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Ocean Colour Climate Change: Approach Identification of Sea Level and Physical Conditions in Setokok Sea

Muhammad Zainuddin Lubis[1], Wenang Anurogo[1], Budiana[2], Widya Rika Puspita[2], Swono Sibagariang[3], Jhon Hericson Purba[2], Sapto Wiratno Satoto[4], Hamdani Arif[3], Rahman Hakim[4], Hanifah Widiastuti[4], Budhi Agung Prasetyo[5], and Husnul Kausarian[6]

[1]*Geomatics Engineering, Politeknik Negeri Batam, Batam, Indonesia*
[2]*Electrical Engineering, Politeknik Negeri Batam, Batam, Indonesia*
[3]*Informatics Engineering, Politeknik Negeri Batam, Batam, Indonesia*
[4]*Mechanical Engineering, Politeknik Negeri Batam, Batam, Indonesia*
[5]*Marine Environmental Science, Institut Teknologi Sumatera, Lampung, Indonesia*
[6]*Department of Geology Engineering, Universitas Islam Riau, Riau, Indonesia*
{zainuddinlubis, wenang, budiana, widya, swono, jhonhericson, sapto, hamdaniarif, hakim, Hanifah}

Keywords: Climate Change, Sea Level, Sea Surface Temperature, Distribution of Chlorophyll A, Bathymetry.

Abstract: Setokok Island located at the South of Batam City, Riau Islands, positioned at longitude coordinates 104.031520° and latitude 0.951068°. The data acquisition technique uses satellite altimeter imagery data, which utilizes level 3 terra fashionable satellite imagery data. The study results show a significant change between one season (east season) with the period of data acquisition in April and May 2020. Sea surface temperature value is 28.7 ℃ in April 2020 and 29.8 ℃ in May 2020. Chlorophyll A distribution has a value of 3.5 mg/l in April 2020 and 3.2 mg/l in May 2020. The transverse profile produced by taking into account the sea level in Setokok Sea yielding in the mean sea level height of 1.86 meters and the average sea level of 2.67 meters. These data show a significant form of bathymetry in Setokok Sea. This research shows that global climate change affects sea level. Furthermore, it involves primary water production and bathymetry value in Setokok Sea.

1 INTRODUCTION

Climate change is the implication of global warming. It has resulted in conditions that are unstable in the lower layer atmosphere, especially the layers closest to the earth's surface. Global warming is caused by increasing greenhouse gases that are dominantly caused by industries. This global warming has increased sea surface and has affected the Chlorophyll A distribution in the seas, especially in islands with many industries (Collins, et al., 2010). Climate change also by high sea levels in an area of water, especially in Indonesia, leading to stagnant water in tidal area, which could cause fluctuating temperatures around the coastal environment (Susandi, Herlianti, Tamamadin, Nurlela, 2008). Other impacts caused by the change of sea level is coastal erosion, a decrease in seawater salinity, higher sea surface temperature, decreased surface water quality, and increased risk of flooding occurring on land in coastal environments (Oude-Essink, Van-Baaren, de-Louw, 2010). In general, the variety of rainfall in Indonesia is strongly influenced by its presence on the equator, monsoon activity, the stretch of the Pacific and Indian oceans, and highly diverse topography. Tropical cyclone disturbances (El-Nino, La-Nina, Madden Julian Oscillation (MJO), and hurricane winds) could also contribute to the types of rainfall (Horhoruw, Atmadipoera, Nanlohy, Nurjaya, 2017)

The sea level in certain area undoubtedly is related to the depth of seawater due to the sea's physical conditions that are in contact with each other. This phenomenon may have an essential role in the sustainability of human life and other living things in coastal areas (Antoni, et al., 2019). The alteration of coastal regions might cause shifting in seasons and could lead to change in the pattern/distribution of rain, which eventually might trigger floods in the rainy season and drought in the dry season. These

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issues have always been significant problems for a lot of islands, especially for Batam Island (Lubis, et al., 2018). The rising sea levels might sink small islands, cause tidal floods, and lead to storm disasters/waves at coastal areas (Dasanto, 2010).

