Bioculture
Bioculture Journal
Bioculture 3(1): 38–51
ISSN 3025-3632

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Satellite-based cultivation scheduling for *Eucheuma* sp. using landsat-8 imagery in coastal aquaculture systems

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Received Date: January 13, 2025 Revised Date: June 19, 2025 Accepted Date: July 31, 2025

ABSTRACT

Background: Seaweed cultivation in Jeneponto Regency has been practiced for a long time and has become the main livelihood for most people in Mallasoro Bay. In cultivating seaweed, obstacles often arise in the form of failure experienced by seaweed farmers, or the quality of the harvest is not good. **Methods:** This study aims to develop a calendar for planting seaweed *Eucheuma* sp. in Mallasoro Bay, Jeneponto Regency based on sea surface temperature and chlorophyll-a distribution obtained from Landsat-8 imagery. **Findings:** Processing of Sea Surface Temperature Imagery and Chlorophyll-a processed using ENVI 4.8 dan 5.3 software, satellite images used in clean conditions and no cloud disturbances. In this research, data analysis was carried out descriptively. The water temperature that is good for seaweed growth is 27-30°C, for the Mallasoro Bay Sea Surface Temperature, which is suitable for planting seaweed in April, May, June, July, August, September, October, and November. While the classification based on the criteria of chlorophyll-a trophic status in marine waters, namely the range < 1 mg/L is classified as Oligotrophic, 1-3 mg/L is classified as Mesotrophic, 3-5 mg/L is classified as Eutrophic, and > 5 mg/L is classified as hypertrophic. **Conclusion:** from the results of image analysis for the distribution of chlorophyll-a in Mallasoro Bay, it shows that Mallasoro Bay throughout the year is at the Mesotrophic level or the fertility level of the waters is quite fertile because it is in the range of 1-3 mg/L. so b the seaweed planting calendar in Mallasoro Bay is obtained, namely in January, February, and December, equipment preparation such as cleaning and repair of seaweed planting equipment can be carried out, then at the end of March, May, July, and September, the procurement of seaweed seeds is carried out , in early of April, June, August, and October, **Novelty/Originality of this article:** it is possible to spread seaweed seeds, then in mid of May, July, September, and November, harvesting is carried out, so that seaweed cultivation in a year can be carried out 4 times cycle.

KEYWORDS: calendar forp lanting seaweed, sea surface temperature, Chlorophyll-a, *Eucheuma* sp., Mallasoro bay

1. Introduction

Indonesia has been widely known as an archipelagic country whose area is 2/3 of the ocean and has the longest coastline in the world, which is ± 80,791.42 km. One of the living things that grow and develop in the sea is seaweed (Gusrina, 2006). Indonesian waters are tropical waters that are very rich in fishery resources, one of which is seaweed (WWF-Indonesia, 2014). Seaweed is one of the marine commodities that has a high economic value. This is due to the content of gelatin and carageenan contained in seaweed which are indispensable in the pharmaceutical, cosmetic industry or as a production process ingredient (Istiqomawati, 2010).

Jeneponto Regency is located at the western end of South Sulawesi Province and is a coastal area that stretches along ±95 k km^2 with an area of 74,979 km in the south.

Cite This Article:
Isnaeni, A. (2025). Satellite-based cultivation scheduling for Eucheuma sp. using landsat-8 imagery in coastal aquaculture systems. *Bioculture Journal. 3*(1), 38-51. https://doi.org/10.61511/bioculture.v3i1.2025.2114

Geographically located between 5°016'13"-5°39'35" South Latitude and 120°040'19"-120°07'51" East Longitude.

Mallasoro Bay was chosen as the research site because the area is in the form of a bay where the ocean is surrounded by land and protected by a small island to the south of this bay, namely Libukang Island, this is what causes the waters in this bay to be good and calm so that many seaweed farmers make this bay as a location for seaweed cultivation (Ariny, 2016). Sea surface temperature can affect the life of aquatic organisms. Sahabuddin and Tangko (2008) said that temperature affects the metabolic activity and development of an organism. The suitable temperature for the growth of karegenophyte ranges from 25 – 30°C, the seaweed will die when the water temperature reaches 31°C. In general, the growth of caragenophytes will decrease or stop during high water temperatures (Baracca, 1999).

Chlorophyll-a is an active pigment that is very important in the process of photosynthesis and the formation of organic matter in waters. The content of chlorophyll-a in a body of water can be used as an indicator of the fertility level of the waters, namely as an indicator of the availability of nutrients in the waters and as an indicator of the occurrence of eutrophication in a body of water (Marlian et al. 2015). Chlorophyll-a has been used as an indicator of water quality, because chlorophyll-a is an indicator of phytoplankton biomass, where its content comprehensively describes the effects of various factors that occur due to human activities (Linus et al. 2016). Along with the development of satellite technology today, which can provide information on chlorophyll-a concentration and sea surface temperature (Astrijaya, 2014). One of the remote sensing satellites equipped with sensors that can detect chlorophyll-a content in the waters is the Landsat satellite. Landsat satellite imagery has been widely used to estimate the concentration content of chlorophyll-a in waters (Hanintyo and Susilo 2016).

In cultivating seaweed, obstacles often arise in the form of failures experienced by seaweed farmers or poor crop quality. This failure can cause quite high damage due to being attacked by pests and diseases because farmers spread seaweed without considering water conditions so that often the results are not as desired, this happens because there is no planting calendar that can be used as a reference. The seaweed planting calendar can be used as a reference, a tool for seaweed farmers to determine the planting season. The planting calendar is compiled by using information on sea surface temperature and chlorophyll-a distribution obtained from Landsat-8 imagery and questionnaires. This study compiled a grass planting calendar in Mallasoro Bay, Jeneponto Regency based on landsat-8 imagery. which can later be a reference for planting seaweed farmers.

2. Methods

This research was carried out in April 2021 – February 2022 in a seaweed cultivation area in Mallasoro Bay, Bangkala District, Jeneponto Regency. The research was conducted at the Marine Remote Sensing Laboratory and in the field. The work process in the laboratory includes image download, image processing, data analysis, chromophyll-a measurement of water taken representing each station and making a final report. Meanwhile, in the field, it includes determining coordinate points, measuring temperature, and taking water samples from each station to measure crolophyll-a in the laboratory as well as distributing questionnaires with seaweed farmers as image validation. In this study, data analysis was carried out descriptively in the Table, from the 12 months of images that were processed to see sea surface temperature data and chlorophyll-a, then combined the images from January to December as well as supporting data, which in accordance with the criteria of sea surface temperature data and chlorophyll-a can be planted seaweed the water temperature that is good for the growth of seaweed is 27-30°C (Duma, 2012), while the classification is based on the criteria of trophic status of chlorophyll-a in marine waters, which is in the range of < 1 mg/L classified as Oligotrophic, ≥ 1–3 mg/L classified as Mesotrophic, ≥ 3–5 mg/L classified as Eutrophic, and > 5 mg/L classified as Hypertrophic (Adani et al., 2013).

