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Composition, Abundance, and Distribution of Phytoplankton at Fitu Waters Ternate of North Maluku in Indonesia

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ABSTRACT

Fitu waters are ecologically and economically a potential area in Ternate City of North Maluku Province, which can be used to develop marine tourism, fishing locations, and aquaculture. However, there is a lack of information on the condition of Fitu waters. This study aimed to analyze the species composition, abundance, and distribution of phytoplankton. The study was conducted in March-April 2023 at 5 stations with a sampling period fortnightly. A filtration method was used to collect the phytoplankton preserved in 4% Lugol's solution. The results showed 51 genera belonging to the classes Bacillariophyceae (36 genera), Chlorophyceae (2 genera), Cyanophyceae (7 genera), and Dinophyceae (6 genera). The abundance of phytoplankton ranged from 47,560 to 232,545 cells.L-1. The Bacillariophyceae class had a broader distribution compared to the other classes. For the ecological indices, the diversity index (H') was 1.9208 - 2.5616, the evenness index (E) was 0.6780 - 0.8764, and the dominance index was 0.0925 - 0.2597.

INTRODUCTION

Coastal and marine resources have a great potential to be developed from an economical and ecological standpoint. This area has a variety of potential and beneficial organisms for the waters concerned and for other stakeholder purposes **(Mutmainnah & Yuliana, 2023)**. An important category of the biota in this area is the phytoplankton.

Phytoplankton are considered an organisms that have a crucial role in supporting the life cycle in coastal areas **(Yuliana *et al*., 2023)**. It can be used as study materials to monitor the water quality by observing its type of composition and abundance **(Rashidy *et al*., 2013)** and to determine the fertility rate or healthy condition of the waters **(Nurmalitasari & Sudarsono, 2023)**. This is necessary to support the utilization and management of coastal and marine resources. There is a positive relationship between the abundance of phytoplankton and the water fertility rate. A higher abundance of phytoplankton means higher productivity in the waters **(Raymont, 1980)**.

The abundance and composition of phytoplankton in various waters will indicate a diversity of numbers and types. They may be in relative proximity and originate from the same water mass due to the influence of various factors that cause the differences **(Davis, 1955)**. A similar phenomenon also occurs in Fitu waters, where differences in species composition and abundance of phytoplankton are caused by the input load received and the influence of various physicochemical parameters in these waters. Fitu waters is located in the south of Ternate, which has a strategic location and has an important role in supporting the economy of Ternate residences. Fitu waters are one of the areas that can be used for the development of marine tourism, fishing locations, and marine culture in North Maluku. A comprehensive study providing a database on the current condition for the economic development of the region is necessarily needed. Related to this, data on the phytoplankton community are one of the main information to provide. The presence of phytoplankton in an area may inform the water condition **(Isnaini, 2012)**. However, a lack of information is presented on Fitu water. Currently, only the structure community of zooplankton has been researched by **Yuliana and Mutmainnah (2021)**. Therefore, a study about species composition, abundance, and distribution of phytoplankton to support the continuity of aquatic resources is important to be conducted.

The purpose of this study was to analyze the species composition, abundance, and distribution of phytoplankton in Fitu waters of Ternate City of North Maluku province.

MATERIALS AND METHODS

This research was conducted in March-April 2023 at 5 located stations (Fig. 1). Sampling was carried out 4 times, with a sampling period fortnightly (05^{th} March 2023, 19^{th} March 2023, 02^{nd} April 2023, and the 16^{th} April 2023).

Phytoplankton specimens were taken by filtering 30 liters of water samples using a 25µm phytoplankton net. The filtered samples were put into a sample bottle and preserved using 4% Lugol's solution. Samples were identified based on the identification keys of **Davis (1955)**, **Tomas (1997)**, and **Yamaji (1979)**.

The abundance of phytoplankton species was calculated based on the formula described by the **APHA (2005)** as follows:

$$N = \frac{O_i}{O_p} \times \frac{V_r}{V_o} \times \frac{1}{V_s} \times \frac{n}{p} \qquad (1)$$

Where, N = Number of individuals per liter
Oi = Area of the cover glass (mm^2)
Op = Area of one field of view (mm^2)
Vr = Volume of filtered water (ml)
Vo = Observed volume of water (ml)
Vs = Filtered water volume (L)
n = Total plankton in the entire field of view
p = Number of visual fields observed

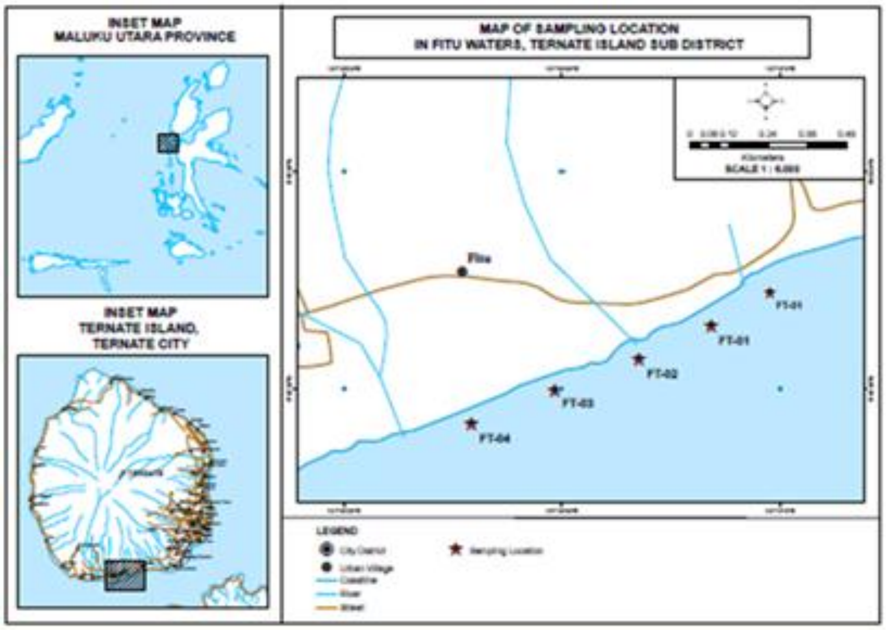


Fig. 1. Research locations in the Fitu waters at Ternate of North Maluku, Indonesia