Setokok Sea located in the South of Batam Island, Batam City, Riau Islands, offer alternative tourism for beach enthusiasts to spend the weekend. In Setokok Sea environment, there is an impact indicated by white sand around the coast. This white sand piled up, forming a small island, at a distance of about 4 meters from the shoreline near the Setokok Sea. The white dune extends to more than 10 meters and is about 3 meters wide, depending on tidal wave conditions and sea-level values. The formation of this small land is a phenomenon of periodical rise and fall of sea-level, combined with the gravitational force and the attractive force of astronomical objects, especially by the sun, earth, and moon (Awak, Gaol, Subhan, Madduppa, Arafat, 2016; Gaol, et al., 2015). It is important to study the effect of climate change on sea-level changes in Setokok Sea, which could provide information about the physical condition of the sea by looking at sea surface temperature values, Chlorophyll A distribution, sea depth, and sea level.

2 RESEARCH METHODS

2.1 Research Location

This research was conducted in Setokok Sea. The longitude and latitude coordinate is 104.031520° and 0.951068°, respectively. The area of study around 4 km^2 shown on the map in Figure 1.

2.2 Data Collection Technique

Terra Modis satellite imagery data, which is quite well known for remote sensing, is Aqua / Terra. MODIS (Moderate Resolution Imaging Spectroradiometer) is an essential instrument in the satellite Terra (EOS AM) and Aqua (EOS PM). The MODIS Aqua / Terra satellite observes the earth's entire surface every 1 to 2 days, obtaining data in 36 spectral band channels or groups of wavelengths (Short, 2009; Sathyendranath, et al., 2012). MODIS is also a satellite with a daily time series, so it is appropriate for collecting the data (Sasmito, Parwati, Budhiman, 2013).

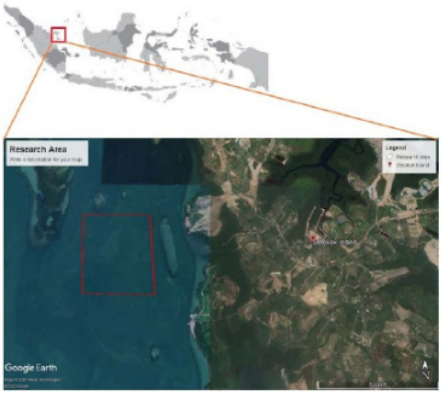


Figure 1: Research location and area of study in Setokok Sea, Batam.

In this study, data produced using recordings from Terra MODIS satellite images for two months (April-May 2020), with one season treatment (east season). Additionally, data of Chlorophyll A distribution were downloaded from https://oceancolor.gsfc.nasa.gov/. The downloaded data was then processed by combining them with the extracted Terra MODIS image data. The sea surface temperature data is obtained from extracted Terra MODIS Image data and then classifying it for the appropriate data. These two parameters are processed using SeaDAS and ODV (Ocean Data View) software. Modis imagery has three image data types, namely, Modis imagery level 1a, 1b, 2, and 3. This study uses MODIS imagery data MODIS level 3.

2.3 Bathymetry

The bathymetry data acquisition technique is conducted with observable data called a fixation point with position and depth information. The bathymetry measurements performed cannot be directly used (processed) because it still contains data shortages (tidal and transducer corrections) that are obtained at the time of tidal data processing (tidal components) to find out the actual depth appearance. The magnitude of the tidal correction is the depth value (which has been corrected by the transducer), which will be fixed by the reduction value at the sea level position when the measurement takes place. This data obtained from the BIG Website (BATNAS) (http://tides.big.go.id/DEMNAS/), downloaded for two weeks in May 2020. The gridded BATNAS data (National Bathymetry) are from 90 to 150 east longitude and 20 southern latitudes to 20 northern

latitudes. This bathymetry data has advantages in coastal areas and shallow sea by using a survey from the BIG Center for Marine and Coastal Environment (PKLP) (Geospatial Information Agency).

2.4 Tidal (sea level)

Tidal data acquisition techniques obtain from the BIG Website (Geospatial Information Agency) (http://tides.big.go.id/) taken based on the location point in May 2020. In determining the water level change in the river, there are factors such as river hydrology, height difference, and the position of the flow from upstream to the estuary. Near the estuary, the water level is influenced by the sea level changes.

