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The relationship of organic matter, nitrate, and phosphate content to diatom abundance in the eastern coastal waters of Rupat Island Province

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Abstract
This study was conducted in March 2023 in the coastal waters of the eastern part of the island of Rupat, Riau Province. The method used in this study used the purposive sampling method at 3 station points. Water samples were used to analyze nitrate and phosphate analyzed using Ultraviolet Spectrophotometry, and analysis of water organic matter using the titrimetric method. Diatom sampling using plankton net measuring 25 µm. The results of the study found 14 species from 3 classes of diatoms namely Bacillariophyceae, Cyanophyceae, and Conjugatophyceae. Diatom abundance ranged from 472.22 - 993.05 cells/L. The regression equation for nitrate on diatoms is Y= 929.151-3194.045x. The coefficient of determination (R^2) of 0.080 indicates that the effect of nitrate on diatom abundance has a weak close relationship. The effect of phosphate on diatom abundance has a coefficient of determination (R^2) of 0.105 and the effect of phosphate has weak proximity. The influence of water organic matter has a coefficient of determination (R^2) of 0.033 with a very weak effect. The analysis shows that the concentration of nitrate (NO_3) is included in the oligotrophic fertility level, namely the low fertility rate.

1. INTRODUCTION

Rupat Island has white sand beaches that stretch from Teluk Rhu Village, Rupat Utara Subdistrict, to Sungai Cingam, Rupat District. The Regional Government (Pemda) of Bengkalis Regency has designated the Rupat Beach area as a marine tourism area as stated in the 2011-2035 Regional Spatial Plan (RT-RW) document and the 2010-2015 Regional Medium-Term Development Plan (RPJMD).

Many human activities in the estuary caused changes in the content of nutrients in the water. The content of constantly changing nutrients can affect the abundance of plankton and biota in these waters (Widyarini et al., 2017). According to Maslukah et al. (2014), entering nutrients into the estuary can affect the abundance of plankton, making the waters more fertile. Plankton that have an essential role in the waters are diatoms. The presence of diatoms significantly affects life in the waters because they play an essential role as a food source for various marine organisms and play a role in the transfer of carbon, nitrogen, nitrate, and phosphate.

Organic matter is an essential source of nutrients that marine organisms need. Through the decomposition process of decomposing organisms, organic matter in the waters will be broken down to become inorganic matter, an essential nutrient in the waters.

Phytoplankton is one parameter that determines primary water productivity (Isnaini et al., 2014). The presence of phytoplankton as primary producers can provide information about the condition of the surrounding waters, so phytoplankton is a biological parameter that can be used as an indicator to determine the quality and fertility of a water body (Munthe et al., 2012).

Nutrients are needed substances that affect the process and development of phytoplankton, mainly nitrate and phosphate nutrients. These two nutrients play an essential role for aquatic organisms in photosynthesis. Nitrate and phosphate compounds naturally come from the water through decomposition, weathering, and decomposition of plants, dead organisms, and waste discharges. Both land waste, such as domestic, industrial, agricultural, and livestock waste or feed residues in the presence of bacteria, decompose into nutrients (Ulqodry et al., 2010). Phosphate and nitrate are needed in the development of living organisms, such as phytoplankton, while aquatic organisms use dissolved oxygen in respiration

2. RESEARCH METHODS

Time and Place

This study was conducted in March 2023. Located in the eastern coastal waters of Rupat Island, Bengkalis Regency, Riau Province. The island can be reached from Pekanbaru, Dumai, or Bengkalis. The analysis was conducted at the Marine Biology Laboratory of the Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau.

