology condition and oceanographic characters such as physics-chemistry characters (Harun et al., 2013). The oceanographic character of water strongly influences the growth and content of seaweed carrageenan (Ohno et al., 1994; Hayashi et al., 2007; Hung et al., 2008; Wijayanto et al., 2011). Oceanographic characters closely related to K. alvarezii including temperature, current, pH, salinity, Disolved Oxygen (DO), nitrates and phosphates (Effendi, 2003; Rani et al., 2012; Fikri et al., 2015; Syamsuddin, 2014).

Study about location criteria grouping of seaweed K. alvarezii farming based on oceanographic character hasn't been widely reported yet. Thus, this research conducts exploration about grouping/categorizing location criteria of K. alvarezii cultivation based on oceanographic character in villages Lobuk, Padike, Palasa and Tonduk. The information obtained in this study can be used as a reference for K. alvarezii farmers to pay more attention to location criteria in cultivating K. alvarezii and improve the quality of K. alvarezii seaweed.

2 MATERIALS AND METHODS

2.1 Time and Research Site

This research was conducted in January-June 2022. the activity of taking the field data, water sample and K. alvarezii sample were carried out in villages of Lobuk, Padike, Palasa and Tonduk, Sumenep, Madura at 10 am - 2 PM WIB.

2.2 The Determination of station for taking the sample

Taking the seaweed sample in villages of Lobuk, Padike and Raas island was conducted at K. alvarezii cultivation location. Station of taking the sample in villageS of Lobuk was conducted in coordinate point of 7o08´09´´S 113o49´34´´E, Palasa of 7o04´18´´S 114o01´49´´E, Tonduk of 7o09´25´´S 114o40´28´´E.

2.3 Taking Sample of water

Water sample in K. alvarezii cultivation location was taken with aseptic method (Largo, 1995) in waters of Lobuk Village and Raas Island. Water samples were taken at the depth of K. alvarezii cultivation at the cultivation site by using a glass bottle which had been sterilized using 70% of alcohol and then immediately covered with a lid. Furthermore, the water sample in a glass bottle was stored in a coolbox. The water samples obtained were then taken to a laboratory for analysis of phosphate and nitrate content.

2.4 Taking Data of Character of Oceanographic Physics and Chemistry

The waters' Oceanographic physics-chemical character measured was temperature using thermometer, acidity (pH) using a pH meter, salinity using a handsalino refactometer, current velocity using cork (styrofoam) associated with a 1-meter thread, then the cork was released in seawater waters. The time taken by the cork to reach a distance of 1 meter was determined using a timer. Furthermore, The speed of the current was recorded in units of cm/second (Pinet, 2000). Whereas dissolved oxygen (DO) was measured using a DO meter.

2.5 Analysis of Conformity Criteria

Conformity criteria was arranged based on relevant bio-physic parameter in each activity. It was conducted referring on the suitability criteria matrix from various literature studies (Wijaya, 2007). Data from observations and measurements at the sampling location included in the physics-chemistry character criteria with a slight modification by adding sociological characters. Weighting and scoring were determined based on the suitability of the location with the study of literature, and the justification of competent experts in the field of fisheries, both in writing and orally. This weighting was carried out by giving a + sign (plus one) for locations which didn't fit the criteria and ++ (plus two) for locations that fit the criteria (Wijaya, 2007; Bonham-Carter, 1994 in Wijaya, 2007).

3 RESULTS AND DISCUSSION

3.1 Oceanographic Character of Location Sampling

Oceanographic physics-chemical character of the waters is growth requirement for seaweed (Gaol & Sadhotomo, 2007; Arifin, 2014). Thus, Complete and accurate information about the oceanographic character of a waters was needed for this research. Oceanographic character data at the sampling locations in the first and second planting seasons can be seen in table 3.1 and 3.2.