Data analysis is generally grouped into several sections based on the type of data used to calculate. The tidal data analysis is performed using Least Square to obtain the value of tidal harmonic constants. According to Rampengan (2009), the classification of tidal types is carried out by comparing the amplitudes of diurnal constants (K1 and O1) with the amplitudes of semidiurnal constants (M2 and S2). Formzahl numbers are used to determine the type of tides that occur in the sea (Hidayah & Fatmawati, 2010) with a formulation presented in Equation (1).

$$F = ((AK1 + AO1))/((AM2 + AS2)) \quad (1)$$

Where:

F = Formzahl,
AK1 = the amplitude of the average daily single tidal wave affected by the declination of the moon and the sun,
AO1 = the amplitude of a single daily tidal wave that is affected by the declination of the moon,
AM2= amplitude of average double daily tidal wave chiefen affected by the moon,
AS2 = the amplitude of the average double daily tidal wave affected by the sun.

According to Oktavia, Pariwono, Manurung (2011), the F value determines the characteristic of tidal wave. The F value of 0 <F 0.25: semidiurnal; 0.25 <F 1.50: mixed tide prevailing semidiurnal; 1.50 <F 3.00: mixed tide prevailing diurnal; F> 3.0: diurnal.

3 RESULTS AND DISCUSSION

3.1 Sea Surface Temperature

Sea surface temperature data obtained from satellite images of fashionable terra level 3 is shown in Figure 2, with the observed location marked with the blue box. The data for sea surface temperature is obtained for the period of April and May 2020 (east season). The sea surface temperature is deemed as one of the parameters that is affected by climate change.

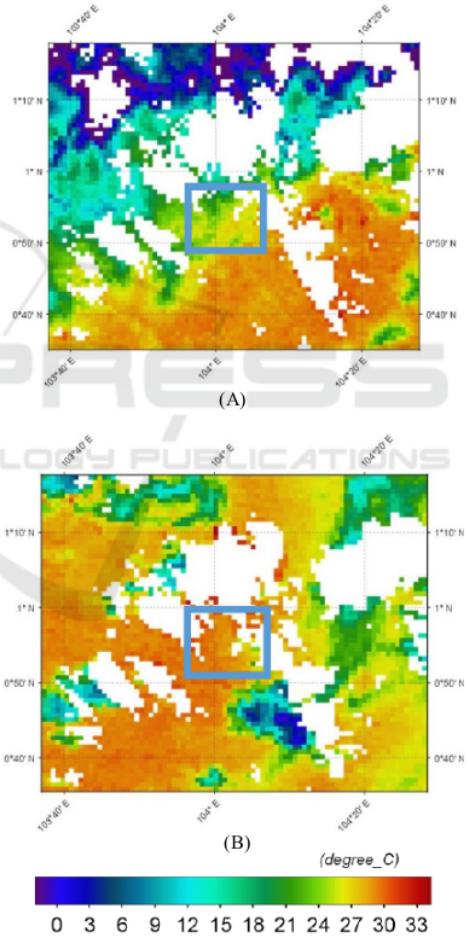


Figure 2: A. Sea surface temperature (April 2020), B. Sea surface temperature (May 2020). (the data are in °C)

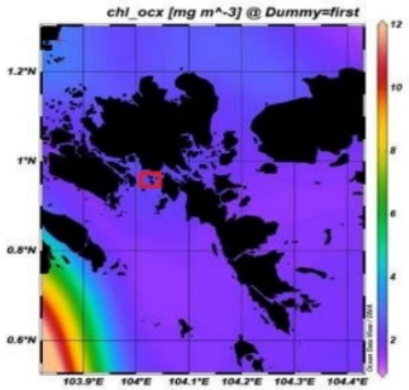
Figure 2 shows that the sea surface temperature is 28.7 °C in April 2020 (A) and 29.8 °C in May 2020 (B). These results indicate a difference in sea surface temperature values between April and May 2020 in Setokok Sea, with a decrease in sea surface temperature of 0.9 °C. This condition undoubtedly affects the distribution of Chlorophyll A that occurred in April and May 2020 (east season) due to the impact of global climate change in 2020. The changes in sea surface temperature due to currents, wind, water, and waves turbidity, are commonly called ocean dynamics. The upwelling process can also increase Chlorophyll A content and decrease sea surface temperature (Feng, Yao, Gu, Guo, 2007). According to Surya, et al., (2017), sea surface temperature in Batam is in the range of 29-31 °C during January-December period.