Determination In this study, consultation was carried out with the supervisor then collected literature on research and collected various kinds of supporting data needed during the research. Landsat-8 imagery is obtained by downloading the image in www.glovis.usgs.gov, by opening a browser by typing https://earthexplorer.usgs.gov/ address, then clicking Data Sets, clicking Landsat then Landsat Collection 1 Level-1, and finally selecting Landsat 8 OLI/TIRS C1 Level-1, then selecting Search Criteria, then selecting the Address/Place box of Mallasoro Bay and clicking search, then clicking the Download icon and selecting the type of Level-1 GeoTIFF data Product After that Click the download icon. Furthermore, the Landsat 8 image processing uses ENVI 4.8 and 5.3 software. The satellite imagery used must be in a clean condition and there is no cloud disturbance at the research site so that it makes the analysis easier. Satellite image data was obtained by taking recording data on (a) January 25, 2020, (b) February 23, 2019, (c) March 13, 2020, (d) April 17, 2021, (e) May 03, 2021, (f) June 15, 2019, (g) July 19, 2020, (h) August 07, 2021, (i) September 08, 2021, (j) October 21, 2019, (k) November 6, 2019, (l) December 10, 2020.

Image processing begins with atmospheric correction. This correction functions to reduce or eliminate atmospheric disturbances when recording using the dark pixel substraction method on band-1 to band-6 using the ENVI application by displaying images starting from band-1 to band-6. The atmospheric correction value can be determined from the pixel value frequency histogram. To display the statistical values of the image, do it on the Quick stats menu Then click on the "select plot" icon and select "Histogram band 1", After that record the DN value of the last Npts which is 0, After recording the DN value, the next step is to click the "Basic tools" menu on the main bar menu > Processing > General purpose utilities > Dark substrate. After that, select the band 1 file as the initial input to adjust the substraction values. After that click on the "choose" icon to choose the location where the file is saved. Then save it with the name "atm1". Choose a storage location and then name the file according to the input band used. for the input of the BAND 1 file then the output is named atm1. perform the same steps on BAND files 2-6. After the six ATM files have been saved, the file will appear on the available band list, The next step is to open the RGB Image.

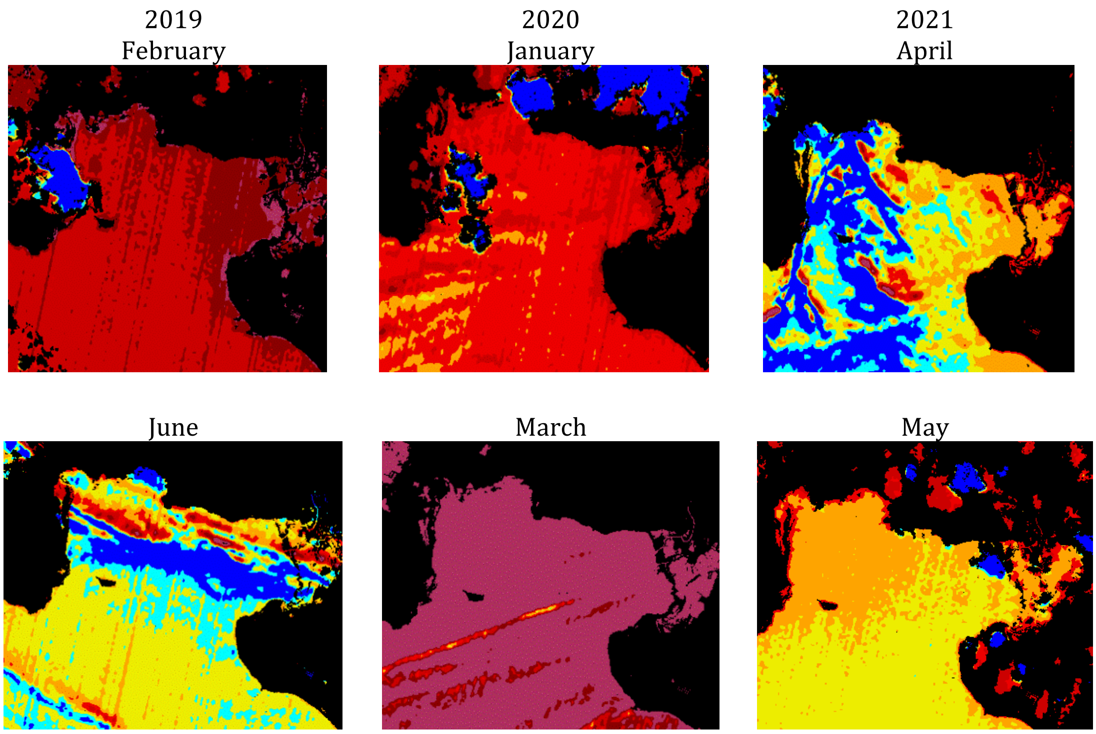
Image cutting is carried out to limit the area in the area to be studied, in this case image cutting is carried out in the Mallasoro Bay area. Satellite image cutting is carried out by making boundary polygons to obtain images in accordance with the research study area. Image cropping can be done through the ROI Tool, by right-clicking on the image page then selecting the "ROI tool" menu, If the "ROI Tool" page has appeared, first change the ROI type by selecting the "ROI_Type" menu on the menu bar, then ticking the "Rectangle" option, After that select the area to be cropped, and right-click on the screen, until the image crop is red, after that save the selection file (ROI) by selecting the "file" menu on the ROI Tool page then select "Save ROIs", If the "Save ROIs to file" page has appeared, then click on the area that has been given a red box, then click the "choose" icon to choose the location where the ROI file is stored, After that, the "Output Filename" page will appear, then choose the storage location then.

