The relationship between phytoplankton community structure and water conditions at Margagiri-Grenyang coastal waters, Banten Bay

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Abstract. Margagiri-Grenyang coastal waters are shallow water with substrate generally in the form of sandy mud that is busy with various activities, i.e. fishing, transportation, beach development for settlements, and industry. This can disrupt the stability of water conditions and the structure of the organism community in the bay. This study aimed to analyze the structure of phytoplankton communities, including the composition and abundance of types, diversity, evenness, and dominance indices, as well as their relationship with the water quality in these areas. This study was conducted for five months (July–November 2022) at six stations. The study showed that phytoplankton in these waters consisted of six classes and was dominated by the class Bacillariophyceae. *Chaetocheros* sp. and *Thallasionema* sp. were the genera commonly found in the waters. The values of the phytoplankton diversity, evenness, and dominance indices were 1.2733–2.5515, 0.3849–0.8003, and 0.1106-0.4912, respectively. Bacillariophyceae, Euglenophyceae,and Chrysophyceae appeared to be correlated with phosphate and total suspended solids (TSS).

1 Introduction

Banten Province is a new province resulting from the division of West Java Province, which was established through Law Number 23 of 2000 concerning the formation of the province Banten Bay is one of the bays in the Banten province [1] and faces the Java Sea to the north. It is bounded by Tanjung Piatu to the west and Tanjung Pontang to the east . The fishery potential in Banten Bay is quite high and varied [2], both for fish commodities (demersal, pelagic, and reef fish) and others such as shellfish, crab, and seaweed [2].

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Margagiri-Grenyang coastal water is one of the beaches in Bojonegara District (Serang Regency, Banten Province), and is busy with various industrial activities and steam power plants [3]. The disposal of waste heat directly into the water can also affect the condition of the water [4]. These two activities in Bojonegara waters can cause changes in water quality [1]. It is important to understand the changes in the aquatic environment (physical and chemical parameters) because these conditions play a beneficial role in aquatic organisms, one of which is phytoplankton [9], because they act as primary organisms [5]. Changes in physical and chemical environment parameters will affect the presence of phytoplankton.

An understanding of the stability of aquatic ecosystems and the community structure of phytoplankton relationships is important to determine environmental pressure, so that monitoring and management can be done more effectively [6]. It is necessary to study the phytoplankton community and its water environment conditions in Banten Bay. This research aims to study the community structure of phytoplankton based on its biological index and its relation to the water environment in the Banten Bay area.

2 Methods

2.1 Time and location

Phytoplankton sampling and water quality observations were conducted monthly for five months (July–November 2022) at six stations in the Margagiri-Grenyang coastal waters of Banten Bay and its surroundings (Figure 1).

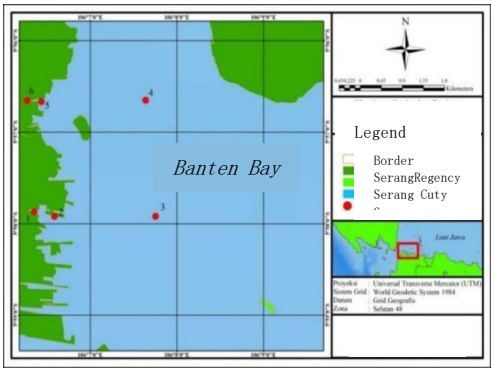

Fig. 1. Sampling location of the study on phytoplankton community structure and its environment at Margagiri-Grenyang coastal waters of Banten Bay.

2.2 Collecting data

A plankton net (mesh size of 45 μm) was used to obtain phytoplankton samples by filtering 70 liters of water to obtain a filtered volume of 65 ml. The sample (0.1 ml) was taken using a pipette, dripped on top of the SRC (Sedgewick Rafter Counter), and placed under a microscope at 10 × 10 magnification for cell counting. Plankton genera were identified using a plankton identification book [6].

Observations of water quality parameters, including dissolved oxygen (DO), pH, transparency, temperature, salinity, turbidity, total suspended solids (TSS), nitrate (NO_3), and total phosphate (PO_4), were carried out in situ and ex situ.