Figure 3 present the distribution of Chlorophyll A is 3.5 mg/l in April 2020 (A) and 3.2 mg/l in May 2020. These results indicate a decrease of 0.3 mg/l in the Chlorophyll A distribution in Setokok Sea. This finding might be caused by the rising sea surface temperature in Setokok Sea, which can decrease the distribution of Chlorophyll A. According to Nontji (2008), Chlorophyll A is an indicator of the abundance of phytoplankton that becomes zooplankton food to measure the productivity level of primer water conditions. Hence, the decreasing concentration of Chlorphyll A indicates the decreased primary water productivity. Another study (Kunarso, Hadi, Ningsih, Baskoro, 2011) has also suggested the close relation between the Chlorophyll A levels with the sea surface temperatures.

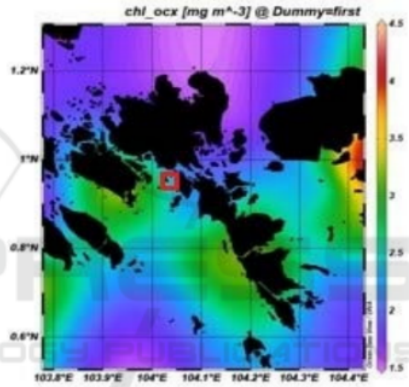
3.2 Tidal Analysis (sea level)

Tidal observations and measurements are made at the coordinate of 1040 1'50 " - 1040 2"35" east longitude and 00 56"35" - 00 57"32" north latitude. The sea in Setokok tend to be double tilt or semi-diurnal (mixed tide prevailing semi- diurnal), meaning that there are two tides in a day, but the two pairs are not as large as the tidal graphs shown in Figure 4.

The tidal component analysis is performed to obtain the value of each tidal component's amplitude and bead phase. The method used is the Least Square. After the analysis is carried out, the constant harmonic values obtained are presented in the Table 1.



(A)



(B)

Figure 3: A. Chlorophyll A distribution (April 2020), B. Chlorophyll A distribution (May 2020).

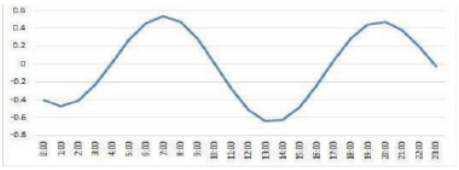


Figure 4: Tidal wave chart (May 20, 2020).

Table 1: The value of amplitude (A) and phase (G) of the harmonic constants of tidal wave studied.

Component	M2	S2	N2	K2
Value	0.3527	0.3884	0.0731	0.3332
Component	O1	P1	M4	MS4
Value	0.2673	0.1819	0.0112	0.0038

The data are taken in the second half of the month in May 2020, where the moon's condition was convex at the end of the month to the end of the month, or it could be called a crescent. By entering these constant values into the Formzahl number equation, an amount of 0.81 will obtain. Based on this number, the type of mixed tides tends to be Semidiurnal. It means that there are two pairs of waves and two times receding with different heights and periods in one day. The dominant tidal components based on the above calculation are the S2 and M2 component with an amplitude value of 0.3884 and 0.3527, respectively. In contrast, the non-dominant tidal element in MS4 with an amplitude value of 0.0038 proves that the regional tidal type is a mixed type. The amount of retroactivity is influenced by intense sun penetration that affects the sea surface temperature due to climate change (Adibrata, 2007). By using the Least Square method, the results obtained from tidal harmonic analysis are harmonic components that can be used to determine sea level elevation values. The results of sea-level elevation in Setokok coastal seawater are:

- Mean High Water Level during the observation period is 1,860 meters.
- Mean Sea Level, which is the mean water level between the mean high water level and the mean low water level. This elevation using as a reference for elevation on land is 2,675 meters.
- Mean Low Water Level is the lowest water level at high tide.

According to Suhelmi (2013), the sea-level values shows that the increase in tidal inundation area due to sea-level rise plays a significant role in the amount of vulnerability index. This is due to the relationship to global climate change that occurs in water. Sea surface anomalies are strongly influenced by tides, topography, wind, ocean currents, density, and seawater pressure, especially in Setokok Sea.

3.3 Cross-profile and Water Bathymetry

The water cross-section profile shows a cross-section of one of the samples in the area's coastal part, with a relatively steep to the sloping surface. In Figure 5, it can be seen that the height of the coastal surface decreases as it heads towards the coast.

From Figure 5, the results of three samples taken in the form of a cross-section, wherein example 1 illustrates that the surface is relatively steep in the northern part of the study area and the southern part of the study area. Whereas in samples 2 and 3, the site's bottom surface looks slightly sloping compared to sample 1. The 3-dimensional and 2- dimensional form of bathymetry for the area of study of the water bottom is shown in Figure 6.