Table 3.1 Table of Oceanographic Characters at Sampling Locations in Planting Season I

Oceanographic Character	Location				
	Reference	**Lobuk**	**Padike**	**Palasa**	**Tonduk**
Underwater	coral and sand (Wijaya, 2007)	Muddy Sand	Sand and coral sand	Mud and Seagrasses	Coral reefs
pH	6-9 Optimum 7,5-8,5	7,5	8,5	7,5	8,1
Tempera ture (0C)	26-33 Optimum 27-32	29	31	30	31
Salinity (‰)	30-38 Optimum 32-34	32	34	32	32
DO (mg/L)	3-8 Optimum 6,5-8	2,74	8,2	2,81	8

Current(cm/s)	10-30 Optimum 15-25	25	22,5	18	25
Phosphat e (mg/)	0,021-0,100 Optimum 0,050-0,075	0,25	0,068	0,18	0,074
Nitrate (mg/L)	1,00-3,2 Optimun 1,5-2,5	1,60	1,86	3,36	2,24

Reference Source: BSNI and SNI KKP No. SNI 01-6492-2010

Based on table 3.1, waters of Padike and Tonduk had suitable substrate waters compared to aquatic substrate in Lobuk and Palasa. In the cultivation of K. alavarezii, the substrate played a role in maintaining the stability of the sediment which included protection from the flow of water and a place to obtain nutrients (Dahuri, 2003; Edward, 2003; Bengen, 2001). Differences in the substrate base in the waters would affect the density and growth of

K. alavarezii (Ain et al., 2014). Thus, the substrate was one of the important components that played a role in seaweed growth (Indrawati et al., 2009).

In addition, based on Table 3.1, it can be seen that waters of Padike and Tonduk had the appropriate physics-chemical oceanographic character for the growth of K. alvarezii. Dissolved oxygen (DO) in the waters of Lobuk and Palasa was below the specified standard of 2.74 and 2.81 mg/L, the phosphate above the standard was 0.18 and 0.25 mg/L and the waters of Palasa had a quite high nitrate of 3.36 mg/L.

Inappropriate dissolved oxygen (DO) with required standard for K. alvarezii growth in waters of Lobuk and Palasa could be caused by high current speed. The Directorate General of Aquaculture (2008) stated that substrates which were not in accordance with the current movement were high enough to affect aeration, nutrient transportation, and water stirring. Thus, they affected turbidity and reduce DO values. In addition, the low DO in these waters was thought to be due to the entry of organic materials into the waters. The more organic waste material that was in the water, the less residual oxygen content was dissolved in. According to Klein in Andriani (1999), the level of dissolved oxygen in a water would decrease due to the process of decomposition of organic matter, respiration, and inhibited reaeration.

The high level of phosphate in Lobuk and Palasa waters was caused by the existence of organic materials such as domestic waste (detergent), agricultural waste or phosphorus rock erosion by water flow (Effendi, 2003; Supriharyono, 2007; Brotowidjoyo et al., 1995; and Hutabarat, 2008). Besides, as in Figure 3.1, the sociological character of the community such as densely populated settlements allowed the entry of domestic waste because many residents threw garbage into the waters coupled with economic activity, transportation routes and the presence of fish factory sewage disposal near the K. alvarezii cultivation area (Wulandari, 2016).

Figure 3.1 Dense Population Settlements Area of Lobuk Waters

Meanwhile, high nitrate concentration in Palasa waters was affected by people's sociology character which didn't use proper Bath wash toilet (MCK), animal feces, urine and carcasses in the water causing anthropogenic pollution (Wulandari, 2020 ; Effendi, 2003; Vinneras, 2006). Nitrate concentrations in Lobuk waters were relatively low when compared to Padike and Tonduk waters. However, nitrate concentrations in Lobuk waters were still at the optimum standard required by K. alvarezii. The low nitrate concentration in Lobuk waters was affected by the entry of nitrate concentration from the river flow, in which the river flow carried material decomposition of plant and animal residues, disposal of industrial waste, feces and animal dung containing a lot of ammonia (Mondoringin, 2013; Dahuri, 2003; Samawi, 2009; Tambaru, 1998). River flow near the cultivation location could affect nitrate concentration. This was due to the breakdown of organic matter on land transported by river flow and into the sea (Rompas, 2010; Anggadinedja et al, 2006; Wulandari, 2020). Oceanographic character data in the second planting season at the sampling location can be seen in Table 3.2.