The species diversity index was calculated using the Shannon-Wiener index, and the evenness index and dominance index were calculated using the following formulas from **Odum (1998)** as follows:

1. Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{s} \left({}^{ni}/_{N}\right) \ln\left({}^{ni}/_{N}\right) \tag{2}$$

2. Evenness index

$$E = {}^{H'}/_{H_{max}} \tag{3}$$

3. Dominance index:

$$D = \sum_{i=1}^{s} \left({}^{ni}/_{N}\right)^2 \tag{4}$$

Where,
- H’ = Shannon-Wiener diversity index
- E = Evenness index
- D = Simpson dominance index
- ni = Number of individuals of genus i
- N = Total number of individuals of all genera
- H_{max} = Maximum diversity index (= ln S, where S = Total type)

The obtained data during the research were analyzed descriptively and presented in the form of tables and graphs. To facilitate data analysis, SPSS IBM 23, Minitab 16, and Excel Stat 2017 software tools were used.

RESULTS

1. The composition of phytoplankton

Species composition is a qualitative parameter that describes the relative distribution of organisms in a community. Based on the study conducted, 49 genera were found from 4 classes, namely Bacillariophyceae (36 genera), Chlorophyceae (2 genera), Cyanophyceae (5 genera), and Dinophyceae (6 genera). The complete composition of phytoplankton types is presented in Table (1). In addition, the genera that had high abundance during the study are presented in Fig. (2). Moreover, the contribution of each class of phytoplankton in Fitu waters is known by means of percentages. The percentage of each phytoplankton class is shown in Fig. (3). Meanwhile, the spatial and temporal abundance of the phytoplankton community during the study in Fitu waters is presented in Fig. (4).

Table 1. The composition of phytoplankton during research in the Fitu waters of Ternate, North Maluku, Indonesia

Class	Order	Family	Genus
Bacillariophyceae	Centrales	Melosiraceae	*Melosira*
		Skletonemaceae	*Skeletonema*
			Stephanopyxis
		Leptocylindraceae	*Dactyliosolen*
			Leptocylindrus
		Thalassiosiraceae	*Lauderia*
			Thallassiosira
		Coscinodiscaceae	*Cossinodiscus*
		Rhizosoleniaceae	*Rhizosolenia*
		Bacteriastraceae	*Bacteriastrum*
		Chaetoceraceae	*Chaetoceros*
		Biddulphiaceae	*Biddulphia*
			Triceratium
			Cerataulina
			Hemiaulus
		Eucampiaceae	*Eucampia*
	Pennales	Fragilariaceae	*Fragilaria*
			Asterionella
		Tabellariaceae	*Diatoma*
			Rhabdonema
			Licmophora
			Climocosphenia

			Plagiogramma
		Achnanthaceae	*Cocconeis*
			Campyloneis
		Naviculaceae	*Navicula*
			Diploneis
			Gyrosigma
			Pleurosigma
		Nitzschiaceae	*Nitzschia*
			Amphiprora
		Surirellaceae	*Surirella*
			Campylodiscus
	Bacillariales	Bacillariaceae	*Bacillaria*
	Hemiaulales	Bellerocheacae	*Streptotheca*
			Bellerochea
Chlorophyceae	Zygnematales	Zygnemataceae	*Spirogyra*
	Chlorococcales	Chlorococcaceae	*Tetraedron*
Cyanophyceae	Oscillatoriales	Oscillatoriaceae	*Trichodesmium*
			Oscillatoria
			Pelagothrix
			Skujaella
	Nostocales	Nostocaleae	*Anabaena*
Dinophyceae	Prorocentrales	Prorocentraceae	*Prorocentrum*
	Dinophysiales	Dinophysiaceae	*Dinophysis*
			Noctiluca
	Gonyaulacales	Gymnodiniceae	*Gymnodinium*
			Gonyaulax
	Peridinales	Peridineaceae	*Peridinium*

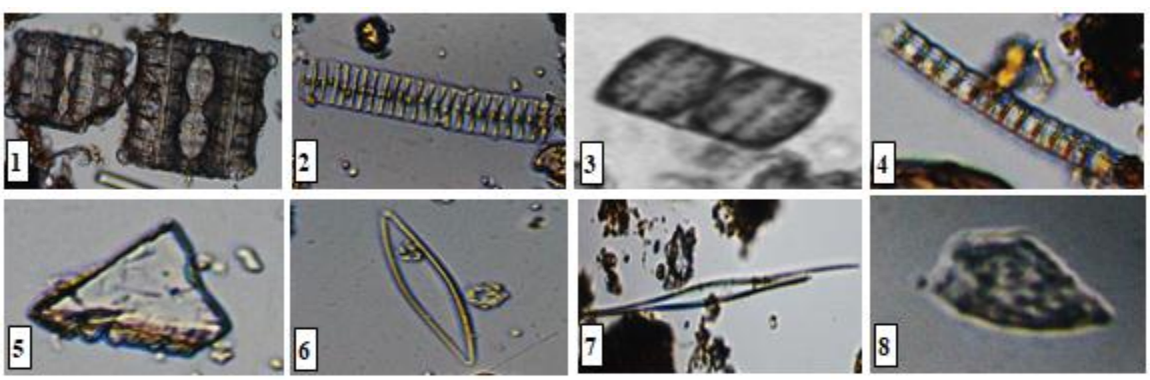


Fig. 2. The genera of phytoplankton that had high abundance during research in the Fitu waters at Ternate of North Maluku, Indonesia: (1) *Biddulphia*, (2) *Oscillatoria*, (3)