Geometric correction is carried out to restore (rotate) the image so that the image coordinates match the geographical coordinates. Geometric correction is performed by opening the atmospheric corrected band-1 to band-6 image file, and band-10 and band-11, displaying composite image 432 of the atmospheric corrected image. Next, determine GCP Based on iconic objects in a certain region that are unlikely to undergo long-term changes by adjusting several points to the coordinate points of objects in the google earth application. To create a GCP first click the "Map" menu on the main menu bar > Registration > Select GCPs image to map, after the page appears then select Geographic Lat/Lon and change the X and Y values to 0.000271, then click "OK" and fill in the values E and N according to the coordinate points of the iconic object obtained from google earth. After that click on the "Add point" icon to add the point as GCP. perform GCP point determination in several places that are not too close, and perform this procedure until 5-8 points have been determined. With an RMS error value < 0.5 to avoid errors. After that to save the GCP file, select the "File" menu on the menu bar, then click "Save GCPs w/lat/lon", if the "Output registration points" page appears, click "choose" to choose the location of the file storage, give the GCP name then click the "Open" icon to save Next create a GEO file based on the predefined GCP, click the "Map" menu on the main menu bar > Registration > Warp from GCPs image to map, when the "Enter GCP Filename" page appears, then select the previously saved GCP file, then click the "Open" icon, when the "Image to Map Registration" page appears, select the settings according to the image below and click "Ok". After that, a "Warp Image Input" page will appear to select the file input to be converted into a GEO file based on the predetermined GCP value. First of all, select the ATM file as the input. After that, clicking the "OK" icon will then appear the "Registration Parameters" page. Click the "Choose" icon to select the location where the file is stored After the "Output Filename" page appears, then give the file a GEO name according to the predetermined ATM input. For example, the atm1 input is named geo1. perform this procedure until all six ATM files have been converted to GEO files based on a predefined GCP. After the GEO file is saved, the file will appear in the available band list, then open the RGB image with composite 4,3,2 with the GEO file in the available band list. After that, click the "Load RGB" icon and wait for the image file to open.

In this study, data analysis was carried out descriptively in the Table, from the 12 months of images that were processed to see sea surface temperature data and chlorophyll-a, then combined the images from January to December as well as supporting data, which in accordance with the criteria of sea surface temperature data and chlorophyll-a can be planted seaweed. The water temperature that is good for the growth of seaweed is 27-30°C (Duma, 2012), while the classification is based on the criteria of trophic status of chlorophyll-a in marine waters, which is in the range of < 1 mg/L classified as Oligotrophic, ≥ 1–3 mg/L classified as Mesotrophic, ≥ 3–5 mg/L classified as Eutrophic, and > 5 mg/L classified as Hypertrophic (Adani et al., 2013).

3. Result and Discussion

Bangkala District is one of 11 sub-districts in Jeneponto Regency which is bordered by Gowa Regency to the north, Tamalatea District to the east, West Bangkala District to the west and Flores Sea to the south. Bangkala District consists of 14 villages/sub-districts with an area of 121.81 km^2.



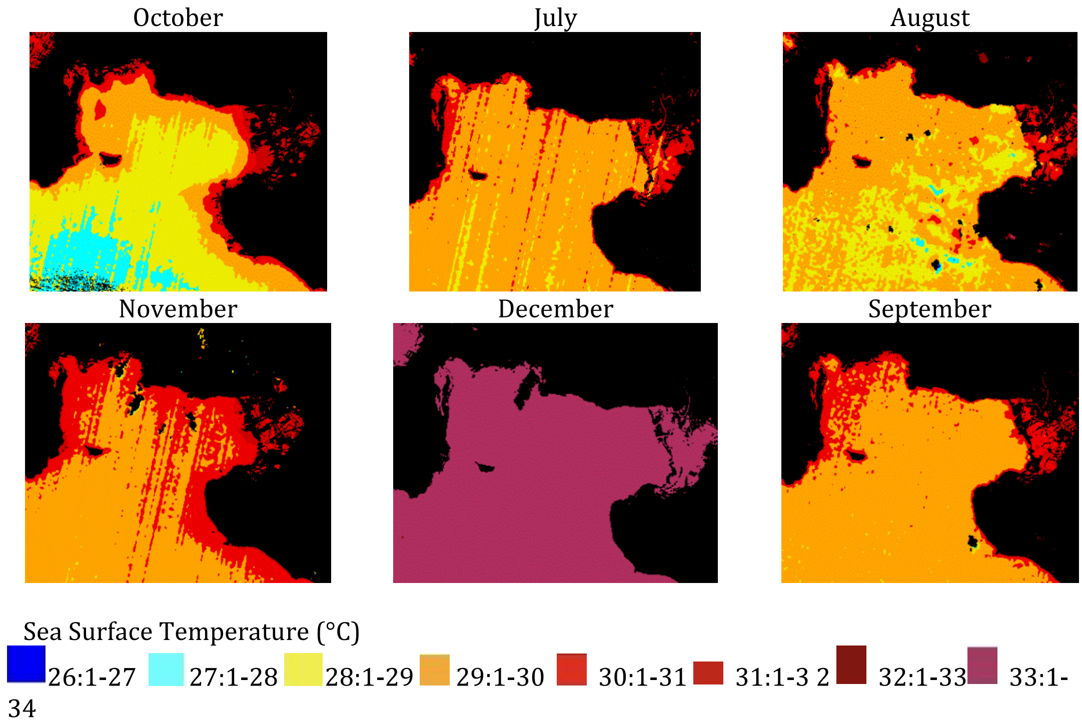
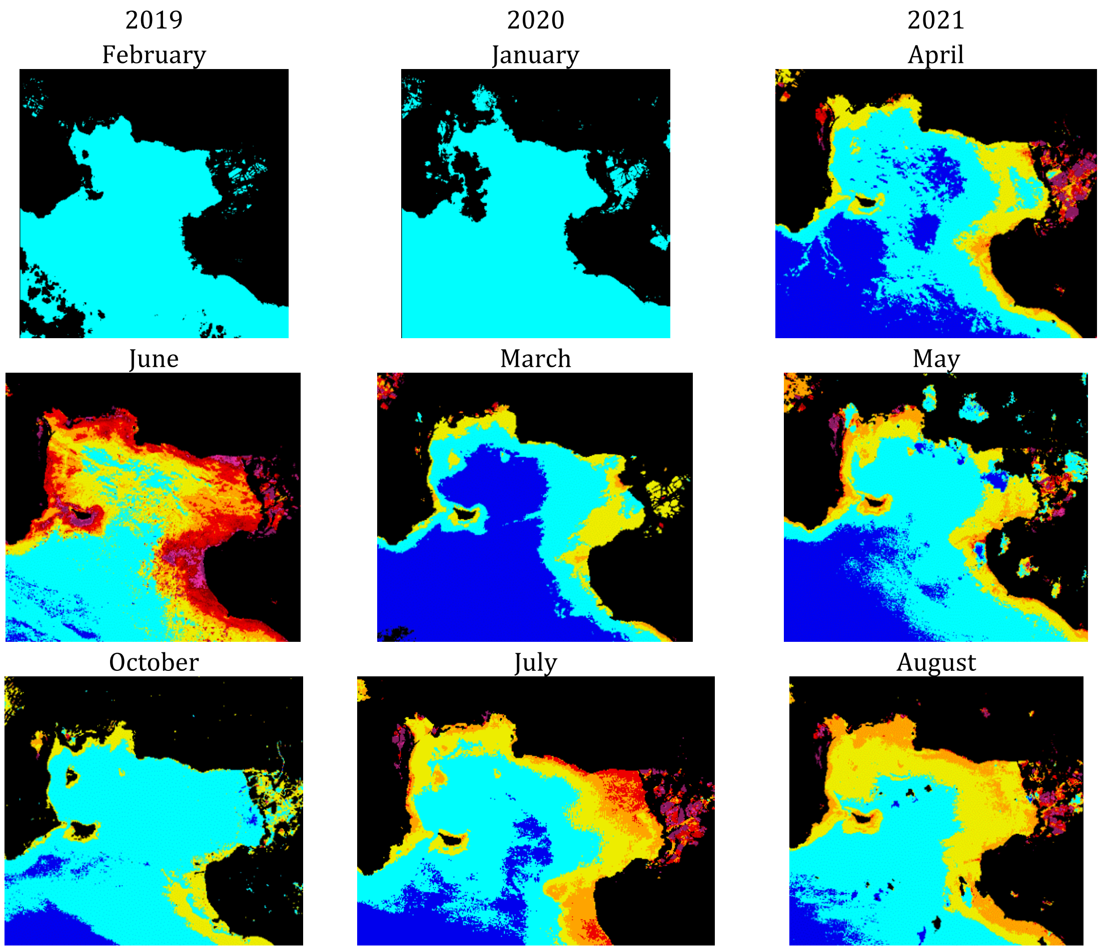


