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STUDY OF BENTHIC DIATOM POPULATIONS IN BUNGKUTOKO WATERS IN RELATION TO THE CONSTRUCTION OF A CONTAINER PORT

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ABSTRACK

Diatoms are a unique and specific group of microscopic algae, the body is composed of two valves, namely epitheca and hypotheca to form frustules, with cell walls made of silica (SiO3). Benthic diatom populations are highly variable and are common in waters. Bungkutoko Island is an island located at the eastern end of Kendari Bay. The rapid development and reclamation activities in the Bungkutoko coastal area, especially the construction of the port will affect the structure and topography of the environment. This study aims to determine the population of benthic diatoms in Bungkutoko waters in relation to the construction of a container port. The research was conducted at six observation stations using the purposive sampling method in August-September 2023. The results of this study found 13 genera of benthic diatoms, with abundance values ranging from 342-492 ind/cm2. The diversity index value ranged from 1.82-2.00, the uniformity index value ranged from 0.82-0.91 and the dominance index value range from 0.15-0.20. Principal component analysis showed a correlation between the abundance of benthic diatoms and water quality parameters in the Bungkutoko waters.

Keywords: Diatom benthic, port, Bungkutoko waters.

INTRODUCTION

Diatoms are a unique and specific group of microscopic algae, their bodies are composed of two valves, namely the epitheca and hypotheca, forming a frustule, with cell walls made of silica (SiO3). Diatom chloroplasts contain pigments a and c which are used in the photosynthesis process. The dominant pigments in diatoms are fucoxanthin and carotenoids, which give them a gold brown color (Suwartimah et al., 2011), so that water rich in diatoms will have a slightly brownish color. Diatoms are widely used as bioindicators of water quality because they have a level of sensitivity to environmental changes in waters and contribute to primary productivity in supporting food web cycles. Diatoms dominate and are found in both fresh and marine waters, in shallow, upwelling and turbulent areas such as coastal areas. Diatoms can live as pactonic organisms (floating passively in water) and as benthonic (attached to substrates). One type of diatom that lives on the bottom substrate of waters is the epipelic diatom (Fitriyah et al., 2016).

Benthic diatom populations vary greatly in waters, due to their wide distribution. Bacillariphyceae are the most common phytoplankton found (Adinugroho et al., 2014; Padang et al., 2021). Several previous studies on benthic diatoms include: Ode, (2021) on the comparison of the density of benthic diatoms and microplastics in sediment in the waters of Kendari Bay; Suwartimah et al., (2011) regarding the species composition and abundance of benthic diatoms at the mouth of the Comal Baru river, Pemalang; Rusmiati et al., (2020) regarding the abundance of benthic diatoms based on differences in substrate types in the waters of Dompak Island, Riau Regency; and Dionfriski et al., (2021) regarding epipelic diatom community structure in the intertidal zone of Mengkapan water, Apit District river, Siak Regency.

Bungkutoko Island is an island located at the eastern end of Kendari Bay. The coastal areas of this island are widely used as community residential centers, tourist attractions, cultivation land, fishing areas and port construction. These various activities can have a negative impact on Bungkutoko waters, such as high pressure on water quality and can degrade the aquatic ecosystem. The rapid development and reclamation activities in the Bungkutoko coastal area, especially the construction of the port, will affect the structure and topography of the environment. One of the organisms affected is diatoms which have an important role, such as natural food sources for fish, primary producers and oxygen producers which have an impact on higher level organisms (Yulma et al., 2017).

It is worried that the decline in quality and changes in water topography will have an impact on the benthic diatom population. The development of studies on benthic diatoms (Bacillariophyceae) in Bungkutoko waters around the container port area is still limited. For this reason, research is needed regarding "Study of benthic diatom populations in Bungkutoko waters in relation to the construction of the Container Port".

This research was aimed to determine the population of benthic diatoms in the Bungkutoko waters around the construction of the container port. It is hoped that the results of this research will provide an overview of the benthic diatom population in the Bungkutoko waters around the construction of the container port.