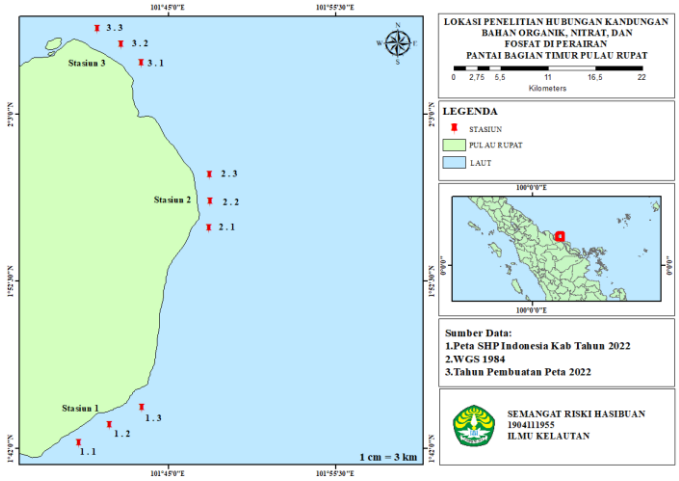

Figure 1. Sampling location

Research method

Determination of sampling locations based on purposive sampling, which is expected to represent the research location. The research location consists of 3 stations. Each station has three sampling points. In this study, the research location is divided into three stations: station I is in the Pergam area of Rupat District, a community shrimp pond area, community oil palm plantations, Pergam Harbor, and Pergam Tourism Park. Station II is located in the Sei Cingam area of Rupat District, a shrimp pond area of PT. Marindo, Sei Cingam watershed, Plantation, and Ketapang Beach tourist area. Furthermore, station III is located in the Tanjung Punak area of Rupat Utara Subdistrict, which is a shrimp pond area UPT Fisheries service, and Tanjung Lapin Beach tourist area, City Park, Lodging, and Rupat Utara Beach Tourism area. The distance between the coastlines of Rupat Island with sampling points at the research station is ±100 m from the shoreline.

Measurements of several physical, chemical, and biological parameters that affect the eastern coastal area of Rupat Island were carried out in situ and ex-situ at the research site. Water quality parameters taken are physical, chemical, and biological parameters. Physical parameters used in this study include brightness, current speed, turbidity and temperature, and salinity. Chemical parameters

used in this study consisted of acidity (pH), nitrate, phosphate, and water organic matter. Measurements were made three times a repetition.

Brightness is calculated by looking at the average depth of the secchi disk visible distance (D1) and the secchi disk missing distance.

$$\text{Brightness (cm)} = \frac{\text{Lost distance (cm)} + \text{visible distance (cm)}}{2}$$

Temperature was measured using a thermometer. Turbidity is calculated using a turbidimeter in the laboratory. Current velocity was measured using a current drogue. A stopwatch was used for time calculation. The current velocity value was calculated using the formula:

$$\text{Velocity (V)} = \frac{\text{distance (meter)}}{\text{time (second)}}$$

Salinity measurements were made using a hand refractometer. Measure of acidity was carried out at each sampling location point using a pH meter by dipping it into the water.

Determination of nitrate concentration is done by reading the absorbance value using an Ultraviolet Spectrophotometer with a wavelength of 220 nm and 275 nm, then by calculating the standard absorbance value curve. The value obtained is in the form of an equation, and the importance of R^2, the equation can be used to find the concentration value of the nitrate sample (SNI 06-688.31-2005).

Determination of phosphate levels was carried out using an Ultraviolet Spectrophotometer. This method reads phosphate levels at a wavelength of 880 nm with a level range between 0.01 mg/l - 1 mg/l. The principle of this method is that in an acidic atmosphere, ammonium molybdate and potassium antimony tartrate react with orthophosphate to form a phosphomolybdic acid compound, then reduced by ascorbic acid to a molybdenum blue complex (SNI 06-2480-1991).

Nitrate and phosphate sampling using Van Dorn Water Sampler, then the sample water is put into a bottle labeled with information (station and sampling point) as much as 100 mL. Then, for the nitrate sample, given a preservative in the form of H_2SO_4 as much as four drops.

Analysis of total organic matter in water samples was carried out in the laboratory using the titrimetric method according to SNI. 06-6989.22-2004. Then, the total organic matter value is calculated with the permanganate value with the following equation:

$$KMnO_4 \left(\frac{mg}{L}\right) = \frac{[(10\text{-}a)b\text{-}(10 \times c)]1 \times 31{,}6 \times 1000}{d} \times f$$

Description

a : Volume of $KMnO_4$ 0.01 N required in the titration
b : Actual normality of KMnO 4
c : Oxalic acid normality
d : Sample volume
f : Dilution factor of the test sample.