Fig. 1. Sea surface temperature

Mallasoro Bay is a form of beach that has a rather deep basin, and there is Libukang Island which is located to the west around the mouth of the bay and in front of it is a wide coral reef, so it is very useful as a wave barrier that makes the water conditions in the bay relatively calm and protected from waves.



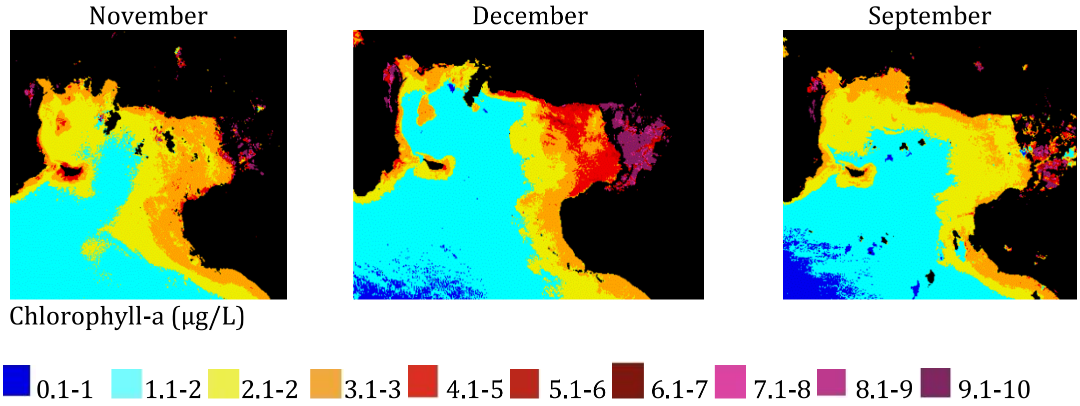


Fig. 2. Chlorophyll-a distribution map

The characteristics and ecosystem in Mallasoro Bay are seaweed habitats so that they have enough potential to be used for the development of seaweed cultivation, Seaweed cultivation activities in Jeneponto Regency have been carried out for a long time and have become the main livelihood for most of the people there, especially in the waters of Mallasoro Bay. The type of seaweed cultivated is *Eucheuma* sp. with the stretch rope cultivation method. This method is used by seaweed farmers in this area because it is straightforward, does not cost much to maintain and is easy to control during the cultivation period (Ariny, 2016).

3.1 Image Validation

The validation results between satellite-derived and in-situ measurements indicate a Root Mean Square Error (RMSE) of 0.479 for Sea Surface Temperature (SST) and 0.56 for chlorophyll-a concentration. The deviation values for SST ranged from 0.3 to 0.6 °C, while those for chlorophyll-a ranged from 0.3820 to 0.3842 mg/l. These findings suggest a reasonably good level of accuracy between remote sensing data and field observations.

Table 1. Field and image validation

Parameters	Station	Coordinates		Image	Field	Deviation	*RMSE*
		X	Y				
SPL (°C)	1	119.62	-5.65	29.5	29.2	0.3	
	2	119.61	-5.64	27.5	28.1	0.6	0.48
	3	119.59	-5.63	27.5	28	0.5	
Chlorophyll-a (mg/l)	1	119.62	-5.65	3.5	2.61	0.3820	
	2	119.61	-5.64	1.5	1.88	0.3842	0.56
	3	119.59	-5.63	1.5	1.68	0.1835	

Table 2 presents the validation results of Aqua MODIS sea surface temperature (SST) imagery with Landsat-8 across the years 2019–2021. The SST values obtained from Aqua MODIS and Landsat-8 generally show consistent patterns, with slight seasonal variations. For instance, high SST values were observed during March and December, while the lowest occurred around July and August. These variations reflect the temporal dynamics of SST in tropical waters, and the comparable values suggest that Aqua MODIS data align reasonably well with Landsat-8 observations.