Table 3.2 Table of Oceanographic Characters at Sampling Locations in Planting Season II

Oceanographic Character	**Location**				
	Reference	**Lobuk**	**Padike**	**Palasa**	**Tonduk**
Underwater	coral and sand (Wijaya, 2007)	Mudd y Sand	Sand and coral sand	Mud and Seagrasses	Coral reefs
pH	6-9 Optimum 7,5-8,5	7,5	8,7	7,9	8,5
Temperat ure (0C)	26-33 Optimum 27-32	30	32	30	31,5
Salinity (‰)	30-38 Optimum 32-34	32	35,5	31	33
DO (mg/L)	3-8 Optimum 6,5-8	2,93	8	2,86	7,8
Current (cm/s)	10-30 Optimum 15-25	32	25	30	28

Phosphate (mg/L)	0,021-0,100 Optimum 0,050-0,075	0,20	0,05 1	0,13	0,06 4
Nitrate (mg/L)	1,00-3,2 Optimun 1,5-2,5	1,52	1,68	3,24	1,84

Reference Source: BSNI and SNI KKP No. SNI 01-6492-2010

Based on Table 3.2, it can be seen that the waters of Lobuk and Palasa in the second planting season also have almost the same oceanographic characters, where dissolved oxygen (DO) is below the standard, namely 2.86 and 2.93 mg/L, phosphate is above the standard, which is 0.13. and 0.20 mg/L, nitrate above the standard of 3.24 mg/L and in the second planting season the current velocity at that location was also above the specified standard of 30 and 32 cm/s, so this condition was not suitable for the growth of K. alvarezii

. Meanwhile in Padike waters the pH and salinity were slightly above the optimum limits required for growth, namely 8.7 for pH and 35.5‰ for salinity. Similar to the Tonduk waters, the current velocity is also slightly above the required optimum of 28 cm/s. The conditions in the waters of Padike and Tonduk are still considered suitable because the standard pH is 6-9, salinity is 30-38‰ and current speed is 10-30 cm/s (Setiyanto et al., 2008; Aslan, 2005; Samsuari, 2006; Soenardjo, 2003).

The high pH of Padike waters (> 7) in the second planting season can be made possible because data collection is carried out during the day, where during the day is the photosynthetic activity and respiration of marine biota so that it affects CO2 levels. Photosynthetic activity during the day requires carbon dioxide (CO2) and produces organic carbon in the form of simple sugars and releases O2 molecules so that the pH of the water during the day will rise (Garrison, 2004; Hickey et al., 1998). While the pH of the waters can be acidic (< 7) possibly due to the process of decomposition or decomposition of organic matter in the waters, organic matter in the form of a collection of organic compounds of living things contains carbon (C) elements (Amiluddin, 2007). Organic compounds are generally unstable and easily oxidized to CO2 and H2O, in addition to causing reduced oxygen levels, can also reduce the pH of the water to become acidic (Lee, 1999). Dissolved inorganic carbon content can increase hydrogen ions so that the pH of the water will also be low or become acidic (Boyd, 1990).

The low salinity in Padike waters in the second planting season can be caused by low rainfall and high temperatures in these waters (Fong and Geyer, 2001; Kalangi, 2008; Kalangi et.al., 2012; Dahuri, 2003). High enough temperatures can affect evaporation in marine waters, this evaporation brings salt particles to evaporate indirectly and low rainfall which results in no dilution of evaporated seawater causing high salinity (Kunarso, 2011; Holiludin, 2010).

Meanwhile, the high currents of Lobuk, Padike and Tonduk waters in the second planting season can be affected by high winds and waves. High winds and waves can affect surface currents of about 2% of wind speed, the speed of these currents will decrease with increasing water depth until finally the wind has no effect at a depth of 200 m (Suardi, 2006 in Fitriani, 2011). The Directorate General of Aquaculture (2008) states that high current movements can accelerate the stirring of the substrate in the form of muddy sand and can affect aeration, nutrient transport, thus affecting turbidity and lowering DO values. Current pattern, current velocity, is a physical character that has an influence on the chemical character and nutrients in the waters (Largo, 2003).

3.2 Conformity Criteria of K. alvarezii seaweed Farming Location Based on Oceanographic Character

Conformity criteria of area as the location of K. alvarezii seaweed cultivation based on oceanographic characteristics was very necessary because the location criteria could be used as a location for the development of large seaweed of 5,870 ha in Sumenep District. Thus, the development of K. alvarezii cultivation in Sumenep District could be directed to the appropriate location (Fatmawati and Wahyudi, 2015). The suitability criteria for oceanographic characters as the location of K. alvarezii cultivation based on oceanographic characters can be seen in Table 3.2.