Water samples for diatom abundance analysis used a 25 µm plankton net and a 10 L volume bucket for 20 times filtering using a 5 L plastic bucket. Water samples for phytoplankton identification were put into a plastic bottle (125 mL capacity) and given 3-4 drops of 4% Lugol solution, and then the bottle was labeled. Diatom abundance was calculated using the sweep method referring to the APHA (1995) formula.

$$\text{Number of Ind/L} = \frac{T}{L} \times \frac{V_0}{V_1} \times \frac{1}{P} \times \frac{1}{W} \times N$$

Description:

N : Number of diatom individuals found per preparation
T : Area of cover glass (22 × 22 m^2)
L : Microscope field of view (1,306m^2)
Vo : Volume of sample water in the bottle (125 mL)

V1 : Volume of sample water under the cover glass (0.06 mL)
P : Number of field of view observed (12 field of view)
W : Volume of filtered water (100 L)

Data Analysis

The relationship between nitrate, phosphate, and organic matter variables was determined using a linear regression correlation analysis approach with the *Microsoft Excel* 2010 program. It utilized simple and multiple linear variable regression analysis. This data analysis can be used to explain the effect of independent variables on the dependent variable. Diatom abundance was the dependent variable, and organic matter, nitrate, and phosphate were the independent variables. This analysis uses SPSS software. Statistically, the commonly used relationships are as follows (Tanjung, 2014):

$$Y = a + bX_1 + bX_2 + bX_3$$

Description :
Y = Diatom abundance (ind/mL)
X1 = Organic matter (mg/L)
X2 = Nitrate (mg/L)
X3 = Phosphate (mg/L)
a = Constanta
b = regression coefficient

The coefficient of determination (R^2) was used to determine the effect of Total Suspended Solid (TSS), Nitrate, and Phosphate on phytoplankton abundance. To see the relationship of nitrate and phosphate with the number of phytoplankton, the correlation coefficient (r) is used where the value of r is between 0-1, according to Tanjung (2014):

Table 1. Correlation index value relationship coefficient

Interval	Relationship Level
0,00 – 0,20	Very Weak
0,21 – 0,40	Weak
0,41 – 0,70	Moderate
0,71 – 0,90	Strong
0,91 – 1,00	Very Strong

3. RESULTS AND DISCUSSION

Rupat Island has an area of 1.524,55 km^2 divided into two sub-districts: the Rupat Sub-district and the Rupat Utara Sub-district. North Rupat sub-district has an area of 638.5 km^2 and a population of 2,903 people. Various ethnic groups can be found on Rupat Island, such as Malay, Javanese, Chinese, Batak, and Akit. The Akit tribe is the original inhabitants of Rupat Island. This area of Rupat Island has mixed mainly semi-diurnal tides, i.e. two high tides and two low tides in one day, but the height of one wave is different from the other or the second (Table 2).

Table 2 shows that the average range of water quality parameters at each station, namely water temperature, ranges from 25.00-29.00^{o}C, the lowest at stations 3.1 and 3.2, and at station 1 with an average value of 25.00-26.00^{o}C. and the highest at station 2 with an average value of 29.00^{o}C. Salinity waters 15 - 29‰, the lowest at station 1.3 with a value of 15‰, and the highest at station 3.2 with a value of 29‰. While the average value of pH is 7. Currents ranged from 0.0286 - 0.0558 m/s.

The highest current velocity is at station 1.2 with an average value of 0.0558 m/sec, while the lowest is at station 2.2 with an average value of 0.286 m/s. Water brightness ranges from 0.25 - 1.75 m, the lowest is located at station 1.3, and the highest is located at station 3.1 with a range of values of 1.75 m. Water depth ranges from 2.1 - 7.70 m with the lowest at station 1.1 and the highest at station 3.1 with a value of 7.70 m.

Table 2. Water quality parameters at the research site

Station	Sampling	Temp (°C)	Salinity (ppm)	pH	Current (m/s)	Brightness (m)	Depth (m)
I	1.1	26.00	25.00	7.80	0.0556	0,35	2,1
	1.2	26.00	20.00	6.90	0,0558	0,352	3,15
	1.3	26.00	15.00	6.80	0,0417	0,25	2,45
	Average	26.00	20.00	7,17	0.0520	0,32	2,57
II	2.1	29.00	29.00	7.40	0.0333	1,4	3,25
	2.2	29.00	28.00	7.60	0.0286	1,5	2,15
	2.3	29.00	27.00	7.70	0.0313	1,57	2,8
	Average	29.00	28.00	7.57	0.0311	1,49	2,73
III	3.1	25.00	28.00	7.90	0.0357	1,75	7.70
	3.2	26.00	29.00	8.00	0.0385	1,2	6.75
	3.3	27.00	26.00	7.90	0.0345	1,4	6.15
	Average	26.00	27.67	7,93	0.0362	1,45	6.87

Nitrate, Phosphate, and Organic Matter Concentrations in Waters

Nitrate (NO_3-N) is the main form of nitrogen in natural waters. Nitrate is one of the nutrient compounds that are important in the protein synthesis of animals and plants. The results of nitrate measurements in the waters of the east coast of Rupat Island can be seen in Table 3.