Melosira, (4) *Trichodesmium*, (5) *Triceratium*, (6) *Pleurosigma*, (7) *Nitzschia*, and (8) *Gymnodinium*

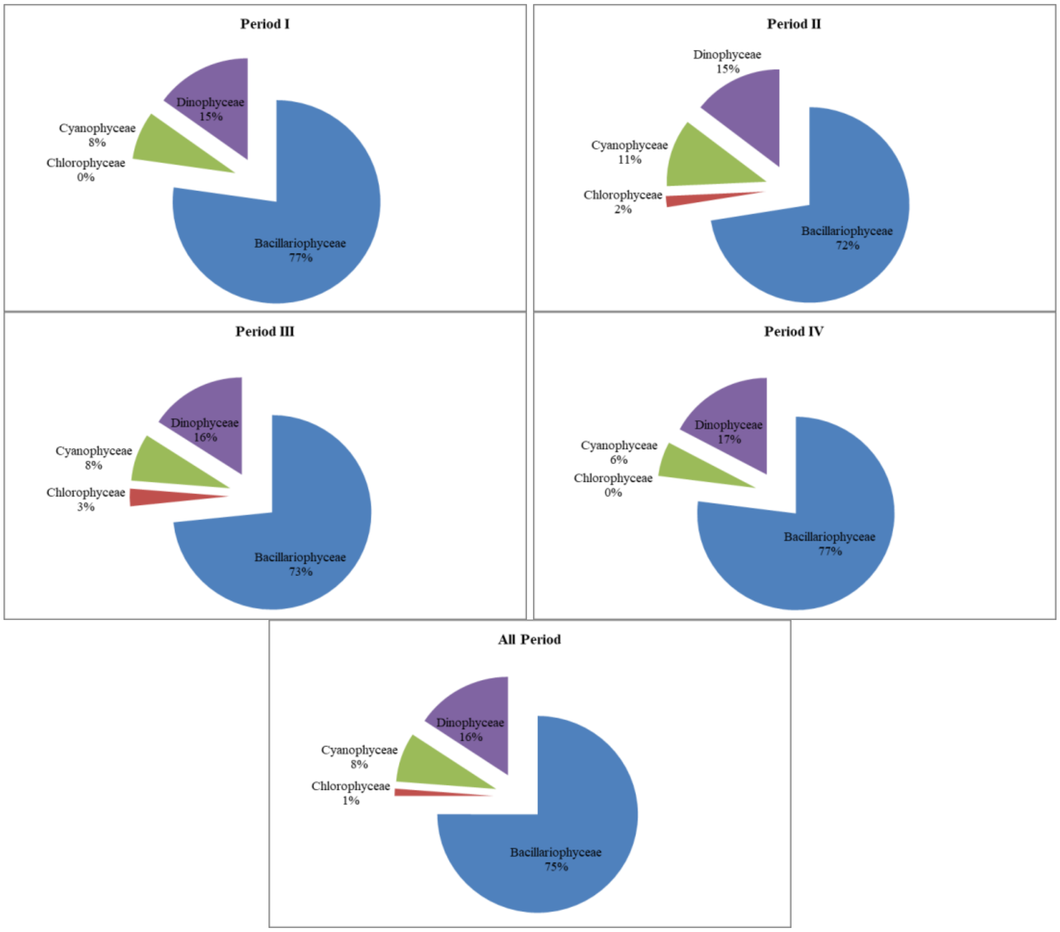


Fig. 3. The percentage of phytoplankton classes found in Fitu waters at Ternate of North Maluku, Indonesia.

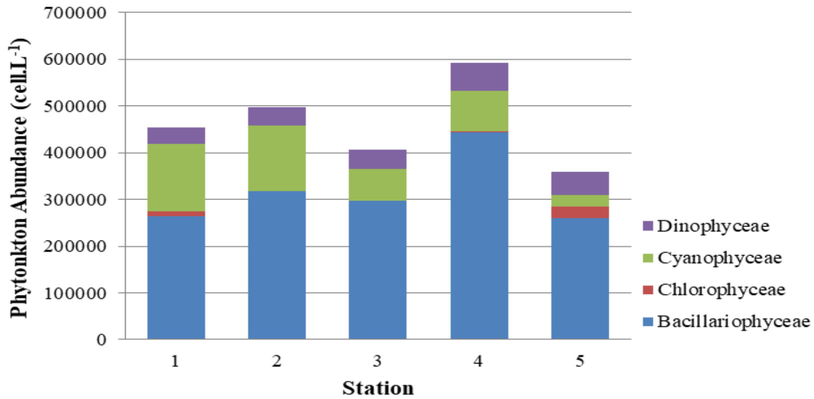
2. The abundance of phytoplankto

The abundance of phytoplankton found during the study varied between each station and time of observation, ranging from 47,560 - 232,545 cells.L-1. Complete phytoplankton abundance data are presented in Table (2).