2.3 Data analysis

Phytoplankton abundance was calculated using the following formula [6] :

$$N = n\ x\ \frac{Vt}{Vd}\ x\ \left(\frac{1000\ mm^3}{L\ x\ D\ x\ W\ x\ S}\right)\ x\ Fp \quad (1)$$

Where,
N = abundance of plankton (cells/L)
n = average number of individuals per field of view (cells)
L = SRC length (mm)
D = SRC depth (mm)
W = SRC width (mm)
S = number of strips counted
Vt = concentrated water volume (mL)
f p = dilution factor

Phytoplankton data were analyzed to obtain ecological indices (diversity, evenness, and dominance). The diversity index shows genera diversity with an H' value of $1 \leq H' \leq 3$ [6]. The Shannon–Wiener equation was used to estimate plankton diversity.

$$H' = -\Sigma pi\ lnp_i,\ \ p_i = n_i/N \quad (2)$$

Where,
H' = diversity index
P_i = individuals proportion of the i-type (ni/N)
N = total of individuals number
n_i = individuals it-i numbers

Based on the above formula, the diversity index of the Shannon-Wiener is categorized as follows [6]. H'<2,3=low community diversity; 2,3<H'<6.9=moderate community diversity; H'>6,9=high community diversity.

The equation used to calculate the phytoplankton evenness index is based on the Shannon–Wiener formula [6].

$$E = \frac{H'}{H\ maks} \quad (3)$$

Where,
E = evenness index
H' = diversity index of Shannon Wiener
H_{max} = lnS

With the criteria [5]: E<0.4 = level of evenness of taxa is not even, 0.4<E<0.6 = level of evenness of taxa is quite even, E>0.6 = level of even distribution of taxa.

The dominance index of phytoplankton was calculated using the dominance index of Simpson [6].

$$C = \sum_{n=1}^{n} \quad (\frac{ni}{N}) \quad (4)$$

Where,
C = dominance index
N = individuals total number
n_i = individuals number it-i
n_i = the number of genera of phytoplankton

The relationship between water quality and phytoplankton community was analyzed using principal component analysis (PCA) by changing the original variables that are correlated with each other into new variables that are not correlated with each other. PCA serves to characterize the physical, chemical, and biological parameters of each group. In addition, this analysis explains the relationship between plankton abundance and water quality [5].

3 Results and discussion

3.1 Composition and abundance

Phytoplankton found at six stations during the study for five months at Margagiri-Grenyang coastal waters consisted of six phyla (39 genera), including Dinophyceae, Euglenophyceae, Chlorophyceae, Chrysophyceae, Cyanophyseae, and Bacillariophyceae. Most of the phytoplankton found on the Margagiri-Gren coast belonged to the Bacillariophyceae class. This condition is in accordance study conducted [11] that the Bacillariophyceae class is one of the dominant classes in the coastal waters of South Sulawesi. In marine waters, previous study states that Bacillariophyceae is one of the most common types of phytoplankton found [9] *Chaetocheros* sp and *Thallasionema* sp were the phytoplankton genera commonly found in the coastal waters.

Table 1. Phytoplankton genera found at the Margagiri-Grenyang coastal waters of Banten Bay.

Classes	Genera			
Dinophyceae	*Ceratium* sp.	*Dinophysis* sp.	*Noctiluca* sp.	*Peridium* sp.
	Prorosentrum sp.	*Pyrocyctis* sp.	*Gymnodium* sp.	
Euglenophyceae	*Euglena* sp.			
Chlorophyceae	*Ankistrodesmus* sp.	*Ulothrix* sp.	*Closterium* sp.	*Chlorella* sp.
Bacillarophyceae	*Bacteriastrum* sp.	*Biddulphia* sp.	*Chaetoceros* sp.	*Coscinodiscus* sp.
	Diploneis sp.	*Flagiraria* sp.	*Leptocylindrus* sp.	*Hemiaulus* sp.
	Melosira sp.	*Navicula* sp.	*Nitzschia* sp.	*Pleurosigma* sp.
	Rhizosolenia sp.	*Skeletonema* sp.	*Thalasionema* sp.	*Thalassiosira* sp.
	Thalassiotrix sp.	*Triceratium* sp.	*Synedra* sp.	*Coconeis* sp.
	Cyclotella sp.	*Eucampia* sp.	*Bacillaria* sp.	*Amphora* sp.
Chrysophyceae	*Distephanus* sp.	*Dictyocha* sp.		
Cyanophyceae	*Trichodesmium* sp.			