MATERIAL AND METHODS

This research was carried out in August-September 2022 in Bungkutoko waters, Nambo District, Kendari City, Southeast Sulawesi. Sediment samples and water quality parameters were taken directly at the research location, while sample identification and water quality analysis were carried out at the Aquatic Productivity and Environment Laboratory (Prolink), Faculty of Fisheries and Marine Sciences, Halu Oleo University, Kendari.

Sampling of benthic diatoms is carried out when seawater is at low tide towards high tide or high tide towards low tide with repetitions once a week at each station for a period of one month. Benthic diatom samples were taken on bottom water substrates using a modified large 60 ml syringe with a diameter of 3 cm. Next, the samples obtained were put into sample plastic to be preserved using 3% formalin. The samples are then marked according to their sampling station and stored in a cool box to be transported to the laboratory for further analysis. Benthic diatom samples were removed from the cool box. Next, the sample was put into a glass beaker, then 30 ml of water was added and stirred evenly so that the benthic diatom sauce obtained separated from the substrate. After that, leave the sample for 2-3 minutes until the water is not too cloudy. The evenly distributed water sample was then taken using a 1 ml dropper pipette and placed on top of the SRC to be observed with a binocular microscope at 10x10 magnification. Next, samples were identified using the books of Saldanha Bay (2001), Sachlan (1982) and Davis (1955). Meanwhile, the water quality parameters taken include temperature, brightness, water pH, salinity, dissolved oxygen, current speed, nitrate, phosphate and silica.

Determination of sampling stations is carried out by purposive sampling or sampling based on certain criteria, namely the distance of the sampling location is less than 500 m from the Container port. The sampling area is divided into six stations as follows:

Station I	:	Located at coordinates 122° 37' 12,688" East Longitude and 3° 59' 11,561" South Latitude, with distance of 103 m from the Container port pier.
Station II	:	Located at coordinates 122° 37' 15.094" East Longitude and 3° 59' 20.808" South Latitude, with distance of 201 m from the Container port pier
Station III	:	Located at coordinates 122° 37' 6.381" East Longitude and 3° 59' 36.289" South Latitude, with distance of 27 m from the Container port.
Station IV	:	Located at coordinates 122° 37' 4.078" East Longitude and 3° 59' 29.147" South Latitude, with distance of 61m from the Container port.
Station V	:	Located at coordinates 122° 36' 55.200" East Longitude and 3° 59' 34.064" South Latitude, with distance of 305 m from the Container port.
Station VI	:	Located in the area behind the settlement with coordinates 122° 36' 49.694" East Longitude and 3° 59' 34.669" South Latitude, with distance of 422 m from the Container Port.

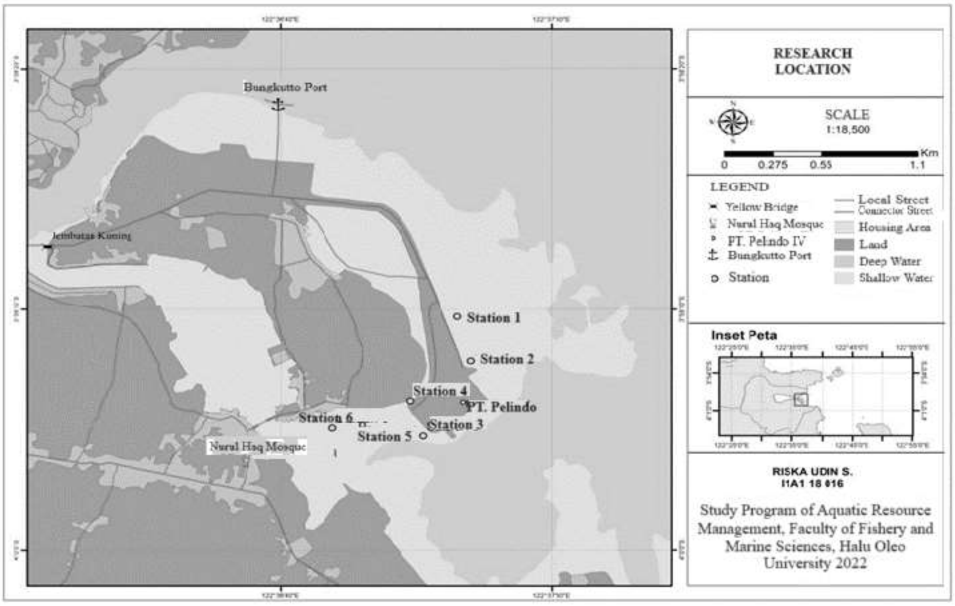

Figure 1. Map of the study location

Data Analysis

Abundance of Benthic Diatom (K)