Table 2. The abundance of phytoplankton (cells.L-1) during research in the Fitu waters of Ternate, North Maluku, Indonesia

Station	Observation time				Average
	Period I	Period II	Period III	Period IV	
1	125,732	120,739	120,608	87,500	113,645
2	152,271	96,565	96,828	152,271	124,484
3	66,216	169,482	70,552	99,456	101,426
4	47,560	141,104	232,151	172,241	148,264
5	72,260	92,098	120,871	73,179	89,602

Average	92,808	123,998	128,202	116,929



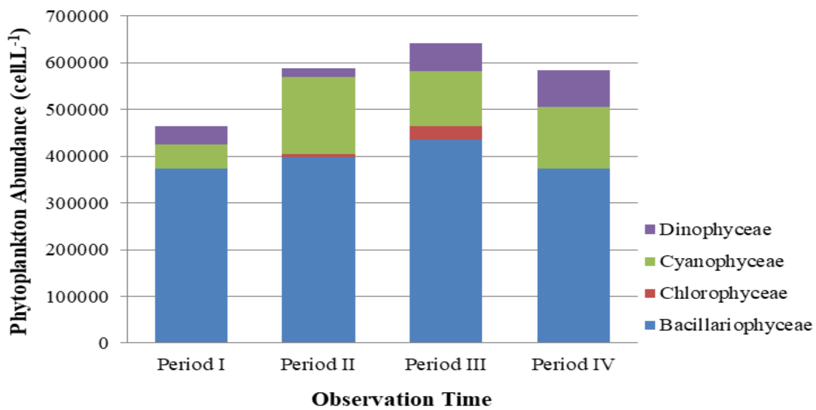


Fig. 4. The abundance of phytoplankton at each station (top) and observation period (bottom) in the Fitu waters of Ternate North Maluku, Indonesia.

3. Distribution of phytoplankton

During the research it was found that, each genus of phytoplankton had a different distribution, some were found at all stations during the study, and some were only found once. The complete distribution of phytoplankton in Fitu waters is presented in Table (3).

Table 3. Distribution of phytoplankton in the Fitu waters of Ternate, North Maluku, Indonesia

Genera	Observation time																			
	Period I					Period II					Period III					Period IV				
	Station					Station					Station					Station				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Bacillariophyceae																				
Amphiprora	21	-	-	-	-	-	-	-	-	8	-	16	-	-	-	-	-	-	-	-
Asterionella	4	-	-	-	9	82	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Bacillaria	21	40	8	-	13	-	-	-	-	-	-	30	36	120	7	69	158	76	79	76
Bacteriastrum	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	1	-	-
Bellerochea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	-
Biddulphia	120	277	116	33	80	9	13	415	292	210	99	79	120	675	128	44	42	135	510	138
Campylodiscus	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Campyloneis	-	-	-	-	-	-	-	-	-	-	-	1	3	4	2	-	-	4	1	-
Cerataulina	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetoceros	-	-	-	-	-	5	-	-	13	3	-	-	-	-	-	-	-	-	-	-
Climocosphenia	-	-	-	3	2	-	8	20	12	3	26	7	5	17	3	-	-	7	23	6
Cocconeis	-	-	-	-	-	-	4	2	2	-	-	2	1	3	2	1	1	-	2	4
Cossinodiscus	13	24	12	17	22	13	18	32	27	26	16	24	63	79	51	13	10	15	34	20
Dactyliosolen	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diatoma	50	50	31	5	2	41	10	78	79	34	15	19	6	57	32	5	-	6	18	12
Diploneis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Eucampia	-	-	-	-	-	-	-	1	-	4	8	-	-	10	-	-	-	-	-	-
Fragilaria	-	379	-	39	4	-	-	-	-	4	-	19	-	-	-	35	17	-	26	-
Gyrosigma	6	-	6	2	-	-	-	-	-	2	8	-	-	-	-	-	-	-	-	-
Hemiaulus	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Lauderia	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptocylindrus	10	-	-	-	-	-	-	-	10	-	24	-	10	7	-	-	15	2	2	2
Licmophora	62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melosira	80	55	45	46	96	60	98	109	77	109	60	40	64	100	47	60	51	35	57	32
Navicula	-	11	6	1	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Nitzschia	138	56	53	25	32	44	42	65	34	20	28	25	13	9	58	58	62	50	31	24
Plagiogramma	-	-	-	-	-	-	-	-	-	-	14	-	43	66	17	4	11	27	6	5
Pleurosigma	-	27	55	24	47	21	56	85	62	54	41	73	62	86	144	-	47	61	120	66
Rhabdonema	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Rhizosolenia	61	36	17	7	17	19	15	23	10	6	5	3	16	15	20	6	6	8	10	4
Skeletonema	102	10	27	2	18	60	53	21	30	-	60	18	-	13	10	-	-	-	-	-
Stephanopyxis	-	5	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-
Streptotheca	-	-	-	24	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Surirella	23	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallassiosira	-	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-	3	-	17
Triceratium	27	30	21	19	65	45	114	63	79	32	65	65	14	120	56	105	81	37	85	53
Chlorophyceae																				
Spirogyra	-	-	-	-	-	-	-	-	7	36	75	-	-	-	155	-	-	-	-	-
Tetraedron	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Cyanophyceae																				
Anabaena	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oscillatoria	-	-	12	-	-	443	138	180	113	58	-	58	-	16	68	119	551	157	163	17
Pelagothrix	-	-	-	-	-	-	-	-	-	-	169	-	-	-	-	-	-	-	-	-
Skujaella	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-	-
Trichodesmium	175	95	20	50	33	18	53	125	93	20	166	181	28	205	-	-	-	-	-	-
Dinophyceae																				
Dinophysis	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Gonyaulax	10	14	3	-	11	3	14	4	12	-	3	11	2	43	28	30	27	21	15	18
Gymnodinium	-	-	16	11	24	36	51	46	58	42	26	58	30	85	53	59	54	63	81	53
Noctiluca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Peridinium	21	19	36	47	72	18	20	19	40	16	9	8	14	37	38	58	26	49	31	10
Prorocentrum	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amount	957	1159	504	362	550	919	735	1290	1074	701	918	737	537	1767	920	666	1159	757	1311	557

Note: - = not detected

4. Physicochemical parameters

The complete results of measurements of the physicochemical parameters of Fitu waters are displayed in Table (1).