The phytoplankton that dominated each observation from July to November belonged to the class Bacillariophyceae. This is in accordance with the statement of Papantoniou a et al. [5] in this study, which stated that Bacillariophyceae is a class that dominates the waters owing to its ability to adapt to the aquatic environment, even with extreme conditions. Bacillariophyceae has a wide distribution in open ocean waters owing to the large number of genera. Bacillariophyceae has more reproductive capabilities than other classes of phytoplankton. This caused the abundance of Bacillariophyceae to be high [10]. According to this study, the abundance of phytoplankton varied for each month. The average abundance of phytoplankton from July to November at each station (Figure 2). Phytoplankton abundance

ranged from 3,898 cells/L to 38,110 cells/L. According to Rikardo et al. [11], an abundance value of 1000-40,000 ind/L is classified as medium to high.

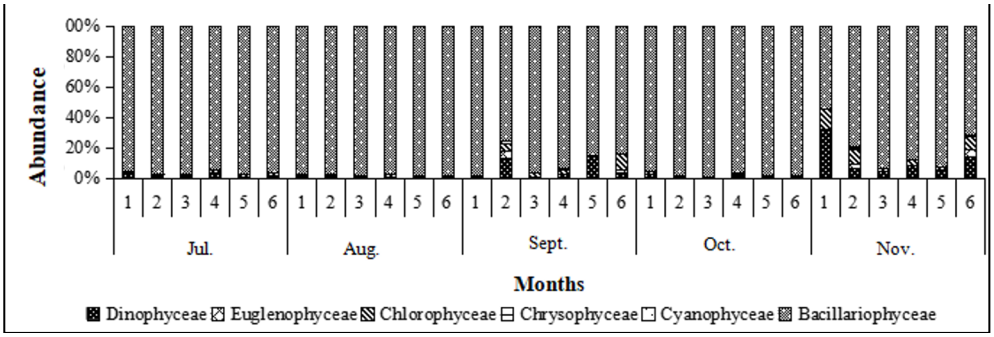

Fig. 2. Composition of the abundance and number of phytoplankton found in the Margagiri-Grenyang coastalwaterss of Banten Bay.

3.2 Biological indices

The diversity of genera is important to obtain as a basis for determining the community structure of phytoplankton. The values of ecological indices (diversity, evenness, and dominance) of the organism can be utilized to estimate the ecological conditions of the Margagiri-Grenyang coastal waters of Banten Bay. The phytoplankton diversity index ranged from 1.2733 to 2.5515. Based on the Shannon-Weaner plankton diversity index criteria [9], phytoplankton diversity in Margagiri waters was classified as moderate with a low distribution.

The evenness index of the phytoplankton ranged from 0.3849 to 0.8003. This range is classified into the medium-to-high category. The phytoplankton evenness index based on the Shannon-Weaner criteria was classified as moderate to high. According to [12] moderate phytoplankton uniformity indicates that these waters have the potential to dominate certain types of phytoplankton, thus causing unstable water conditions.

The dominance index of phytoplankton ranged from 0.1106 to 0.4912. This range was classified as low because the value was close to zero. The plankton dominance value was classified as close to zero. Based on the Shannon-Weaner criteria [9], the value of plankton dominance is low. When the dominance index is close to 1, this condition means that in the community there is a genus that dominates other genera; conversely, if it is close to 0, then there is no genus that dominates in the extreme.

This condition is in accordance with previous research [12]. *Chaetoceros* sp. is one of the most abundant types of microalgae in marine water. The high level of this type of phytoplankton does not produce toxins for water, but when blooming occurs, it irritates the gills of fish because it stimulates the formation of mucus, making it difficult for fish to breathe, which eventually causes death [13].