Table 3.2 Table of Conformity Criteria of K. alvarezii Cultivation Location Based on Oceanographic Character

Cultivation Character	**Location**				
	Reference	**Lobuk**	**Padike**	**Palasa**	**Tonduk**
1. Oceanographic Character					
a. Geographical location (WWF, 2014)					
Bay	++		+ +		
Strait	++			+ +	
Attol Ragion	++				++
Waters between 2 Islands	++	+ +			
Watershed					
There is watershed		+			
There is no watershed	++		++	++	++
b. Type of underwater (Wijaya, 2007)					
Mud	-			+	
Sand	++				
Muddy Sand	-	+			
Sand with coral fractures	++		++		
Coral	++				++
c. Physics (BSNI dan SNI KKP No. SNI 01-6492-2010)					
Current Speed (15-25 cm/s)	++	+	++	+	++
Wave (m)					
Low (<0,75)					

Moderate (0,75-1,25)	++		++		++
High (>1,25)		+		+	
Rainfall (mm/day rain)					
Very Low (<13.6)					
Low (13.6-20.7)					+
Moderate (20.7-27.7)	++		++		
High (27.7-34.8)		+		+	
Very High (>34.8)					
Temperature (27-30 0C)	++	++	++	++	++
Salinity (32-34‰)	++	+	++	++	++
d. Chemical (BSNI dan SNI KKP No. SNI 01-6492-2010)					
pH (7,5-8,5)	++	++	++	++	++
Phosphate(0,050-0,075mg/L)	++	+	++	+	++
NITRATE (1,5-2,5 MG/L)	++	++	++	+	++
Dissolved Oxygen (6,5-8 MG/L)	++	+	++	+	++
2. Sociology Character					
Population					
Not Densely Populated	++		++		++
Densely Populated		+		+	
Home Industry And Industry					
Doesn't Exist	++		++	++	++
Exist		+			
Sanitasion					
Using Proper Bath Wash Toilet (MCK)	++	++	++		++
Not Using Proper Bath Wash Toilet (MCK)				+	
Quality	**15**	**6**	**15**	**6**	**14**
Conformity Group (SCORE)		**N**	**S1**	**N**	**S2**

Information: + (not required the criteria)
++ (required the criteria)

Categorization of oceanographic character group or scoring in location criteria was conducted based on the weighting of the FAO classification (1976) referred to by Hardjowigeno (2001) in Wijaya (2007). Oceanographic character groups were divided into 3, as follow: S1 (Highly Suitable), S2 (Suitable), and N (Not Suitable) groups.

a. Group S1 (Highly suitable) had a quality of 15. This S1 group was a very suitable character to be used as a cultivation location for K. alvarezii, this group had a stable character which could even increase production or yields of cultivation.

b. Group S2 (Suitable) had a quality of <15 and> 10, as follow: oceanographic character was not highly influential on the results of cultivation. Thus, it affected the stable production.
c. Group N (Not Suitable) had a quality of <10. Group N placed the oceanographic character as a limiting factor which highly affected the production results. Thus, it was not used for sustainable locations.

Based on Table 3.2, it can be seen that Lobuk and Palasa waters belonged to group N, in terms of the physical-chemical oceanographic characteristics of these two waters, they were less supportive for K. alvarezii cultivation because they had unstable flow velocity, low DO and high phosphate and nitrate levels. Some of the inappropriate physics-chemical oceanography characters could cause a decrease in the quality of seaweed because these four characters affected the photosynthesis process, seaweed endurance and an abundance of pathogenic bacteria which could cause ice-ice disease (Arisandi, 2013; Emerenciano , 2011; Koch-Larrouy, 2008).

Padike waters was included in the S1 group, which meant that Padike waters was very suitable to be used as a location for the cultivation of K. alvarezii because they had a quality of 16 in accordance with predetermined criteria and based on field observations in Padike waters had highly appropriate physical-chemical oceanographic characteristics. Physico-chemical oceanography characters which played an important role in Padike waters was pH and salinity, both of these characters played a role in increasing biomass and carrageenan content (Choi et al., 2010; Villanueva, 2003). While in the Tonduk waters belong to the S2 group, this shows that the Tonduk waters have appropriate criteria for the cultivation of K. alvarezii. However, this appropriate criterion had an influence on stable production results

Based on table of conformity criteria of oceanographic character for in the cultivation of K. alvarezii, the most suitable criteria was in the S1 group (Highly Suitable). This was because the S1 group could increase production compared to the S2 and N. Groups. Therefore, it was recommended to plant K. alvarezii seaweed in Sumenep District. It should be conducted more in waters that had criteria such as the S1 group to obtain better production results.