Table 2. Validation of aqua modis sea surface temperature imagery with Landsat-8

Moon	Sea Surface Temperature					
	Aqua Modis			Landsat-8		
	2019	2020	2021	2019	2020	2021
January	31.2	31.11	-	-	30.44	-
February	30.74	-	30.26	31.72	-	-
March	31.28	30.90	30.83	-	33.35	-

April	29.63	29.26	29.34	-	-	28.31
May	29.72	28.60	28.98	-	-	29.12
June	27.16	28.88	29.51	28.37	-	-
July	26.26	27.21	28.23	-	29.62	-
August	26.46	26.96	27.31	-	-	29.35
September	26.90	27.53	28.62	-	-	29.70
October	27.15	28.62	28.23	29.21	-	-
November	29.35	29.83	29.85	29.93	-	-
December	31.27	-	-	-	33.5	-

Table 3. Validation of Fashionable Aqua Chlorophyll-a with Landsat-8

Moon	Chlorophyll-a					
	Aqua Modis			Landsat-8		
	2019	2020	2021	2019	2020	2021
January	1.27	1.32	1.56	-	1.5	-
February	1.43	-	-	1.5	-	-
March	1.09	1.23	1.20	-	1.14	-
April	1.54	1.55	1.52	-	-	1.59
May	1.56	1.52	1.56	-	-	1.67
June	2.95	2.64	2.98	3.00	-	-
July	1.97	1.89	1.97	-	2.08	-
August	2.14	1.94	1.98	-	-	2.18
September	2.37	2.25	2.30	-	-	2.38
October	1.31	1.38	1.46	1.57	-	-
November	2.21	1.99	-	2.44	-	-
December	2.37	-	-	-	2.46	-

3.2 Seaweed planting calendar and image processing

From the results of image and field data processing, it can be presented in the following table

Table 4. Image and field data processing

Parameters	Moon											
	1	2	3	4	5	6	7	8	9	10	11	12
SPL	30.4	31.7	33.4	28.3	29.1	28.4	29.6	29.4	29.7	29.2	29.9	33.5
Chlorophyll-a	1.5	1.5	1.14	1.6	1.67	3.01	2.09	2.18	2.38	1.57	2.44	2.46
Questionnaire												

Information:

Not meeting cultivation requirements

The image chosen to be processed in this study is an image that is free from clouds is an image in 2019 – 2021 because there are several cloud coverings that can interfere with the image processing process, resulting in the months obtained not sequentially every year, but complementary to each other in different years, as for the processed images, namely 12 images, covering recordings of January 25, 2020, February 23, 2019, March 13, 2020, April 17, 2021, May 03, 2021, June 15, 2019, July 19, 2020, August 07, 2021, September 08, 2021, October 21, 2019, November 06, 2019, December 10, 2021.

3.3 Image validation

The verification stage of Landsat 8 Satellite Image data with field measurement data is by comparing the sea surface temperature value at each predetermined station with sea surface temperature data and Chlorophyll-a data, the results of the Landsat 8 Satellite Image classification at the same station coordinates and points. The validated image is a recording image of September 8, 2021 with three station points, the first station is located at coordinate point 119.627104 -5.653189, the second station is located at coordinate point 119.616843 -5.64094, and the third station is located at coordinate point 119.596788 -

5.634057, each station is validated at sea surface temperature and water sampling for chlorophyll-a calculation and 3 repeats are carried out. From the results of image processing data and field data, it shows that there is a difference in the value of sea surface temperature and chlorophyll at each station, which shows an error at each station. The results of the verification of field taking data with image data have an average error value or Root Mean Squared Error (RMSE), while the RMSE value of Sea Surface Temperature is 0.479 and the RMSE value of Chlorophyll-a is 0.56 with the calculation in appendix 3. This value shows that the accuracy obtained is good as mentioned by Parmadi and Sukajo (2016) who stated that if the result of the RMSE calculation is ≤ 1, the accuracy is better.

Validation of Aqua modis imagery, using level 3B data and taking sea surface temperature data, and chlorophyll-a in Mallasoro Bay then using seaDAS software to process images in 2019, 2020, and 2021, with the aim of seeing a comparison of Sea Surface Temperature and Chlorophyll-a values in Aqua Modis imagery with Sea Surface Temperature and Chlorophyll-a values in Landsat-8 imagery, However, there are some images that have no value because the images are covered by clouds, from the results it is found that there is no very noticeable difference in the three years. In January, February, March, and December the sea surface temperature values in the Aqua modis images still showed numbers above 30 °C as with the Landsat-8 imagery, then in the Chlorophyll-a processing using the Aqua Modis imagery showed that Mallasoro Bay throughout the year was at the Mesotrophic level in the range of ≥ 1-3 mg/L as was the case with the Landsat-8 imagery.

3.4 Sea surface temperature

One of the most important oceanographic parameters is Sea Surface Temperature (SPL), sea surface temperature can affect the life of aquatic organisms (Sahabuddin and Tangko, 2008) so that it becomes one of the important limiting factors in the marine environment (Koesobiono, 1979). Every living thing has a different tolerance to temperature changes, according to (Duma et al, 2012) The water temperature is good for the growth of seaweed is 27-30°C, the seaweed will die when the water temperature reaches 31°C. changes in sea surface temperature are caused by currents, waves, wind and turbidity of water (Rochmady, 2008).

Image processing in April, June, and October displays varied images because they are influenced by changes in the transition season as researched (Badraeni, 2020) the impact of seasonal changes is the occurrence of seawater turnover due to the meeting of two water masses that have different characteristics, both temperature and salinity. Problems that often arise in seaweed cultivation activities are decreased productivity due to seasonal changes that have an impact on water quality, seasonal changes that trigger extreme environmental pressure that impacts temperature fluctuations, and the consistency of nutrients needed in the photosynthesis process which has an impact on the quality and quantity of seaweed (Syamsuddin & Rahman, 2014)

The results of the Luat Surface Temperature image processing showed varying SPL values, spatially it was seen that the pattern of SPL distribution in Mallasoro Bay in December – February (Western Season) showed a relatively high temperature in the range of 30.4°C - 33.5°C. This relatively high temperature range is still seen in the period of March which is the beginning (Transitional Season I) because in March it is still influenced by the western season, entering April – May there are symptoms of a decrease in sea surface temperature in Mallasoro Bay, this decrease is also increasingly visible in June – August (eastern season), in August – November (transition season II) the distribution of SPL shows an increase in the value of SPL in Mallasoro Bay when compared to with the previous season period, namely the eastern season.

The results of sea surface temperature image processing range from 28.37°C - 33.49°C (figure 4), The results of satellite image analysis for sea surface temperature in January are 30.4°C, in February 31.7°C, in March 33.3°C, in April 28.3°C, in May 29.1°C, in June 28.4°C, in July 29.6°C, in August 29.3°C, in September 29.7°C, in October 29.2°C, in November

29.9°C, and in December 33.5°C, so that the sea surface temperature is appropriate or in the range of 27°C - 30°C for the optimal temperature for seaweed growth in April, May, June, July, August, September, October, and November as the results of Baracca's research, (1999) The suitable temperature for seaweed growth ranges from 25 – 30°C, seaweed will die when the water temperature reaches 31°C.