3.3 Water quality environemnt

Water quality environmental conditions at the Margagiri-Grenyang coastal waters were measured in-situ and ex-situ (Table 2). The temperature of Margagiri-Grenyang waters ranged from 29.2 to 29.9ºC. The salinity in the coastal waters for each station showed a value that was not significantly different, ranging only from 30 to 33 ppt. The pH of the coastal waters ranged from 7.40 to 7.46. The normal pH value for plankton life ranges from 7 to 8.5. Nitrate levels at all six stations ranged from 0.00 to 0.05 mg/L. Nitrate can produce a higher

number of phytoplankton [14]. Phosphate levels in the waters average between 0.02-0.10 mg/L, phosphate levels in these waters are high compared to phosphate levels in normal sea. However, the presence of phosphate did not exceed quality standards [14]. The low concentration of TSS in the waters does not cause any obstacles to the reach of sunlight penetrating the waters, so that the photosynthesis process carried out by autotroph biota is not disturbed [16]. The relationship between the water quality parameters and phytoplankton communities is shown in Figure 3.

Table 2 Water quality parameters observed at Margagiri-Grenyang coastal waters of Banten Bay.

Parameters	Units	Stations						Quality standard [26]
		1	2	3	4	5	6	
Temperature	˚C	29.2±1.1	29.4±0.9	29.7±1.2	29.7±0.6	29.9±1.0	29.9±0.8	28-32
Turbidity	NTU	7.2±2.6	8.6±3.6	7.1±2.5	8.1±1.1	8.2±10.8	8.4±12.6	5
TSS	mg/L	7.4 ±4.06	9.4±5.67	7.6±4.3	7.7±3.95	8.03±4.44	9.4±3.8	20
pH	-	7.4±0.4	7.2±0.1	7.5±0.4	7.4±0.3	7.5 ±0.3	7.45±0.3	7-8.5
DO	mg/L	5.4±1.2	5.8±1.1	6.7 ±1.2	6.6±0.7	6.6 ±0.1	5.49 ±0.7	>5
Salinity	ppt	31.0±3.1	32.0±2.2	33.2±2.4	32.4±2.3	31.4±2.1	30.6±4.6	Experience
NO_3	mg/L	0.03±0.01	0.04±0.01	0.04±0.01	0.04±0.01	0.04±0.01	0.02 ±0.02	0.06
PO_4	mg/L	0.02±0.03	0.03±0.03	0.04 ±0.05	0.02 ±0.02	0.02 ±0.03	0.10 ±0.18	-

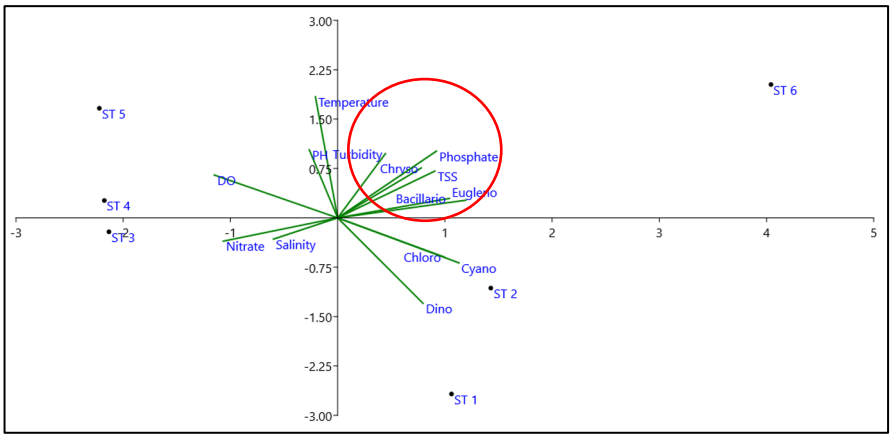

Fig. 3 PCA showing the water quality and phytoplankton relationship at Margagiri-Grenyang of Banten Bay.

4 Conclusion

Phytoplankton composition and abundance found in coastal waters of Margagiri-Grenyang (Banten Bay) consisted of six classes, with Bacillariophyceae being the most abundant genera. *Chaetocheros* sp and *Thallasionema* sp. were genera commonly found in the coastal waters. The diversity, evenness, and dominance indices of the organisms were 1.2733-2.5515; 0.3849-0.8003; and 0.1106-0.4912, respectively. Based on these values, the phytoplankton in Margagiri-Grenyang coastal waters is classified into a moderate category with even distribution and dominance on a small scale. Bacillariophyceae, Euglenophyceae, and Chrysophyceae appeared to be correlated with phosphate and total suspended solids.