Table 4. Physicochemical parameters during research in the Fitu waters of Ternate, North Maluku, Indonesia

Observation time	Station	Parameters					
		pH	**Temperature (^{o}C)**	**Salinity**	**Nitrate ($mg.L^{-1}$)**	**Phosphate ($mg.L^{-1}$)**	**Silica ($mg.L^{-1}$)**
Period I	1	7.9	28.7	35	0.0718	0.0235	5.6738
	2	7.6	29.1	35	0.0441	0.0115	5.1159
	3	7.7	29.1	35	0.0341	0.0180	3.0987
	4	7.7	29.1	35	0.1157	0.0279	4.0429
	5	8.3	29.0	35	0.1726	0.0303	3.0558
Period II	1	7.7	28.6	31	0.0603	0.0228	5.1588
	2	7.8	29.3	30	0.0256	0.0260	5.6738
	3	7.4	29.1	32	0.0233	0.0177	2.7554
	4	7.6	28.9	30	0.0210	0.0186	2.9700
	5	7.5	28.8	30	0.0218	0.0158	2.3262
Period III	1	7.8	28.5	31	0.0533	0.0235	7.7339
	2	7.7	29.0	30	0.0549	0.0180	4.3863
	3	7.6	29.3	30	0.0479	0.0110	3.6137
	4	7.7	29.3	30	0.2696	0.0350	8.4635
	5	7.7	29.4	30	0.0526	0.0210	7.0043
Period IV	1	8.1	29.1	31	0.0549	0.0228	8.6781
	2	8.0	29.8	30	0.0418	0.0122	4.0429
	3	7.8	29.2	30	0.0503	0.0228	7.3906
	4	7.8	29.6	30	0.0549	0.0167	5.5021
	5	7.7	29.1	30	0.0533	0.0165	6.2747

5. Ecological indices of phytoplankton

Several ecological indices were measured including diversity index (H'), evenness index (E), and dominance index (D), which can be seen in Table (5). These index values describe the species richness in a community and the balance of the number of individuals on each species.

6. The correlation between the phytoplankton abundance with the physicochemical

The correlation between phytoplankton abundance and water physicochemical parameters was carried out using Pearson correlation analysis. The complete analysis results are presented in Table (6).

Table 5. Ecological indices of phytoplankton at each station and observation period in the Fitu waters of Ternate in North Maluku, Indonesia

Observation time	Station	Ecological indices		
		H'	E	D
Period I	1	2.5252	0.8294	0.1026
	2	2.1521	0.7596	0.1823
	3	2.5413	0.8792	0.1044
	4	2.5331	0.8764	0.0925
	5	2.4721	0.8553	0.1039
Period II	1	1.9691	0.6950	0.2591
	2	2.4929	0.8625	0.1050
	3	2.2422	0.7615	0.1554
	4	2.5110	0.8008	0.1194
	5	2.3749	0.7801	0.1415
Period III	1	2.5363	0.8331	0.1048
	2	2.5082	0.8372	0.1114
	3	2.4585	0.8350	0.1116
	4	2.2489	0.7387	0.1823
	5	2.5293	0.8443	0.0992
Period IV	1	2.3610	0.8718	0.1084
	2	1.9078	0.6881	0.2610
	3	2.4205	0.8221	0.1141
	4	2.1743	0.7258	0.1918
	5	2.3979	0.8296	0.1226

Description : H '= Diversity index, E = Evenness index, and D = Dominance index

Table 6. Pearson correlation value between phytoplankton abundance and water physicochemical parameters in the Fitu waters of Ternate in North Maluku, Indonesia

Parameter	Nitrate	Phosphate	Silica	pH	Temperature	Salinity
Abundance of Phytoplankton	0.305	0.083	0.258	-0.186	0.235	-0.261

**. Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

The number of phytoplankton genera found during research in Fitu waters is categorized as higher than other similar studies near the sampling site. **Yuliana *et al*. (2021)** found 32 genera in Sasa waters; **Yuliana *et al*. (2023)** collected 27 genera in Kastela waters, and **Ramili *et al*. (2023)** detected 24 genera in Ternate waters. However, those numbers are lower than those recorded in other studies on different waters, such as Jakarta bay recorded 62 genera **(Nastiti & Hartati, 2013)**, Lusi Sidoarjo Island registered 53 species **(Rahmadani & Kuntjoro, 2021)**, and Bantul regency detected 54 species **(Nurmalitasari & Sudarsono, 2023)**.

The high category of phytoplankton genera in Fitu waters indicates some factors influencing the growth, development, and reproduction are in a relatively proper condition for these organisms. The crucial factors for the growth and survival of phytoplankton are light intensity and nutrients. At the study site, sunlight is not a limiting factor because the position is closed by the equator, which is around $0^{O}45$ NL (Fig. 1). Likewise, activities around the study site, such as fish rearing in the net cages and seaweed culture, are potentially considered to become nutrients input mainly for N, P, and Si.