3.5 Chlorophyll-a

Chlorophyll-a is a pigment from phytoplankton that can be used as a parameter of aquatic productivity (Susanto et al., 2001) Aquatic fertility is usually associated with the concentration of nutrients in aquatic bodies. The high and low content of chlorophyll-a is closely related to the supply of nutrients that come from land through river flows that enter water bodies (Linus et al. 2016). Chlorophyll-a is a parameter that greatly determines the primary productivity of the ocean. The distribution and low levels of chlorophyll-a concentrations are directly related to the oceanographic conditions of the waters themselves (Nuriya et al., 2010). Sihombing et al., (2013). In general, seaweed cultivation locations must have good water quality, According to Sihombing et al., (2013) one of the parameters that greatly determine the fertility level of the waters is chlorophyll-a. The oceanographic conditions of the body of water are closely related to the distribution and low concentration of chlorophyll-a. If chlorophyll-a is high in waters, then the fertility rate of the waters will be high and conversely, if chlorophyll-a is a low water, then the fertility rate of the waters will be low.

Spatially, chlorophyll-a concentration levels don't look too different from season to season. However, in the western season in January - February, it was seen that the concentration level of Chlorophyll-a in Malalsoro Bay was lower on average compared to other seasons. However, the relatively high concentration level is found in coastal areas, the chlorophyll-a content in coastal areas has a higher value of chlorophyll-a compared to chlorophyll-a in the middle of the bay, this is due to the influence of nutrient input from the mainland, Wirasatriya (2011) said the distribution pattern shows a high gradient of chlorophyll-a concentration values in coastal areas, especially river mouths and lower towards the open sea. Because the coastal and river areas are places where nutrients from the mainland accumulate so that they lead to these waters, The results of this study are in accordance with the results of research by Riyono et al., (2006) in Klabat Bay where the general pattern of the distribution of Chlorophyll-a Phytoplankton, and nutrients shows greater values in waters relatively close to the mainland and river mouths, Meanwhile, in waters far from the mainland, the chlorophyll-A content is getting lower, especially in the outer part of the bay.

From the results of the image analysis for the distribution of chlorophyll-a in Mallasoro Bay in January, it was obtained that the value was 1.5 (mg/l), in February 1.5 (mg/l), in March 1.14 (mg/l), in April 1.60 (mg/l), in May 1.68 (mg/l), in June 3.00 (mg/l), in July 2.08 (mg/l), in August 2.18 (mg/l), in September 2.38 (mg/l), in October 1.57 (mg/l), in November 2.44 (mg/l), and in December 2.46 (mg/l). According to Adani et al (2013), the fertility rate of waters is classified into 4, namely: range of < 1 mg/L classified as Oligotrophic, ≥ 1–3 mg/L classified as Mesotrophic, ≥ 3–5 mg/L classified as Eutrophic, and > 5 mg/L classified as Hypertrophic. This shows that Mallasoro Bay throughout the year is at the Mesotrophic level or the water fertility level is quite fertile because it is in the range of ≥ 1–3 mg/L, according to (Pauwah et al 2020) although the water fertility level is low and sufficient but still provides optimal growth, so it is still within the range to support the growth of seaweed.

3.6 Questionnaire

Questionnaire data collection was carried out on 15 seaweed cultivators, 5 people each at each station. The questionnaire data was taken using the open questionnaire method, which is a questionnaire that contains questions by giving respondents the opportunity to write their opinions about the questions given. The results obtained are that the people of Mallasoro Bay have been working as seaweed farmers for more than 10 years, stretches installed in one cultivation as many as 100-400 stretches, seaweed is maintained for approximately 40-50 days before harvesting. The obstacles that are often faced when cultivating seaweed are weather, diseases (white and yellow spots), weeds (mosses) and pests that often occur at the beginning of the year as research (Badraeni, 2020) the impact of changes in water quality affects the quality and quantity of seaweed, such as production, carrageenan content, epiphytes, and ice-ice diseases, (Akmal et al., 2017) several studies have found that changes in water temperature have an impact on the increase in epiphytes and ice-ice diseases, In addition, there are some weeds that are perennial or their presence based on the season. Although there are obstacles in January – February, if farmers have the capital they continue to sow seaweed seeds, this often results in crop failure.

3.7 Seaweed calendar

In January, February and December, preparations can be made for tools and materials such as cleaning the location of aquaculture waters from wild plants and other disturbing plants that usually thrive in the cultivation area, and repairing and cleaning planting equipment because in that month it is not possible to plant because the sea surface temperature conditions in that month are not optimal for seaweed growth. It was emphasized in the study (Badraeni, 2020) that in the rainy season which coincided with December to March there was no seaweed planting at the research site, because it was constrained by environmental factors, In that season it was not possible to carry out cultivation activities, because of large waves, high rainfall that could damage seaweed and the stretch rope easily broke by strong currents. Then based on the results of the questionnaire, information was obtained that in that month there were obstacles experienced by seaweed farmers, namely the presence of pests, and diseases that attacked seaweed which were characterized by the presence of white and yellow pedicabs and caused seaweed to be easily cut off, according to (Maryanus, 2018) in contrast to weeds and effifics, ice-ice disease infections in seaweed which were characterized by the occurrence of a change in the color of the talus to pale yellow and finally to white and easily disconnected.

Seaweed production fluctuates based on the season, in general, the productive planting season is from April to October, while the less productive planting season is in January, November, and December (Arisandi et al., 2013). So that in one year 4 cultivation cycles can be carried out, namely in the first cycle it is carried out at the end of March (seed procurement), early April (seed sowing and harvesting), and the end of May (harvest). Then cycle 2 at the end of May (seed procurement), early June (seed sowing and mid-July (harvest), then cycle 3 at the end of July (seed procurement), early August (seed sowing and harvesting), and finally cycle 4 at the end of September (seed procurement), early October (seed sowing and mid-November (harvest). Seaweed planting at each cultivation location in various regions generally only lasts three to four months in a year which is the peak season of seaweed production, and the rest is the transition season where seaweed production is relatively lower than the peak season (Badreani, 2020).

4. Conclusion

Based on the results of the research, the seaweed planting calendar in Mallasoro Bay was obtained, namely in January, February, and December, equipment preparations such as cleaning and repairing seaweed planting equipment could be carried out, then at the end of March, at the end of May, at the end of July, and at the end of September, seaweed seedlings were procured, in early April, early June, early August, and early October seaweed seedlings could be sown, then in mid-May, mid-July, mid-September, and mid-November harvesting is carried out, so that seaweed cultivation in one year can be carried out 4 cycles.