Benthic diatom abundance calculations were carried out using the sub-sample method (APHA, 2017) with units of ind/cm2, which was quoted by Rusmiati et al., (2020) as follows:

$$K = n\ x\ \frac{Vp}{Vcg} x \frac{1}{A}$$

Where:
K = Abundance (ind/cm^2)
n = Total number of individual (sel)
Vp = Dilution volume (30 ml)
Vcg = Sample volume under cover glass of SRC (1ml)
A = Area of core sampler (63.585 cm^2)

Diversity Index (H')

This index is used to determine the level of diversity of an organism in waters. A higher diversity index value means that the plankton community in the waters is diverse and not dominated by one or two species or genera. Species diversity was calculated using the Shannon-Wiener formula (Parsons et al., 1977) quoted by Arazi et al., (2019) as follows:

$$H' = -\sum_{i:1}^{s} Pi\ Ln\ Pi$$

Where:
H' = Diversity Index of Shannon-Wiener
Pi = ni/N

ni = Numbers of individual of the i-th species;
N = Total number of individuals, S = Number of species

Determination of diversity index criteria can be categorized as follows:

H' < 2.0 : Low diversity

2.0 < H' < 3.0 : Moderate diversity;

H' > 3.0 : High diversity.

Similarity Index (E)

The Similarity index can be calculated using the formula Odum, (1993) as quoted by Ulfa et al., (2020) in the following equation:

$$E = \frac{H'}{Hmax}$$

Where:
E = Similarity Index;
H' = Shanno Wiener Diversity Index;
H_{max} = Maximum Diversity = (Ln S);
S = Number of genera

The uniformity index value describes the balance of species distribution in a community. With the following uniformity index value criteria:

E < 0.4 low evenness, depressed community;

0,4 ≤ E ≤ 0.6 Moderate evenness, unstable community;

E > 0.6 High evenness, Stable community.

Dominance Index (C)

The dominance index can be calculated using the Simpson index formula (Odum, 1998) quoted by Ulfa et al., (2020), namely:

$$C = \sum_{i:1}^{n} \left(\frac{ni}{N}\right)^2$$

Where:
C = Dominance Index of Simpson;
ni = Number of individual of the i-th species;
N = Total number of individu.

The categories of dominance index values are as follows

0 < C < 0.50	Low Dominance
0.50 < C < 0.75	Moderate Dominance
0.75 < C < 1.00	High Dominance

Principal Component Analysis (PCA)

Principal component analysis is used to determine the characteristics of the habitat in a study area (Setyobudiandi et al., 2014) with the formula:

$$d(i,i')^2 = \frac{\sum(Xij - Xi"j)2}{Xj}$$

Where:
Xi = Number of row-i at column-j
Xj = Number column-j for all row-i

RESULTS AND DISCUSSION

Abundance of Benthic Diatom

The results of research on the abundance of benthic diatoms in Bungkutoko waters found thirteen (13) genera. All the genera found each had different abundance values, as presented in table 3. Based on the results of the analysis of the abundance of benthic diatoms from all four weeks of observations in Bungkutoko waters, it is known that the abundance values ranged from 43-199 ind/cm2.