Bacillariophyceae has the largest number of genera compared to other phytoplankton classes. There are 36 genera, which are dominant in marine waters (Table 1). This is similar in South Sulawesi waters **(Lestari *et al.*, 2021)**, in the waters of the west coast of South Sulawesi **(Tambaru *et al.*, 2021)**, and in the waters of Tiwoho Village, north Minahasa **(Rimper *et al.*, 2023)**. Another study by **Yuliana (2015)** in Jailolo waters of West Halmahera found that the Bacillariophyceae class has the most species. This is caused by this species being more tolerable and adaptable in wider water conditions in supporting their survival rate **(Dewanti *et al*., 2018; Arazi *et al*., 2019; Aryawati *et al*., 2021)**. In addition, they are easily adaptable to extreme environments **(Zulfandi *et al*., 2014)**. The advantage of Bacillariophyceae is that they are the main constituent of microalgae in marine waters, and has high reproductive capabilities compared to other classes of phytoplankton **(Aryawati & Thoha, 2011).**

The other class is Chlorophyceae. Only 2 genera were observed since these types are usually found abundantly and dominantly in fresh waters. One allegation is that the presence of the Chlorophyceae class in the research location is caused by land-based runoff. It may carry Chlorophyceae through the river flow into the ocean.

The percentage of Bacillariophyceae is higher than other phytoplankton classes during observation periods, which is around 72- 77% (Fig. 3). The lowest percentage is Chlorophyceae with approximately only 2- 3%, and it is not even found in periods I and IV (Fig. 3). According to **Yuliana *et al*. (2023)**, the percentage of Bacillariophyceae in Kastela Water is 79- 90%, while the research done by **Katili and Kasim (2022)** revealed 93- 99% in Tanjung Casuarina Sorong beach. In contrast, the results of **Kadim *et al*. (2018)** found that the Chrysophyceae class is more dominant than other classes, with a percentage of 63.3% in Gorontalo bay. Furthermore, **Lestari *et al.* (2021)** reported that Dinophyceae consitituted 41% in Pangkep regency and classified it as the highest percentage among the categories.

In general, the contribution of each class of phytoplankton for the whole observation period shows 75% and Chlorophyceae is only 1% (Fig. 3). The dominance of the Bacillariophyceae class indicates that the environmental conditions of Fitu waters are suitable for these types, which can be seen from the proper growth compared to other types, such as Chlorophyceae, Cyanophyceae, and Dinophyceae. In addition, the Bacillariophyceae class has broader adaptability to the environmental conditions changes in marine waters. Another advantage is that they are cosmopolitan and have been described as the most abundant class of phytoplankton that is commonly found in Indonesian waters **(Sachlan, 1982)**. According to **Samiaji (2015)**, they can live and breed in various polluted water conditions and can adapt to nutrient content alteration and limited light.

The abundance of phytoplankton obtained during the study is categorized as higher composition than that recorded in the previous study of **Fitrianti *et al*. (2022)** on the Coastal waters of the Batang PLTU Megaproject, recording an abundance of 2,581-10,137 cells.L-1 and the research of **Yuliana *et al*. (2023)** on Kastela waters, which obtained an abundance value ranges of 17,549 - 71,021 cells.L-1. However, the result found is lower than that registered in a study **(Meirinawati & Fitriya, 2018)** on Halmahera Maluku, with values ranging from 721,500 - 9,100,000 cells.L^{-1}, or that conducted on Bangka island which revealed 286,000 - 318,000 cells.$L^{-1,}$ and the value recorded for Tanah Merah waters with an abundance of 188,000 - 200,000 cells.L^{-1} **(Yusuf *et al.*, 2021)**.

The highest abundance was discovered at station 4 period III with a value of 232,545 cells.L^{-1} and the lowest at station 4 period I with a value of 47,560 cells.L^{-1} (Table 2). Physico-chemical parameters of the waters particularly N, P, and Si are supported by the growth, development, and reproduction, as well as several other parameters such as temperature, salinity, and pH. Nitrate and phosphate elements in the waters are known to become the limiting factors for phytoplankton growth since they are crucial in cell membrane forms **(Nontji, 2006)**. While, silica is needed for the formation of phytoplankton cell walls **(Nontji, 2008)**. The content of each of these nutrients is nitrate (0.2696mg.L^{-1}), phosphate (0.0350mg.L^{-1}), and silica (8.4635mg.L^{-1}) (Table 4). The nitrate concentration is the optimal range. This is in accordance with what was stated by **Mustofa (2015)** that the optimum value of nitrate for phytoplankton is 0.09 - 3.5mg.L^{-1} **)**. According to **Pugesehan (2010)**, nutrient concentrations can affect the abundance of phytoplankton and conversely, dense phytoplankton reduces nutrient concentrations in the water. Thus, it is suspected that the available nitrate had been consumed by the phytoplankton to maintain their metabolism activities during sampling dates. Similarly, phosphate concentration obtained lower results. **Sumardianto (1995)** and **Fajar *et al*. (2016)** mentioned that phytoplankton requires an orthophosphate content of around 0.08 - 1.8mg.L^{-1} or 0.27 - 5.51mg.L^{-1} for optimal growth. Lower phosphate might have been utilized by phytoplankton at the measurement time; however, it still promotes its growth. Silica concentration is within the range required by phytoplankton for its growth and development. Based on Turner's statement (1980) in **Widjaja *et al*., (1994**), phytoplankton, especially diatoms, cannot develop properly when silica is below $0.5mg.L^{-1}$. Water quality parameters are in the optimal range, particularly temperature (29.3^oC), salinity (30ppt), and pH (7.7) (Table 4). For the growth rate of phytoplankton, some references stated the optimum salinity is 25 - 32 ppt **(Nybakken, 1992)**, the optimal temperature is 20 - 32^oC **(Effendi, 2003; Kusumaningtyas *et al*., 2014; Kadir *et al*., 2015**), and the optimal pH value range is 7 - 8.5 **(Berge *et al*., 2010)**.