4. CONCLUSION

Based on the oceanographic character of location sampling, the suitability criteria of the location as a *K. alvarezii* cultivation location can be categorized into 3 group as follow: S1 groups (Highly Suitable) in Padike waters, S2 groups (Suitable) in Tonduk waters, N groups (NotSsuitable) in the waters of Lobuk and Palasa. Planting *K. alvarezii* seaweed in Sumenep should be conducted more in waters which have criteria as S1 group to increase production result.

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REFERENCES

Ain, N., Ruswahyuni dan N. Widyorini. 2014. Hubungan Kerapatan Rumput Laut dengan Substrat Dasar Berbeda di Perairan Pantai Bandengan, Jepara. Diponegoro Journal of Maquares. 3(1): 99 – 107.

Anggadiredja, J.T., Z. Achmad, P. Heri, dan I. Sri. 2008. Rumput Laut Pembudidayaan, Pengolahan dan Pemasaran yang Potensial. Jakarta: Penebar Swadaya.

Arifin, Z. 2014. Arah dan Rencana Riset Oseanografi pada Samudera Hindia 2015 – 2020. Pusat Penelitian LIPI – Oseanografi. Jakarta: 64 hal.

Arisandi A, Farid A, Wahyuni EA dan Rokhmaniati S. 2013. Dampak infeksi ice-ice dan epifit terhadap pertumbuhan Eucheuma cottonii. J. Kelautan. 8 (1): 1-6.

Badan Standarisasi Nasional Indonesia. 1990. Metode Pengujian Berat jenis dan Penyerapan Agregat Halus. SNI 03-1970-1990. Badan Standarisasi Nasional (BSN) Indonesia.

Bengen, GD. 2001 Sinopsis Ekiosistem Dan Sumberdaya Alam Pesisir Dan Laut. Pusat Kajian Sumberdaya Pesisir Dan Lautan. IPB. Bogor. 61 hal.

Brotowidjoyo, D.M., Tribowo, D., Eko. M. 1995. Pengantar Lingkungan Perairan dan Budidaya Air. Liberty, Yogyakarta. 87 hal.

Campo, V. L., D.F. Kawano, D. B. Silva Júnior, I. Ivone Carvalho. 2009. "Carrageenans: biological properties, chemical modifications and structural analysis". Carbohydrate Polymers. 77. 167- 180.

Choi, T.S., E.J. Kang, J.H. Kim, & K.Y. Kim. 2010. Effect of salinity on growth and nutrient uptake of Ulva pertusa (Chlorophyta) from an eelgrass bed. Algae, 25 (1): 17-25.

Dahuri, R. 2003. Pengelolaan Sumber Daya Wilayah Pesisir dan Lautan Secara Terpadu. PT. Pradnya Paramita. Jakarta.

Direktorat Jendral Perikanan Budidaya. 2008. Petunjuk teknis budidaya rumput laut Eucheuma spp. DKP RI, Ditjenkanbud. Jakarta. Hal 41

Edward, Tarigan, Z. 2003. Pemantauan Kondisi Hidrologi di Perairan Raha P. Muna, Sulawesi Tenggara dalam Kaitannya dengan Kondisi Terumbu Karang. Makara, Sains. Vol. 7(2):73- 82.

Effendi, H. 2003. Telaah Kualitas Air, Bagi Pengelolaan Sumber Daya dan Lingkungan Perairan. Kanisius.Yogyakarta.

Emerenciano M, Ballester EL, Cavalli RO dan Wasielesky W. 2011. Effect of biofloc technology (BFT) on the early postlarval stage of pink shrimp Farfantepenaeus paulensis: growth performance, floc composition and salinity stress tolerance. Aquaculture International. 19 (5): 891-901.