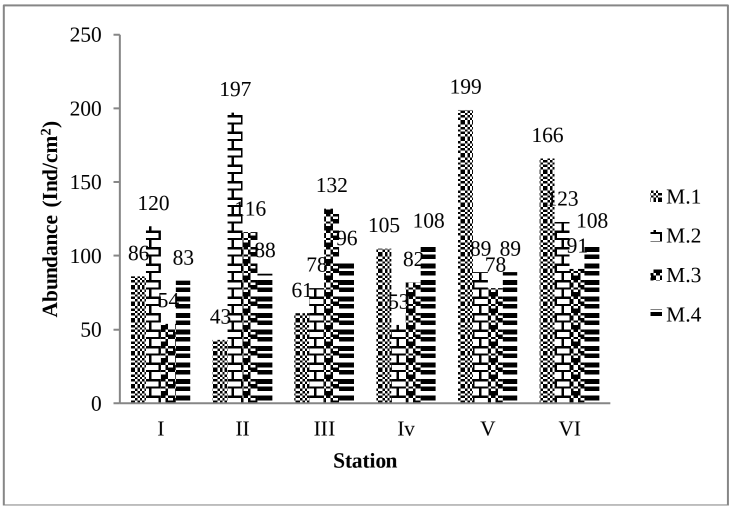

Figure 2. Abundance of benthic diatom diatom

Diversity (H'), Uniformity (E), and Dominance (C) Index of Benthic Diatoms

Based on the results of the analysis carried out in this research, the diversity index from the six observation stations was classified as low to medium with values ranging from 1.82 to 2.00. The uniformity index at all stations is classified as the same, namely high uniformity because the value is close to 1 with a range of 0.82-0.91. Meanwhile, the dominance index obtained in this study was relatively low at all stations, i.e., around 0.15-0.20. The research results for each observation after analyzing the diversity index, uniformity and benthic dominance of diatoms in Bungkutoko waters can be seen in table 2.

Table 2. Diversity (H'), Uniformity (E) and Dominance (C) Index Values of Benthic Diatoms in Bungkutoko Waters.

Stationn	H’	Category	E	Category	C	Category
I	1.90	Low	0.82	High	0.20	Low
II	2.00	Moderate	0.91	High	0.15	Low
III	1.93	Low	0.84	High	0.17	Low
IV	1.88	Low	0.91	High	0.18	Low
V	1.84	Low	0.89	High	0.19	Low
VI	1.82	Low	0.88	High	0.20	Low

Water Quality Parameter

Water quality parameters measured in Bungkutoko waters include temperature, salinity, water pH, brightness, current speed, dissolved oxygen, nitrate, phosphate and silica. The complete results of measuring quality parameters are presented in table 3.

The results of the correlation analysis between water quality parameters and the abundance of benthic diatoms using principal component analysis (PCA) explain that there are 2 main axes (F1 and F2) with a contribution of 38.52% for each axis. for axis (F1) and 25.93% for axis (F2) with a total contribution of 64.45% (Figure 3).

Table 3. Values ofthe water quality parameter in Bungkutoko water.

Parameter	Station					
	I	II	III	IV	V	VI
Temperature (ºC)	30.3	29.9	30.4	30.0	30.7	30.8
Salinity (ppt)	29	31	28	28	28	27
Water pH	7.6	7.9	7.9	7.8	7.8	7.8
Brightness (cm)	49.3	53.8	24.8	69.8	57.3	47.3
Current velocity (m/s)	1.7	1.1	0.9	0.7	0.8	0.6
Dissoved Oxygen (mg/L)	5.8	5.6	5.5	5.6	6.1	5.9
Nitrate (mg/L)	0.137	0.151	0.149	0.150	0.164	0.166
Phosphate (mg/L)	0.049	0.061	0.057	0.058	0.061	0.058
Silica (mg/L)	3.41	3.70	2.83	3.73	4.11	3.68

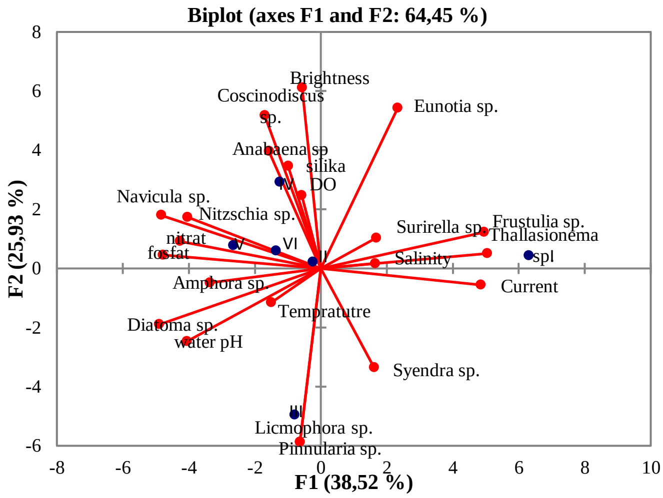

Figure 3. Graph of Principal Component Analysis (PCA)