Table 3. Nitrate Measurement Values at Each Station

Station	Sampling	Concentration (mg/l)	Average (mg/L)	Quality Standard (*)
I	1.1	0,1167	0,1098	0,06
	1.2	0,1063		
	1.3	0,1063		
II	2.1	0,0958	0,0993	
	2.2	0,0958		
	2.3	0,1063		
III	3.1	0,0854	0,0958	
	3.2	0,0958		
	3.3	0,1063		

Source: (*Government Regulation of the Republic of Indonesia Number 22 of 2021)

Table 4. Phosphate Value at Each Station

Station	Sampling	Phosphate (mg/L)	Average (mg/L)	Quality Standard (*)
I	1.1	0,1128	0,1084	0,015
	1.2	0,1040		
	1.3	0,1084		
II	2.1	0,0996	0,1040	
	2.2	0,1040		
	2.3	0,1084		
III	3.1	0,0951	0,0966	
	3.2	0,0951		
	3.3	0,0996		

Source: (*Government Regulation of the Republic of Indonesia Number 22 of 2021)

The nitrate concentration on the east coast of Rupat Island waters ranges from 0.0854 - 0.1167 mg/l. Station I has the highest nitrate concentration, with an average of 0.1167 mg/L, and the lowest at

Station III with an average of 0.0854 mg/L. The average nitrate concentration in the Rupat Island area is relatively high, ranging from 0.0993 - 0.1098 mg/L. The high concentration in the Rupat Island area is feared to cause eutrophication and endanger marine biota. Nitrate concentration experiencing eutrophication ranging more than 0.2 mg/L. Nitrate concentrations at stations located in the Rupat Strait have exceeded 0.1.

Phosphate (PO_4-P) is one of the essential elements for metabolism and protein formation. Phosphate is one of the most important nutrient compounds in the sea. The results of phosphate measurements in the waters of Rupat Island can be seen in Table 4. The phosphate concentration in the eastern coastal waters of Rupat Island ranged from 0.0951 - 0.1128 mg/L. Station I has the highest phosphate concentration, with an average of 0.1128 mg/L, and the lowest at Station III with an average of 0.0951 mg/L.

Organic material matter plays an important role as a source of energy and nutrient recycling in public waters in both flowing and stagnant types. The results of the measurement of water organic matter in the waters of Rupat Island can be seen in Table 5

Table 5. Water organic matter measurement

Station	Sampling	Concentration (mg/L)	Average (mg/L)
I	1.1	26,982	28,028
	1.2	28,977	
	1.3	28,124	
II	2.1	28,124	28,882
	2.2	29,262	
	2.3	29,262	
III	3.1	29,262	29,641
	3.2	30,115	
	3.3	29,546	

The table shows that the concentration of water organic matter in the eastern coastal waters of Rupat Island ranges from 26.982 - 30.115 mg/L. Station III has the highest concentration of water organic matter, with an average of 29.641 mg/L, and the lowest concentration is at Station I with an average of 28.028 mg/L. The high concentration of total organic matter in the waters of the Rupat Island area is thought to be due to anthropogenic activities from inside and outside the Rupat Island area. In the Rupat Island area, there are many palm, rubber, and coconut plantations and vannamei shrimp farming activities. This activity contributes to the total organic matter in the Rupat Island area. In areas in public waters, organic matter, either from within the waters themselves (autochthonous) or from outside (allochthonous), is a basic component of aquatic metabolism.

Diatom Composition and Abundance

Based on the results of the analysis of the composition of phytoplankton species found when analyzed in the laboratory. Based on Table 6, it can be seen that the composition of diatom species found in the waters of Rupat Island consisting of 3 stations and nine side points obtained three diatom classes, namely Bacillariophyceae, Cyanophyceae, and Conjugatophyceae. Bacillariophyceae class, there are eight species, namely *Nitzchia* sp*, Synedra ulna, Itshmia obliquata, Rhabdonema adriaticum, Grammatophora* sp, *Guinardia striata, Rhizosolenia alata, Cyclotella atomus*. In class Cyanophyceae, there are three species: *Oscillatoria* sp*, Lyngbya* sp, and *Tolypothrix* sp. In Class Conjugatophyceae, there are three species, namely *Pleurotaenium* sp, *Closterium* sp, and *Gonatozygon* sp. So, 14 types of species are obtained. The most commonly found species, and almost at all sampling points, is *Grammatophora* sp from the Bacillariophyceae class, located at all research stations. The species that is rarely seen is *Oscillatoria* sp from the Cyanophyceae class.