The lowest abundance at station 4 period I is subjected to current flow at the sampling time. Although current is mentioned as one of the determinants of the abundant level and distribution pattern of phytoplankton, a stronger current may reduce the availability of specific types of phytoplankton. Plankton distribution is affected by the speed of the current because the movement and float are related to the current **(Aramita *et al*., 2015)**. Further explanation by **Giyanto *et al.* (2017)** reported that, currents will carry phytoplankton and nutrients in line with the speed and current pattern. In addition, the low abundance of phytoplankton is caused by grazing of zooplankton, as phytoplankton is the main food for zooplankton. Hence, there is a negative correlation between phytoplankton and zooplankton **(Yuliana *et al*., 2021)**.

In spatial and temporal measurement, Bacillariophyceae has the highest average abundance, followed by Cyanophyceae, Dinophyceae, and Chlorophyceae (Fig. 4). Chlorophyceae has the lowest average abundance and is not even found at stations 2 and 3, as well as during periods I and IV (Fig. 4).

Genus *Biddulphia* (Fig. 2) from class Bacillariophyceae showed the highest abundance, and genera *Campylodiscus*, *Diploneis*, *Rhabdonema* (class Bacillariophyceae), *Tetraedron* (kelas Chlorophyceae), and *Noctiluca* (class Dinophyceae) are the lowest ones, giving a result similar to that of **Yuliana *et al*. (2023)** in respect to Kastela waters. This finding is in contrast with that of **Lestari *et al.* (2021)** who conducted a study on the coast of South Sulawesi and recorded that the *Ceratium* genus had the highest abundance, as well as other research by **Meirinawati and Fitriya (2018)** on Halmahera Maluku waters, **Kadim *et al*. (2018)** on Gorontalo bay, and **Rahmah *et al*. (2022)** on the Sei Carang Tanjungpinang Estuary who found that the genus *Chaetoceros* was found as the dominant type of phytoplankton.

The distribution of phytoplankton during the study showed that phytoplankton has a different distribution between each genus. Only a few genera are found at all stations and observation times. Those genera are belonging to the class Bacillariphyceae (*Biddulphia*, *Cossinodiscus*, *Melosira*, *Nitzschia*, *Rhizosolenia*, and *Triceratium*), and the class Dinophyceae (*Peridinium*) (Table 3). This indicates that those genera have a wide distribution and a high ability to adapt to the environmental conditions of Fitu waters. The genera found only once during the study are *Bellerochea*, *Campylodiscus*, *Cerataulina*, *Diploneis*, *Hemiaulus*, *Lauderia*, *Licmophora*, and *Rhabdonema* from Bacillariophyceae class; *Tetraedron* from Chlorophyceae class; *Anabaena*, *Pelagothrix*, and *Skujaella* from Cyanophyceae class; *Dinophysis*, *Prorocentrum*, and *Noctiluca* from Dinophyceae class (Table 3). This phenomenon illustrates that these genera are not able to adjust to relatively unstable water conditions during the study.

From Table (3), class Bacillariophyceae has a wider distribution than other types of phytoplankton from other classes. This indicates that the physical and chemical parameter conditions of Fitu waters are suitable for the growth and development of Bacillariophyceae, even for the limited nutrient supply from the land **Yuliana *et al*. (2023)**. Bacillariophyceae class has a fairly large number of genera, and this class is a unicellular microalga with a universal distribution in entire water types **(Samiaji, 2015; Putri *et al*., 2019)**. This class is characterized by having a wide distribution and playing an important role in marine waters, and it is very tolerant to environmental condition alterations **(Munthe *et al*., 2012; Tungka *et al*., 2016)**. In addition, it has a very fast response to the addition of nutrients compared to genera from other classes **(Nybakken, 1992;Lagus *et al*., 2004)**.

Basically, on the spatial distribution of research location in Fitu waters, several genera are collected from Bacillariophyceae mainly *Bacillaria*, *Biddulphia*, *Climocosphenia, Cocconeis, Cossinodiscus, Diatoma, Leptocylindrus, Melosira, Nitzschia, Plagiogramma, Pleurosigma, Rhizosolenia*, *Skeletonema*, and *Triceratium*; from Cyanophyceae class are *Gleotrichia, Oscillatoria, and Trichodesmium*; and from Dinophyceae class are *Gonyaulax, Gymnodinium*, and *Peridinium*. While, the genera only found at one station are *Dinophysis*, *Noctiluca*, and *Prorocentrum* (Table 3). Furthermore, on the temporal distribution, the genera found during all observation periods from the class Bacillariophyceae are *Biddulphia*, *Climocosphenia*, *Cossinodiscus*, *Diatoma, Fragilaria*, *Leptocylindrus*, *Melosira*, *Nitzschia*, *Pleurosigma*, *Rhizosolenia*, and *Triceratium*; from the class Cyanophyceae namely *Gleotrichia* and *Oscillatoria*; and from the class Dinophyceae namely *Gonyaulax, Gymnodinium*, and *Peridinium* (Table 3). Yet, the genera that are only found in one observation period are from the Bacillariophyceae class, namely *Bellerochea, Campylodiscus, Cerataulina, Chaetoceros, Dactyliosolen*, *Diploneis*, *Hemiaulus*, *Lauderia*, *Licmophora*, *Rhabdonema*, and *Surirella*; from the Chlorophyceae class, *Tetraedron* was detected; from the Cyanophyceae class, *Anabaena*, *Pelagothrix*, and *Skujaella* were recorded; and from the Dinophyceae class, *Dinophysis*, *Noctiluca*, and *Prorocentrum* were adjusted (Table 3).