Fikri, M., Rejeki, S. dan Widowati, LL. 2015. "Produksi dan Kualitas Rumput Laut (Eucheuma cottonii) dengan Kedalaman Berbeda di Perairan Bulu Kabupaten Jepara". Journal of Aquaculture Management and Technology 4 (2) Hal: 67–74.
Gaol, J. L dan B. Sadhotomo. 2007. Karakteristik dan Variabilitas Parameter Oseanografi Laut Jawa Hubungannya dengan Distribusi Hasil Tangkapan Ikan. Jurnal Penelitian Perikanan Indonesia. Vol. 13. No.3: 1-12.
Harun, M., Montolalu, RI. dan Suwetja, K. 2013. "Karakteristik Fisika Kimia Karaginan Rumput Laut Jenis Kappaphycus alvarezii pada Umur Panen yang Berbeda di Perairan Desa Tihengo Kabupaten Gorontalo Utara". Jurnal Media Teknologi Hasil perikanan 1 (1) Hal: 7
Hayashi L., Paula EJD., dan Chow F. 2007. "Growth Rate and Carrageenan Analyses in Four Strains of Kappaphycus alvarezii (Rhodophyta, Gigartinales) Farmed in the Subtropical Waters of São Paulo State, Brazil. J Appl Phycol 19". Hal: 393–399.
Hung, LD., Hori K., Nang, HQ., Kha, T., dan Hoa, LT. 2008. Seasonal Changes in Growth Rate, Carrageenan Yield and Lectin Content in the Red Alga Kappaphycus alvarezii Cultivated in Camranh Bay, Vietnam. J Appl Phycol 21. Hal: 265–272.
Hurtado, A., Critchley, A., Trespoey, A., 2008. Growth And Carrageenan Quality of Kappaphycus Striatum Var. Sacol Grown at Different Stocking Densities, Duration of Culture and Depth. J Appl Phycol 20:551–555
Hurtado, N. G. Guanzon, Jr. T. R. de Castro-Mallare, dan M. R. J. Luhan (Eds). 2000." Recent development in seaweed disease". Proceedings of the National Seaweed Planning Workshop. Tigbauan, ilolo: SEAFDEC Aquaculture Department.
Hutabarat, S. dan Evans, S.M. 2008. Pengantar Oseanografi. UI Press. Jakarta.
Indrawati, G., I.W. Arthana dan I.N. Merit. 2009. Studi Komunitas Rumput Laut di Pantai Sanur dan Pantai Sawangan Dua Bali. Jurnal Ecotrophic. 4(2): 73 – 79.
Kementrian Kelautan dan Perikanan (KKP). 2010. Keputusan Menteri Kelautan dan Perikanan Republik Indonesia Nomor 45 Tahun 2011 tentang Estimasi Potensi Sumberdaya Ikan di Wilayah Pengelolaan Perikanan Republik Indonesia. Jakarta (ID): KKP.
Klein Tank, A.M.G. and KönnenG.P., (2003): Trends in indices of daily temperature and precipitation extremes in Europe, 1946–99. Journal of Climate, 16, 3665–3680.
Koch-Larrouy A, Madec G, Iudicone D, Atmadipoera A dan Molcard R. 2008. Physical processes contributing to the water mass transformation of the Indonesian Throughflow. Ocean Dynamics. 58 (3-4): 275-288.
Largo, D.B., Fukami, K., Nishijima, T., and Ohno, M. 1995. "Laboratory-induced development of the "ice-ice" disease of the farmed red algae Kappaphycus alvarezii and Eucheuma denticulatum (Solieriaceae, Gigartinales, Rhodophyta)". J. Appl. Phycol. 7: 539-543.
Mendoza W. G., Montano N.E., Ganzon-Fortes E.T., Villanu Eva R.D. 2002. "Chemical and Gelling Profile of ice-ice Infected Carageenan from Kappaphycus striatum (Schmitz) Doty "Sacol" Strain Soliecirìciae, Gigartinales, Rhodophyta)". Journal of Applied Phycology. (14) 409-418.

Mondoringin L, Tiwa RB, Salindeho I. 2013. Pertumbuhan Rumput Laut Kappaphycus alvarezii pada Perbedaan Kedalaman dan Berat Awal di Perairan Talengen Kabupaten Kepulauan Sangihe. Laporan Penelitian. Sulawesi Utara

Mustapha, S., H. Chandar, Z. Z. Abidin, R. Saghravani dan M. Y. Haru. 2011. "Production of semi- refined carrageenan from Eucheuma cottonii". Journal of Scientific & Industrial Research. Vol. 70 : 865-870.

Neish, I. C. 2003. The ABC of Eucheuma Seaplant Production. Agronomy, Biology and Crop-handling of Betaphycus, Eucheuma and Kappaphycus the Gelatine, Spinosum and Cottonii of Commerce. SuriaLink Monograph.

Ohno, M., Largo, DB., dan Ikumoto, T. 1993. "Growth Rate, Carrageenan Yield and Gel Properties of Cultured kappa-carrageenan Producing Red Alga Kappaphycus alvarezii (Doty) Doty in the Subtropical Watersof Shikoku, Japan". J Appl Phycol 6. Hal:1–5.