References

1. E. Juniardi, S. Sulistiono, S. Hariyadi, A. Ervinia, D.M. Wildan, N. Rohim, A. Asriansyah, T. Hestirianoto, T. Nugroho, H. Thoha, N. Fitriyah, Plankton community in the sea waters around Panjang and Pamujan Besar islands, Banten Bay. IOP Conf. Series: Earth and Environmental Science. **1119**, 012008 (2022).
2. S. Sulistiono, D.M. Wildan, A. Ervinia, N. Rohim, D.A. Hedianto, F. Baihaqi, D. Abdillah, I.N.Y. Parawangsa, G. Wahyudewantoro, M. Yokota, Diversity, distribution, and species status of the fish in Banten Bay, Indonesia. E3S Web of Conferences. **339**, 03003 (2022).
3. E. Kusumawati, I. Pratikto, P. Subardjo, Studi perubahan garis pantai di Teluk Banten menggunakan citra satelit landsat multitemporal. Journal of Marine Research. **3**, 4 (2014).
4. M.A. Safwan, S. Widodo, P. Subarjdo, Pengaruh arus sepanjang pantai terhadap sebaran sedimen dasar di Perairan Teluk Awur, Jepara. Jurnal Oseanografi. **5**, 4 (2016).
5. G. Papantoniou, Y. Cladas, V. Ketsilis-Rinis, Z. Vaitsi, N. Fragopoulu, Effects of HAB's and dystrophic event on zooplankton community structure in Mediteranian Lagoon. Estuarine, Coastal, and Shelf Science. **245**, 1 (2020).
6. Y. Yuan, M. Jiang, X. Liu, H. Yu,M.L. Otte, C. Ma, Y.G. Her, Environmental variables influencing phytoplankton communities in hydrologically connected aquatic habitats in the Lake Xingkai basin. Ecological Indicator. **91**, (2018).
7. [APHA] American Public Health Association, Standard Methods for the Examination of Water and Wastewater, Ed ke-23, (AWWA-American Water Works Association and WEF-Water Environment Federation, Washington DC, 2017).
8. H. Pratiwi, A. Damar, Sulistiono, Phytoplankton community structure in the Estuary of Donan River, Cilacap, Central Java, Indonesia. Biodiversitas. **19,** 6 (2018).
9. S.R. Samudra, S.F. Islami, D. Sanjayasari, A.M. Firdaus, A.K. Putri, N. Fikriyya, A.N. Attaqi, Phytoplankton community structure in PB. Soedirman Reservoir, Banjarnegara District, Central Java, Indonesia. Biodiversitas. **25**, 5 (2024).
10. A. Sartimbul, E. Trishnayana, E. Rohadi, N. Muslihah, O.M. Lutfi, F. Iranawati, L.I. Harlyan, E. Wulandari, A.B. Sambah, Plankton's abundance and its implications for *Sardinella lemuru* catch in Prigi waters. IOP Conf. Series: Earth and Environmental Science. **763**, 012049 (2021).
11. H.A. Lestari, M.F. Samawi, A. Faizal, A.M. Moore, J. Jompa, Diversity and Abundance of Phytoplankton in the Coastal Waters of South Sulawesi. Hayati. **28,** 3 (2021).
12. A. Rachman, Checklist and estimation of total number of phytoplankton species in Pari, Tidung, and Payung Islands, Indonesia. Biodiversitas. **21**, 6, (2020).
13. A. Choirun, S.H.J. Sari, F. Iranawati, Phytoplankton Harmfull Algae Bloom (Hab) Identification during Tide Period in Brondong Coastal Waters, Lamongan, East Java. Jurnal Ilmu Kelautan dan Perikanan. **25,** 2 (2015).
14. J.M. Miró, C. Megina, I. Donázar-Aramendía, M.J. Reyes-Martínez, J.E. Sánchez Moyano, J.C. García-Gómez, Environmental factors affecting the nursery function for fish in the main estuaries of the Gulf of Cadiz (south-west Iberian Peninsula). Science of The Total Environment. **737**, 139614 (2020).
15. P.M. Chapman, A. Hayward, J. Faithful, Total suspended solids effects on freshwater lake biota other than fish. Bulletin of Environmental Contamination and Toxicology. **99,** 4 (2017).