RESULT AND DISCUSSION

Abundance of Bentic Diatom

Diatom abundance is the number or concentration of diatoms in a body of water which can vary depending on time, location and environmental conditions that influence either directly or indirectly the water (Haryo, 2013). Of the thirteen genera found, five of them are genera that are only found in a few locations, i.e., *Anabaena* sp., *Frustulia* sp., *Licmophora* sp., *Pinnularia* sp., and *Thallasionema* sp., while other genera are scattered throughout the observation locations, such as *Amphora* sp., *Coscinodiscus* sp., *Diatoma* sp., *Eunotia* sp., *Navicula* sp., *Nitzschia* sp., *Surirella* sp., and *Syendra* sp. Based on the number of individuals found, the genus *Surirella* sp. has the largest number, i.e., 1,328 individuals, this is because it is widely distributed and can be attached to sediment or rock. Genus *Surirella* sp. in these waters it is higher than in the waters of the Sebangun River at Kereng Bengkiray Harbor, namely 73 ind/L (Nirmalasari, 2018) and in the waters of Bintan Island at 64 ind/L (Hilmi et al., 2018).

The abundance value of benthic diatoms in Bungkutoko waters is classified as oligotrophic waters, namely waters that have a low level of fertility. This is shown by the abundance values obtained ranging from 43-199 ind/cm2. Kamila et al. (2014) stated that the waters around the port are of poor quality, so they can only be inhabited by clans that are tolerant of pollution. Various human activities in coastal areas such as beach landfilling can cause changes in the natural hydrological conditions of coastal systems which cause a decrease in diatom abundance (Alvarez et al., 2006; Holly et al., 2014; Munandar et al., 2017). The high abundance of phytoplankton is influenced by daily community activities as well as the influence of household waste, resulting in the input of a lot of inorganic materials into the waters (Roito, 2014). In line with Amedia (2013) that when there is an increase in nutrient concentrations, diatoms are able to reproduce three times in 24 hours. The low abundance of benthic diatoms in Bungkutoko waters was also found by several researchers who found that the area around the port had a low abundance value. Adriana et al. (2017) in Tanjung Balai waters with an abundance of 48-79 ind/L, Rozalina et al. (2020) in Meral waters of 90.3-204.3.

Diversity (H'), Evenness (E), and Dominance (C)

The stability of a water community can be described from the diversity index (H'), uniformity index (E), and dominance index (C). The diversity index shows a measure of the number and proportion of different species in a community. This index includes the number of species and evenness which lists each species obtained. The higher the diversity index, the more species there are in a commpeciesunity. In this research, it is known that the diatom benthic diversity index is in the low to medium category, which means that there are not many species in the community. This condition shows that productivity is low, ecosystem conditions are less stable and ecological pressure is high (Carong, 2011). The cause of this low index is thought to be influenced by several factors including destruction of natural habitats by humans, climate change, pollution and predation. All of these factors can disrupt the balance of the ecosystem and cause a decline in the population of certain species, which in turn can reduce overall biodiversity (Elisa, 2019). Several studies also show a low diversity index, namely 0.124-0.168 (Ulfa et al., 2020); 1.21-2.6 (Sirait et al., 2018); and 1,528-1,844 (Yulianto et al., 2014).

The uniformity index measures how evenly distributed individuals of different species are in a community. The higher the uniformity index, the more even the distribution of individuals of the species in a community. The uniformity index in this study is classified as high because it is almost close to 1. This shows that the ecosystem is in relatively good condition, namely that the distribution of the number of individual species is relatively equal and the waters are considered balanced. A uniformity index that is close to 0 tends to indicate an unstable community, whereas if it is close to 1, the community is stable and the number of individuals between species is the same. In line with the statement above, research that has been carried out also found high uniformity index values by Balqis et al. (2021) 0.84-0.99 and Adriana et al. (2017) namely 0.77-0.80.