Table 3. Diatom composition

Class	Species	Station I			Station II			Station III		
		1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
Bacillariophyceae	*Nitzchia* sp	-	-	-	-	-	+	+	+	+
	Synedra ulna	-	+	-	-	-	+	+	+	+
	Itshmia obliquata	+	+	-	+	+	+	+	+	+
	Rhabdonema adriaticum	-	-	-	+	-	+	+	+	+
	Grammatophora sp	+	+	+	+	+	+	+	+	-
	Guinardia striata	-	-	-	-	+	-	+	-	-
	Rhizosolenia alata	+	+	-	-	-	-	-	+	+
	Cyclotella atomus	+	-	-	-	-	-	+	-	+
Cyanophyceae	*Oscillatoria* sp	+	-	-	-	+	-	-	-	+
	Lyngbya sp	+	-	-	-	-	+	+	+	-
	Tolypothrix sp.	+	+	-	-	+	+	+	-	+
Conjugatophyceae	*Pleurotaenium* sp.	+	+	-	+	-	-	+	-	+
	Closterium sp	-	-	+	-	-	-	+	+	-
	Gonatozygon sp.	-	-	-	-	-	-	+	+	+

The average abundance value ranged from 472.22 cells/L, while the highest average abundance was found in the Station III area, with an average value of 993.05 cells/l. Bacillariophycea class dominates the waters of the Rupat Island area. Diatoms from the Bacillariopyceae Class can adapt to changes in aquatic environmental conditions that are very high, this is supported by the statement of Wiyarsih (2019), which states that the Bacillariopyceae Class can survive in polluted ecological conditions in this area there are many factories and residential waste.

Station I is known for its sea transportation activities because this area is directly opposite Sumatra Island. So that the waters experience stirring and increase the turbidity value, thereby reducing the penetration of sunlight into the waters, the value of diatom abundance in the Station II area is higher than the stations in the Rupat Strait area.

The high abundance of phytoplankton in the Station II area compared to the Station I area in the Rupat Strait is thought to be due to the fulfillment of sunlight needs intended for diatoms to photosynthesize due to the low turbidity value in this area compared to the site in the Rupat Strait. The most abundant diatoms in the Rupat Island area are in the Station III area because the Station III area has the highest abundance value in the Rupat Island area due to the penetration of light into the water. According to Abida (2010), if light penetration into the water is reduced, it will greatly reduce the activity of diatoms in photosynthesis.

Relationship of Organic Matter, Nitrate and Phosphate Content to Diatom Abundance

The results of the analysis of the linear equation of the effect of nitrate content with diatom abundance in the Rupat Island area are as follows: Y = 929.151 - 3194.045x. Based on the analysis results, the determination value (R^2) for nitrate on phytoplankton abundance is 0.080, which means that phytoplankton abundance is influenced by nitrate content by 8%. The R^2 coefficient value is 0.080, which means the relationship of diatom density to concentration is weak. Based on the classification of the relationship based on the R^2.

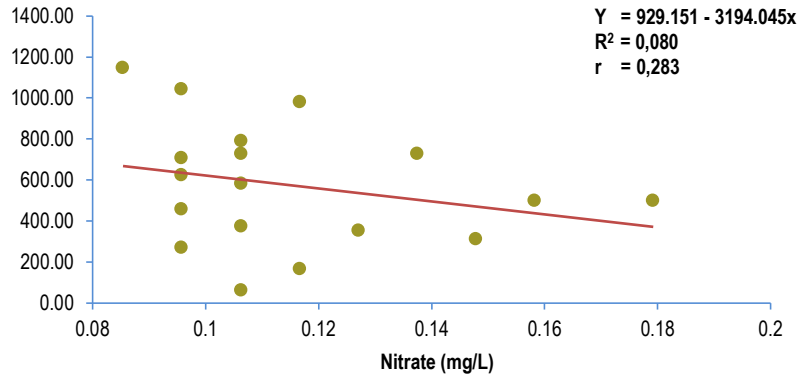

Figure 2. Relationship between diatom abundance and nitrate concentration

The linear equation of the effect of phosphate content with diatom abundance is Y = 1025.645 - 4054.525x. Based on the analysis results, the determination value (R^2) for phosphate on diatom abundance is 0.105, which means that diatom abundance is influenced by nitrate content by 10.5%. The R^2 coefficient value is 0.105, which means the relationship of diatom density to concentration is weak. The weak relationship between nitrate and phosphate concentrations with diatom abundance is because the main factor affecting diatom abundance is sunlight.