Rani, C., Samawi, MF., Nelwan, A. dan Faizal, A. 2012. Potensi dan Kondisi Sumber Daya Perikanan dan Kelautan. Masagena Press. Makassar

Rompas, R.M. 2010. Toksikologi Kelautan. Sekertariat Dewan Kelautan Indonesia. Walau Bengkulen. Jakarta.

Sahabuddin dan Tangko, A.M. 2008. "Pertumbuhan dan Mutu Kadar Karaginan Rumput Laut Eucheuma cotonii Pada Substrat Dasar Yang Berbeda di Perairan Bantaeng Sulawesi Selatan. Balai Riset Perikanan Budidaya Air Payau Maros". Seminar Nasional Tahunan V Hasil Penelitian Perikanan Dan Kelautan.

Samawi, M.F. 2011. "Hubungan Antara Konsentrasi Klorofil-a dengan Kondisi Oseanografi di Perairan Pantai Kota Makassar". Jurnal Torani, 18 (2): 121-128.

Standar Nasional Indonesia (SNI) (ID). 2010. Produksi rumput laut kotoni (Eucheuma cottoni) – Bagian 2: Metode Long-line. Badan Standarisasi Nasional. SNI : 7579.2:2010.

Supriharyono. 2007. Konservasi Ekosistem Sumber Daya Hayati di Wilayah Pesisir dan Laut Tropis. Yogyakarta: Pustaka Pelajar.

Syamsuddin, R. 2014. Pengelolaan Kualitas Air: Teori dan Aplikasi di Sektor Perikanan. Pijar Press. Makassar.

Tambaru. 2008. Dinamika Komunitas Fitoplankton Dalam Kaitannya dengan Produktivitas Perairan di Perairan Pesisir Maros Sulawesi Selatan. Pascasarjana. Institut Pertanian Bogor.

Tokan, M.K. 2009. Morphology Characteistics of Microorganisme of the Seaweed (Eucheuma spinosum) Suffering of The Ice-Ice Disease. Journal Biotropical Sains. No. 2.Vol. 3: 18 – 25.

Van de Velde F., S. H. Knutsen, A. I. Usov, H. S. Romella, dan A. S. Cerezo. 2002. "1H and 13 C high resolution NMR spectoscopy of carrageenans: aplication in research and industry". Trend in Food Science and Technology. 13. 73-92.

Villanueva R.D., & N.M.E. Montaño. 2003. Fine Chemical Structure of Carrageenan from The Commercially Cultivated Kappaphycus striatum (sacol variety) Solieriaceae, Gigartinales, Rhodophyta). J. Phycol., 39: 513–518.

Vinneras, B. 2006. Faecal Separation and Urine Diversion for nutrient Management of Household Biodegradable Waste and Wastewater. Tesis. Swedish University of Agricultural Sciences. Uppsala.

Wijaya, N. I. 2007. Analisis Kesesuaian Lahan dan Pengembangan Kawasan Perikanan Budidaya di Wilayah Pesisir Kabupaten Kutai Timur. Institut Pertanian Bogor. Bogor.

Wijayanto, T., Hendri, M. dan Aryawati, R. 2011. "Studi Pertumbuhan Rumput Laut Eucheuma cottonii dengan Berbagai Metode Penanaman yang Berbeda Di Perairan Kalianda, Lampung Selatan". Maspari Journal 3 Hal:55.

Wilson, T.L.Y., Poh, Y.L., Siew, H.T., Grace, J.W.L.C., Kenneth, F.R., and Ann, A. 2013. "Profiling of Lectin Production in WildType and in Vitro Cultivated Kappaphycus alvarezi"i. European International Journal of Science and Technolog. Vol. 2 No. 9 November, 2013.

Wulandari,S.A., Isdiantoni,I., Prasetyo,E.N. Bacterial Community Stratification Related to Ice ice Disease on Seaweed (Kappaphycus alvaresii). Proceeding of ICMSE, 2016. https://journal.unnes.ac.id/sju/index.php/icmse/article/view/13352.

Wulandari,S.A., Isdiantoni,I., Prasetyo, E.N. Analisis Fisika Kimia Perairan dan Komunitas Bakteri Terkait Kemunculan Penyakit Ice-ice pada Rumput Laut (Kappaphycus alvarezii). Science Education and Application Journal, 2020. doi: 10.30736/seaj.v2i2.277. https://doi.org/10.30736/seaj.v2i2.277