Acknowledgments

The author expresses gratitude to all parties who contributed to this research, including those who provided valuable insights, guidance, and support throughout the study. Appreciation is also extended to individuals who assisted in data collection, analysis, and review, as well as to those who offered constructive feedback that helped improve the quality of this work.

Author's Contributions

I., contributed to the literature search, interpretation, writing, and proofreading of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding

This research did not receive external funding.

Statement of the Ethics Review Board

Not available.

Statement Informed Consent

Not available.

Data Availability Statement

Not available.

Conflict of Interest

The author states that there is no conflict of interest.

References

Adani, N. G., Hendrarto, B., & Muskanonfola, M. R. (2013). Kesuburan Perairan Ditinjau dari Kandungan Klorofil-a Fitoplankton: Studi Kasus di Sungai Wedung, Demak. *Management of Aquatic Resources Journal (MAQUARES)*, *2*(4), 38-45. https://doi.org/10.14710/marj.v2i4.4266

Akmal, A., Syamsuddin, R., Trijuno, D. D., & Tuwo, A. (2020). Morfologi, kandungan klorofil a, pertumbuhan, produksi, dan kandungan karaginan rumput laut Kappaphycus alvarezii yang dibudidayakan pada kedalaman berbeda. *Jurnal rumput laut Indonesia*, *2*(2). https://core.ac.uk/pdf/233601353

Ariny A. P. (2016). *Estimasi Produksi Rumput Laut Eucheuma sp. di Teluk Mallasoro Kabupaten Jeneponto Menggunakan Citra Landsat 8.* Universitas Hasanuddin.

APHA., (1992). *Standard Methods for the Examination of Water and Waste and Wastewater Including Bottom sediment and Sludges*. 12-th ed. Amer. Publ. Health Association Inc., New York

Arisandi, A., Farid, A., Wahyuni, E. A., & Rokhmaniati, S. (2013). Dampak infeksi ice-ice dan epifit terhadap pertumbuhan *Eucheuma* cottonii. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, *18*(1), 1-6. https://doi.org/10.14710/presipitasi.v%25vi%25i.401-425

Aryawatia, R., & Thohab, H. (2018). Hubungan kandungan klorofil-a dan kelimpahan fitoplankton di Perairan Berau Kalimantan Timur. *LEGENDA*, *20*(20), 10. http://ejournal.unsri.ac.id/index.php/maspari/article/view/1292

Badraeni, Radjuddin S, Haryati, Farid. S. (2020). *Growth response of Kappaphycus alvarezii of green strain seaweed cultivated on different seasons and locations in Indonesia*. Plant Cell Biotecnology and Molecular Biology, 21 (21 &22): 1-6; 2020. https://core.ac.uk/download/pdf/267821991.pdf

Badraeni, Radjuddin S, Haryati, Farid. S. (2020). Weeds, epiphytes and ice ice disease on green-strained kappaphycus alvarezii in Takalar waters, south Sulawesi in different seasons and locations of cultivation. *Plant Archives*, 20 (20), pp. 2327-2332. https://www.plantarchives.org/SPL%20ISSUE%2020-2/387__2327-2332_.pdf

Bahar, Ahmad. (2015) *Pedoman Survei Laut*. Masagena Press.

Baracca R.T. (1999). *Seaweed (Carrageenophyte) Culture. Coastal Resourse Management Project*. Cebu City.

Pratiwi, D. A., Muslimin, M., & Sari, W. K. P. Penentuan Pola Musim Tanam Optimal Rumput Laut *Eucheuma* Striatum Di Perairan Kabupaten Pohuwato, Gorontalo. In *Prosiding Forum Inovasi Teknologi Akuakultur* (Vol. 1, No. 1, pp. 431-438). https://ejournal-balitbang.kkp.go.id/index.php/fita/article/view/1820

Direktorat Jendral Perikanan Budidaya. (2005). *Profil Rumput Laut Indonesia.* DKP RI, Ditjenkanbud.

Doty, M.S. (1987). *The Production and Use of Eucheuma. Department of Botany University of Hawaii*. Honolulu.

Duma, L. O. (2012). *Pemeliharaan Rumput Laut Jenis Kappaphycus alvarezii dengan Menggunakan Metode Vertikultur pada Berbagai Kedalaman dan Berat Bibit Awal Yang Berbeda di Perairaan Desa Langkule Kecamatan GU Kabupaten Buton*. Universitas Haluoleo.

Febriani, R. (2014). *Studi Tentang Komposisi Jenis Dan Kepadatan Organisme Penempel Pada Rumpon Sebagai Alat Bantu Penangkapan Ikan Di Perairan Teluk Mallasoroo Kabupaten Jeneponto.* Universitas Hasanuddin. Makassar.

Fleurence, J. (1999). Seaweed Protein: Biochemistry. *Nutritional Aspects and Potential*.

Hanintyo, R. (2016, November). Comparison of chlorophyll-a measurement using multi spatial imagery and numerical model in Bali Strait. In *IOP Conference Series: Earth and Environmental Science*, 47(1). https://doi.org/10.1088/1755-1315/47/1/012010

Indriani, H. & Suminarsih, E. (1999). *Budidaya, pengolahan, dan pemasaran rumput laut. Penebar Swadaya*. Penebar Swadaya

Jana, T., (2006). *Rumput Laut.* Penebar Swadaya

Kusdarwati, R., & Istiqomawati, I. (2010). Technique Of Seaweeds Culture (Gracilaria Verrucosa) At Brackish Water Aqua Culture Development CENTER Situbondo Of East Java. *Jurnal Ilmiah Perikanan dan Kelautan*, *2*(1), 77-86. https://doi.org/10.20473/jipk.v2i1.11671

Linus, Y., Salwiyah, I. N., & Irawati, N. (2016). Status kesuburan perairan berdasarkan kandungan klorofil-a di Perairan Bungkutoko Kota Kendari. *Jurnal Manajemen Sumber Daya Perairan*, *2*(1), 101-111. https://ojs.uho.ac.id/index.php/JMSP/article/view/2498/1851

Ma, S., Tao, Z., Yang, X., Yu, Y., Zhou, X., Ma, W., & Li, Z. (2014). Estimation of marine primary productivity from satellite-derived phytoplankton absorption data. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *7*(7), 3084-3092. https://ieeexplore.ieee.org/abstract/document/6728688

Marlian, N., Damar, A., & Effendi, H. (2015). Distribusi horizontal klorofil-a fitoplankton sebagai indikator tingkat kesuburan perairan di teluk meulaboh aceh barat. *Jurnal Ilmu Pertanian Indonesia*, *20*(3), 272-279. https://doi.org/10.18343/jipi.20.3.272