According to Mustofa (2015), light entering the water becomes a limiting factor for diatom life because it is related to photosynthesis. So, diatoms cannot live without light. The deeper the water, the more sunlight can no longer penetrate the water column, so no phytoplankton are found.

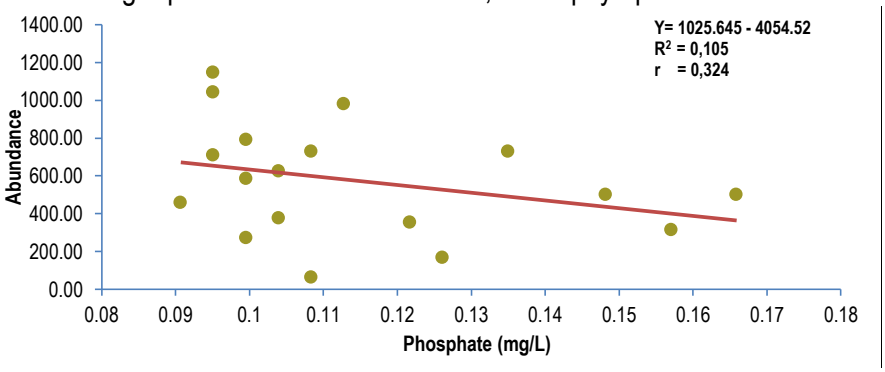

Figure 3. Relationship of diatom abundance with phosphate concentration

The linear equation of the effect of organic matter content with diatom abundance is Y = 1122.459 - 18.468x. Based on the analysis results, the determination value (R^2) for water organic matter on diatom abundance is 0.033, meaning that nitrate content influences phytoplankton abundance by 3.3%. The coefficient of R^2 is 0.033, which means the relationship of diatom density to concentration is very weak.

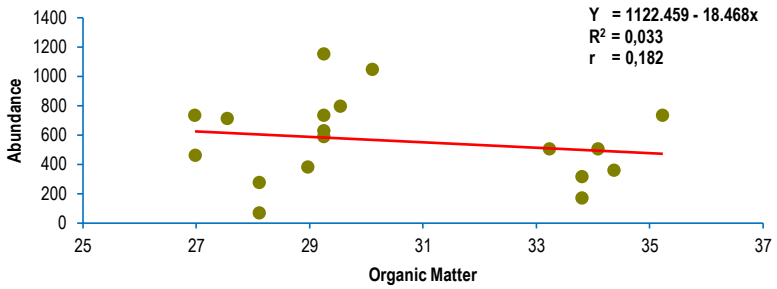

Figure 4. Relationship of diatom abundance with organic matter content

The relationship between diatom abundance and the concentration of nitrate, phosphate and organic matter content of water in the waters of Rupat Island is very weak, where the connection ranges from 8%, 10.5%, and 3.3%. Sidaningrat et al. (2018) state that three water divisions exist. Based on diatom abundance, oligotrophic waters are waters with low fertility with diatom densities ranging from 0 - 2,000 cells/L, mesotrophic waters are waters with moderate fertility with phytoplankton abundance going from 2,000 - 15,000 cells/L, and eutrophic waters are waters with high fertility with diatom abundance > 15,000 cells/L.

The waters category based on nitrate concentration of the Rupat Island water area is included in oligotrophic waters. According to Mustofa (2015), oligotrophic waters have nitrate levels of 0-1 mg/L, mesotrophic waters have nitrate levels between 1-5 mg/L, and eutrophic waters are between 5-50 mg/L. Based on the phosphate concentration, the waters of Rupat Island are included in eutrophic waters.

4. CONCLUSIONS

The nitrate concentration in the east coast waters of Rupat Island ranges from 0.0854 - 0.1167 mg/l. Phosphate concentration in the range of 0.0951 - 0.1128 mg/L. The concentration of water organic matter in the Eastern coastal waters of Rupat Island ranged from 26.982 - 30.115 mg/L. There were 14 species of diatoms found, with the lowest diatom abundance found at Station I and the highest at Station III, with abundance values ranging from 472.22 - 993.05 cells/L. The relationship between nitrate, phosphate and organic matter content with phytoplankton abundance in the Rupat Island area is not significant or weak with the coefficient of determination (R^2) 8%, 10.5% and 3.3%.

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