The condition of the bathymetry of the sea in the location indicates that the location is suitable for a port and its support. The ship sailing activities generally requires water depth that is equal to the ship's requirements (draft) plus different depth. Based on the data observed, this water area is eligible for shipping activities. The depth of the port/pier/terminal water is usually determined from the size of ships that are frequently entering the dock. The giant ship that rarely comes could only enter the port when the sea is in high tide. The depth of the ocean around Batam Island is already mapped by BATNAS BIG, which divided the area into four depth levels, namely depth of 1-5 meters, 5-10 meters, 10-20 meters, and> 20 meters. Sea with the depth of 1-5 meters locates around the coast and spread throughout Batam City. For the depth of 5-10 meters, categorized as inter-island sea belong to the Regency of Batam and other areas. The area with the depth of 1-5 meters are included in the development of the coastal regions while the area with the depth of 5-10 meters is intended for shallow sea areas. The area with the depth of 10-20 meters and >20 meters is for the development of deep-sea areas.

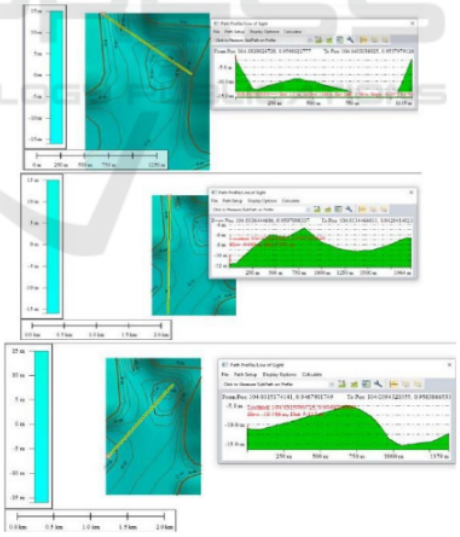
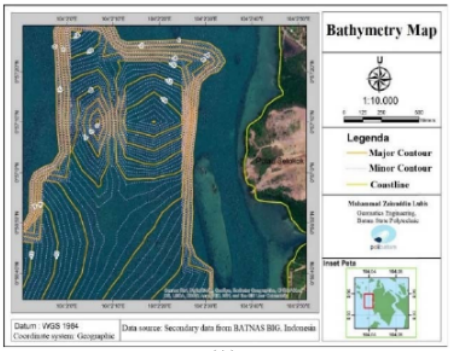
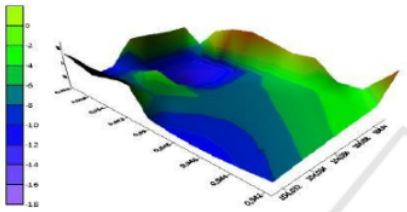


Figure 5: The cross-sectional profile of Setokok Sea.



(A)



(B)

Figure 6: Bathymetry of Setokok Sea (A) 2 dimensions, and (B) 3 dimensions

Setokok Sea is part of the shallow area with the depth distribution ranging from 0 to 16 meters below sea surface. The deepest point locates at a distance of 16 m to the northeast while the lowest depth (0-5 meters) can be placed around the Setokok beach. Setokok Sea has a relatively steep surface in the north and south. On the east, the sea floor looks more gentle. As for the coastal areas of Setokok, the surface is relatively steep until the sloping height of the coastal surface decreases as it heads towards the coast. Thus, it can be seen that the sea level's value must have a significant effect on the steepness of the bathymetry in an area of water, especially in seawater like Setokok. Hasan (2004) studied that other important factors that can influence climate change are the average topography and the value of the depth of the ocean in water.

4 CONCLUSIONS

From the results of research conducted in one season, it can show the difference in sea surface temperature and the distribution of Chlorophyll A in April and May 2020 (east season). The higher the sea surface temperature, the lower the Chlorophyll A's distribution value in Setokok Sea. This is also related to the sea level that changes every day, and dramatically affects the bathymetry and steepness of the transverse profile in Setokok Sea. The results show climate change observed from the parameters studied, namely the sea surface temperature, the distribution of Chlorophyll A, tides (sea level), cross profile, and bathymetry values. The change of those parameters caused by global climate chage tend to affect the primary water condition in Setokok Sea Batam islands.

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