The dominance index measures the proportion of individuals of the most common species in a community. The higher the dominance index, the more individuals are commonly found in a community. Dionfriski et al. (2021) stated that changes in the dominance of plankton species are influenced by environmental factors such as: changes in temperature, pH variations, nutrient content in waters, light penetration and biological conditions. The dominance obtained in this study is relatively low, which indicates that there are no benthic diatoms that dominate other genera in these waters. The dominance of a species can affect the population balance in a community. This was also found in research by Ulfa et al., (2020) amounting to 0.022-0.061; Adriana et al., (2017) 0.20-0.23; and Robertus et al., (2021) 0.25-0.30.

Water Quality Parameters

The existence of benthic diatoms is influenced by water parameters, both physical and chemical. The combination of these water parameters can influence the abundance and structure of benthic diatom communities. Often the influence of these water parameters creates a succession of diatom species and increases species diversity. Therefore, the benthic diatom community can be used to describe the quality of waters. The results of the principal component analysis between the abundance of benthic diatoms and environmental parameters in Bungkutoko waters show that there is a correlation or influence between the abundance of benthic diatoms and environmental parameters. Each location is influenced by its own environmental parameters. The station that has the highest abundance value is influenced by the temperature, pH, nitrate and phosphate. Temperature has a strong influence on physiological functions. High temperatures will affect metabolic processes, increase the speed of cell changes, respiration, and affect the movement of diatoms due to changes in the viscosity of the cytoplasm in the raphe. Temperature in relation to other climatic factors is a determining variable controlling the abundance and distribution of diatoms. According to Puji et al. (2012) that the temperature range of 25-30 ºC is a suitable temperature for phytoplankton life. The degree of acidity (pH) is a limiting factor for life, most marine organisms are sensitive to changes in pH. The pH value required to support the growth of diatom cells ranges from 7-9 with an optimum value ranging from 8.2-8.7. Optimal pH values are very important for the physiological processes of diatom cells (Diah et al., 2016).

Nitrate nutrients are needed and influence the growth and development of benthic diatoms as a source of food. Muchtar (2012), said that nitrate levels are low on the surface because these nutrients have been used by diatoms for living growth. The minimum requirement for nitrate that can be absorbed by diatoms is around 0.001-0.007 mg/L (Diah et al., 2016;.Suwartimah et al. 2011) argue that the nitrate content in normal waters ranges from 0.1-0.36 mg/L. Phosphate, which is one of the nutrients needed for the growth and metabolism of benthic diatoms and other marine organisms in determining the fertility of waters, is in unstable condition because it is easily subjected to processes of erosion, weathering and dilution waters.

Meanwhile, locations that are classified as low are influenced by current speed and salinity. Currents play a role in determining the movement and distribution of plankton in waters (Hanum et al., 2016). Salinity is a very important factor for diatom growth. Changes in salinity affect benthic diatoms in maintaining the balance of osmotic pressure between protoplasm and water so that they can affect the abundance and distribution of plankton (Diah et al., 2016).

CONCLUSION

The abundance of benthic diatoms in Bungkutoko waters ranges from 42-199 ind/cm2 which is classified as low abundance (oligotrophic) with thirteen genera found where the genus Surirella sp has the largest number of individuals and is found in all observation locations. The diversity index is classified as low to moderate with high uniformity and low dominance, which shows that the benthic diatom population in Bungkutoko waters is in good condition and supports the ecosystem.

REFERENCES

Adriana, A., Thamrin, Sofyan, H. S. (2017). Struktur Fitoplankton di Perairan Tanjung Balai Kota Kabupaten Karimun Provinsi Kepulauan Riau. Jurnal perikanan dan kelautan. 22(2) :18-26.

Adinugroho,M., Subiyanto, Haeruddin. (2014). Komposisi dan distribusi plankton di perairan teluk semarang. Saintifika. 16(2): 39-48.

Alvarez, C.G., Jorge, A., Herrera, S. (2006). Variationsof Phytoplankton Community Structure Related to Water Quality Trends in a Tropical Karstic Coastal Zone. Marine Pollution Bulletin. 52: 48-60.

Amedia, I. (2013). Diatome sebagai bioindikator air. Semarang: Universitas Diponogoro.