Maryunus, R. P. (2018). Pengendalian penyakit ice-ice budidaya rumput laut, Kappaphycus alvarezii: Korelasi musim dan manipulasi terbatas lingkungan. *Jurnal kebijakan perikanan Indonesia*, *10*(1), 1-10. https://ejournal-balitbang.kkp.go.id/index.php/jkpi/article/view/6027/5717

Mustafa, A. (2010). Hubungan antara faktor lingkungan dengan produktivitas tambak untuk rumput Laut (Gracilaria verrucosa) di Pantai Timur Provinsi Sulawesi Selatan. *Media Akuakultur*, *5*(1), 38-46. https://ejournal-balitbang.kkp.go.id/index.php/ma/article/view/1275

Nontji A. (2002). *Laut Nusantara*. Djambatan

O'Reilly, J. E., S. Maritonema, D.A. Siegel, M.C. O'Brien, D. Toole, B.G. Mitchell, M. Kahru, F.P. Chavez, P. Strutton, G.F. Cota, S.B. Hooker., 2000. Ocean color chlorophyll a algorithms for SeaWiFS, OC2, and OC4: Version 4. SeaWiFS postlaunch calibration and validation analyses.

Parmadi, W. T., & Sukojo, B. M. (2016). Analisa Ketelitian Geometrik Citra Pleiades Sebagai Penunjang Peta Dasar RDTR (Studi Kasus: Wilayah Kabupaten Bangkalan, Jawa Timur). *Jurnal Teknik ITS*, *5*(2), A411-A415. https://doi.org/10.12962/j23373539.v5i2.17213

Pauwah, A., Irfan, M., & Muchdar, F. (2020). Analisis Kandungan nitrat dan fosfat untuk mendukung pertumbuhan rumput laut Kappahycus alvarezii yang dibudidayakan dengan metode longline di Perairan Kastela Kecamatan Pulau Ternate Kota Ternate. *Hemyscyllium*, *1*(1). http://dx.doi.org/10.29303/mediaakuakultur.v2i2.1733

Radiarta, I. N. (2013). Hubungan antara distribusi fitoplankton dengan kualitas perairan di Selat Alas, kabupaten Sumbawa, Nusa Tenggara Barat. *Jurnal Bumi Lestari*, *13*(2), 234-243. https://ojs.unud.ac.id/index.php/blje/article/view/6640

Rochmady, R. (2015). Analisis parameter oseanografi melalui pendekatan sistem informasi manajemen berbasis web (Sebaran suhu permukaan laut, klorofil-a dan tinggi permukaan laut). *Agrikan: Jurnal Agribisnis Perikanan*, *8*(1). https://doi.org/10.29239/j.agrikan.8.1.1-7

Romimohtarto, K., & Juwana, S. (2001). *Pengelolaan Sumberdaya Wilayah Pesisir Secara Berkelanjutan*. Djambatan

Sahabuddin, T. A. (2008, April). Pengaruh jarak lokasi budidaya dari garis pantai terhadap pertumbuhan dan kandungan karaginan rumput laut *Eucheuma* cottoni. In *Seminar Nasional Kelautan IV* (Vol. 24).

Samada, W., Amrana, M. A., Muhiddina, A. H., & Tambarua, R. (2016, November). Dinamika Spasial Temporal Sebaran Klorofil-a Perairan Selat Makassar Kaitannya dengan Lokasi Penangkapan Ikan. In *Seminar Nasional Pengelolaan Perikanan Pelagis–MEXMA* (Vol. 35, No. 1, pp. 35-39).

Sidik, A., Agussalim, A., & Ridho, M. R. (2015). Akurasi nilai konsentrasi klorofil-a dan suhu permukaan laut menggunakan data penginderaan jauh di Perairan Pulau Alanggantang Taman Nasional Sembilang. *Maspari Journal*, *7*(2), 25-32. http://ejournal.unsri.ac.id/index.php/maspari/article/view/2487

Sihombing, R. F., Aryawaty, R., & Hartoni, H. (2013). Kandungan Klorofil-a Fitoplankton di Sekitar Perairan Desa Sungsang Kabupaten Banyuasin Provinsi Sumatera Selatan. *Maspari Journal*, *5*(1), 34-39. http://ejournal.unsri.ac.id/index.php/maspari/article/view/1295

Susanto, A.B. (2003). *Rumput Laut Bukan Sekedar Hidup di Laut.*

Susanto, A. B. (2005). Metode lepas dasar dengan model cidaun pada budidaya *Eucheuma* spinosum (Linnaeus) Agardh. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, *10*(3), 158-164. https://doi.org/10.14710/ik.ijms.10.3.158-164

Susanto, R. D., Gordon, A. L., & Zheng, Q. (2001). Upwelling along the coasts of Java and Sumatra and its relation to ENSO. *Geophysical research letters*, *28*(8), 1599-1602. https://doi.org/10.1029/2000GL011844

Sutanto. (1987). *Penginderaan Jauh*. Gadjah Mada University Press

Syamsuddin, R., & Rahman, S. A. (2014). Penanggulangan penyakit ice-ice pada rumput laut

Kappaphycus alvarezii melalui penggunaan pupuk N, P, dan K. *Simposium Nasional I Kelautan dan Perikanan. Makassar*.
USGS. (2013). *Using USGS Landsat 8 Product*, diakses melalui http://landsat.usgs.gov.
Utama, M. B. P., Handoyo, G., Setiyono, H., Ismunarti, D. H., & Suryoputro, A. A. D. (2020). Analisa Sebaran Suhu Permukaan Laut Berdasarkan Citra Landsat-8 TIRS di Sekitar Outfall PLTU Tarahan Lampung Selatan. *Indonesian Journal of Oceanography*, *2*(1), 90-97. https://doi.org/10.14710/ijoce.v2i1.7493
Utojo, U., Mansyur, A., Pantjara, B., Pirzan, A. M., & Hasnawi, H. (2007). Kondisi lingkungan perairan teluk mallasoro yang layak untuk lokasi pengembangan budi daya rumput laut (*Eucheuma* sp.). *Jurnal Riset Akuakultur*, *2*(2), 243-255. https://ejournal-balitbang.kkp.go.id/index.php/jra/article/view/2280
Wetzel, R.G,. 1983. Limnology. W.B. *Sounders Company*, Phyladelphia. 743 p.
Wirasatriya, A. (2011). Pola distribusi klorofil-a dan total suspended solid (TSS) di Teluk Toli Toli, Sulawesi. *Buletin Oseanografi Marina*, *1*(1). https://doi.org/10.14710/buloma.v1i1.2990

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