Arazi, R., Isnaini, Fauziyah. (2019). Struktur Komunitas dan Kelimpahan Fitoplankton serta Keterkaitannya dengan Parameter Fisika Kimia di Perairan Pesisir Banyuasin. Kabupaten Banyuasin. Jurnal Penelitian Sains. 21(1):1-8.

Balqis, N., Sayyid, A.E.R., Adrian, D. (2021). Keanekaragaman Dan Kelimpahan Fitoplankton di Perairan Ekosistem Mangrove Desa Rantau Panjang, Kecamatan Rantau Selamat, Kebupaten Aceh Timur. Jurnal Kelautan dan Perikanan Indonesia. 1(1): 35-43.

Boedi, I,H., dan Mustofa, N. (2011). Biodiversity of Benthic Diatom and Primary Productivity of Benthicmicro-Flora in Mangrove Forestson Central Java. Journal of Coastal Development. 14(1):131-140.

Corong, S. (2011). Struktur Komunitas Ikan di Perairan Pantai Kabupaten Mimika Provinsi Papua Indonesia. Makassar : Skripsi Jurusan Biologi Universitas Hasanuddin.

Davis, C.C. (1955). The marine and fresh water plankton. United states of America, michigan state university press.

Diah, R.P., Djuwito., & Irwani. 2016. Pengaruh Kandungan Nitrat dan Fosfat terhadap Kelimpahan Diatom di Muara Sungai Wulan, Demak. Diponegoro Journal of Maquares. 5(4):224-232.

Dionfriski, A., Sofyan, H.S., Irvina, N. (2021). Epipelic Diatom Community Structure in The Intertidal Zone Mengkapan Waters, Sungai Apit District, Siak Regency. Journal of Coastal and Ocean Sciences. 2(3):207-216.

Elisa, L.A. (2019). Kelimpahan dan Keanekaragaman Fitoplankton di Perairan Pesisir Holtekamp Kota Jayapura. Jurnal Biosilampari: Jurnal Biologi. 2(1): 6-15.

Fitriyah, Y., Bambang, S., & Niniek, W. (2016). Struktur Komunitas Diatom di Perairan Tandon Air untuk Tambak Garam di Desa Kedung Mutih Kecamatan Wedung, Demak. Diponegoro journal of Maquares. 5(2):11-16.

Hanum, C.A., Irma, D., & Chitra, O. (2016). Struktur Komunitas Perifiton pada Makroalga Ulva lactuna di Perairan Pantai Ulee Lheue, Bnada Aceh. Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah. 1(3): 337-347.

Haryo, D.I.(2013). Analisis Komponen Utama pada Hubungan Distribusi Spasial Komunitas Fitoplankton dan Faktor Lingkungan. Ilmu Kelautan. 18(1):14-19.

Hilmi, M.R., Fatrin, E.S.P., Meutia, S.F., Muhammad, F., & Riani, W. (2018). Analisa Kelimpahan Mikroalga Epifitik (Diatom dan Dinoflagellata) pada Makroalga Berdasarkan Perbedaan Faktor Lingkungan di Pulau Bintan, Kepulauan Riau. Pertemuan Ilmiah Nasional Tahunan XV ISOI 2018. Universitas Indonesia.

Holly, S.L., Kevin, B.J. (2014). The Effects of Fine-scale Substratum Roughness on Diatom Community Structure in Estuarine Biofilms. Biofouling : the Journal of Bioadhesion and Biofilm Research. 29(8) : 879-890.

Kamilah, F., Rachmadiarti, F., Indah, K.N. (2014). Keanekaragaman Plankton yang Toleran Terhadap Kondisi Perairan Tercemar di Sumber Air Belerang, Sumber Beceng Sumenep, Madura. Jurnal Lenterabio.3(3):226-231.

Muchtar, M. (2012).Distribusi Zat Hara Fosfat, Nitrat dan Silikat di Perairan Kepulauan Natuna. Jurnal Ilmu dan Teknologi Kelautan Tropis. 4(2) : 304-317.

Munandar, Yuli, E., Marzuki. (2017). Struktur Komunitas Fitoplankton di Pelabuhan Jetty Pasca Kegiatan Bongkar Muat Batubara Meulaboh Aceh Barat. Journal of Aceh Aquatic Sciences. 2(2): 1-17.

Ode, L. M. (2021). Perbandingan Kepadatan Bentik Diatom dan Mikroplastik pada Sedimen di perairan Teluk Kendari. Skripsi Program S1 Jurusan Manajemen Sumberdaya Perairan. Universitas HaluOleo. Kendari.

Padang, A., Niete, V.H., Rochman,S., Tekat, D.C. (2021). Benthic diatoms utilization as foodforthe sand sea cucumber (Holothuria scabra). Egyptian journal of aquatic biology and fisheries. 25(1):633-642.

Puji, R.A., Philip, T.I., & Gede,S.S. (2012). Kelimpahan Beberapa Jenis Mikroalga Diatom di Perairan Pulau Gumilamo-Magaliho, Halmahera Utara. Jurnal Ilmu dan Teknologi Kelautan Tropis. 4(1):97-106.

Robertus, F. G., Dwi, C.P., Erfan, R., Nurul, M., Dian, A., Aida, S. (2021). Struktur Komunitas Fitoplankton pada Perairan Mayangan Probolinggo, Jawa Timur. Journal of Fisheries and Marine Research. 5(1): 146-153.

Roito, M. (2014). Analisis Struktur Komunitas Diatom Planktonik di Perairan Pulau Topang Kabupaten Meranti Provinsi Riau. Jurnal Perikanan dan Kelautan. 19(4): 22-32.

Rozalina, Syahril, N., & Irvina, N. (2020). Analysis of Nitrate Concentration, Phosphate and Silicate Relationship with the Abundance of Planktonic Diatomin Meral Waters, Karimun District. Asian Journal of Aquatic Sciences. 3(1):60-68.

Rusmiati, Fadhliyah, I., Tri, A. (2020). Kelimpahan diatom bentikberdasrkan perbedaan tipe substrat diperairan pulau dompak kepulauan riau. Jurnal la'ot ilmukelautan. III(1):45-53.

Sachlan, M. (1982). Planktonologi. Correspondence course center. Direktorat Jenderal perikanan, departemen pertanian. Jakarta.

Saldanha, Bay. (2003). Phytoplankton Identification Catalogue-Saldanha Bay, South Africa, April 2001. Globallast Monograph Series No.7. Imo London.

Setyobudiandi, I., Rubal., E. Cacabelos., C. Maldonado., I. Sousa-Pinto. (2014). Spatial Variability of Macrobentic Zonation on Exposed Sandy Beaches. Journal of sea Research. 90: 1-9.

Sirait, M., Firsty, R., Pattulloh. (2018). Komparasi Indeks Keanekaragaman dan Indeks Dominansi Fitoplankton di Sungai Ciliwung Jakarta. Jurnal Kelautan. 11(1): 75-79.

Suwartimah, K., Widianingsih, Retno, H., & Sri, Y.W. (2011). Komposisi Jenis Dan Kelimpahan Diatom Bentik Di Muara Sungai Comal Baru Pemalang. Ilmu Kelautan. 16(1):16-23.

Ulfa, H., Ma'ruf, K., & Nur, I. (2020). Perbandingan Kepadatan dan Keanekaragaman Diatom (Bacillariophyceae) pada Thallus kappaphycus alvarenzii dan Eucheuma denticulatus pada Kedalaman Berbeda di Perairan Desa Tanjung Tiram Kecamatan Moramo Utara Kabupaten Konawe Selatan. Jurnal Manajemen Sumber Daya Perairan. 5(1):60-69.

Yulianto, D., Max, R.M., Pujiono, W.P. (2014). Tingkat Produktivitas Primer dan Kelimpahan Fitoplankton Berdasarkan Waktu yang Berbeda di Perairan Pulau Panjang, Jepara. Diponegoro Journal of Maquares.3(4) :195-200.

Yulma, Ihsan B., Sunarti, Malasari, E., Wahyuni, N., Mursyban. (2017). Identifikasi Bakteri pada Serasah Daun Mangrove yang Terdekomposisi di Kawasan Konservasi Mangrove dan Bekantan (KKMB) Kota Tarakan. Journal of Tropical Biodiversity and Biotechnology. 2(1): 28-33

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