The diversity index ranges from 1.9208 - 2.5616 (Table 5), the highest value is found at station 1 period III (2.5616), with the lowest value at station 2 period IV (1.9208). This is caused by inappropriate environmental parameters that affected improper growth and development. The diversity index value is grouped in the moderate category as referring to the criteria mentioned by Wilhm and Dorris (1968) in **Mason (1981)** that the diversity index value 1> H'< 3 is classified as a medium diversity level.

The evenness index describes the balance of the community or shows the distribution pattern of biota in water. The range of evenness index values during the study is 0.6780 - 0.8764 (Table 5). The highest value is at station 4 period I (0.8764) and the lowest is at station 2 period IV (0.6780). This value is categorized as quite high. As explained by **Brower *et al*. (1998)** that an evenness index value of more than or equal to 0.6 indicates high evenness. The range of evenness index values obtained indicates that the phytoplankton community in Fitu waters during the study has a more even distribution at each station and time of observation. This is in line with what was stated by **Syakti *et al*. (2019)** that a high evenness index value indicates that each type of phytoplankton has the same opportunity to grow and develop so that no one species is dominant.

Dominance index values found during the study at all stations and observation periods have a value of less than 0.5 or close to zero, with a range between 0.0925 - 0.2597 (Table 5). The highest value is obtained at station 2 period IV (0.2597) and the lowest at station 4 period I (0.0925). This indicates that in the community structure of the phytoplankton being observed, there are no species that extremely dominate other species; the physicochemical parameters of the water are in the appropriate range so that competition does not occur, and whole species have the same opportunity to grow and develop. This shows that the condition of the community structure is stable, environmental conditions are suitable, and there is no ecological pressure on the phytoplankton in the habitat.

The results of the Pearson correlation analysis (Table 6) between phytoplankton abundance and several water quality parameters during research in Fitu waters showed that there were parameters that were positively correlated (in the same direction), and some were negatively correlated (not in the same direction). In detail, it can be explained that nitrate has a positive and sufficient correlation with phytoplankton abundance, phosphate with phytoplankton abundance has a positive and very weak correlation, silica with phytoplankton abundance has a positive and strong correlation, temperature with phytoplankton abundance has a positive and very weak correlation. This means that an increase in the concentration of nitrate, phosphate, silica, and temperature in the waters will be followed by an increase in the abundance of phytoplankton. Meanwhile, pH and phytoplankton abundance are negatively and very weakly correlated, and salinity and phytoplankton abundance are negatively and strongly correlated. This indicates that if the pH and salinity concentrations are high in the waters, the abundance of phytoplankton will actually be low.

In Fitu waters, several species were found that can be used as aquatic bioindicators. Among them are *Melosira* sp., *Spirogyra* sp., and *Nitzschia* sp. (Table 1). *Melosira* sp. is an indicator of clean waters. Meanwhile, *Spirogyra* sp. and *Nitzschia* sp. are phytoplankton indicators of pollution **(Sukarti *et al*., 2012)**.

CONCLUSION

The phytoplankton composition in Fitu waters consists of four classes, namely Bacillariophyceae, Chlorophyceae, Cyanophyceae, and Dinophyceae, with an abundance value ranges of 47,560 - 232,151 cells.L^{-1}. The widest distribution class is Bacillariophyceae.

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REFERENCES

APHA. (2005). Standard methods for the examination of water and wastewater, 21th edition. Washington: APHA, AWWA (American Waters Works Association) and WPCF (Water Pollution Cobtrol Federation). pp: 3 - 42.

Aramita, G. I.; Zainuri, M. and Ismunarti, D. H. (2015). The effect of currents on the distribution of phytoplankton in Morosari Waters Demak, Jurnal Oseanografi, 4(1): 124 - 131.

Arazi, R.; Isnaini and Fauziyah. (2019). Community structure and abundance of phytoplankton and their relationship with physico-chemical parameters in the Banyuasin Coastal Waters, Banyuasin Regency, Jurnal Penelitian Sains, 21(1): 1 - 8.

Aryawati, R; Ulqodry T. Z.; Isnaini and Surbakti, H. (2021). Phytoplankton as a bioindicator of organic pollution in the Downstream Musi River, South Sumatra, Jurnal Ilmu dan Teknologi Kelautan Tropis, 13(1): 163 - 171.

Aryawati, R. and Thoha, H. (2011). The Relationship between chlorophyll-a and phytoplankton abundance in Berau Waters, East Kalimantan, Maspari Journal, 2: 89 - 94.

Berge, T.; Daugbjerg, N.; Andersen, B. B. and Hansen, P. J. (2010). Effect of lowered pH on marine phytoplankton growth rates. Marine Ecology Progress Series, 416: 79 - 91.

Brower, J. E.; Jerrold, H. Z. and Car, I. N. V. (1998). Field and laboratory methods for general ecology. USA New York: Wm. C. Brown Publisher. 273 pp

Davis, G. C. (1955). The marine and freshwater plankton. Michigan State University Press, USA. 526 pp.

Dewanti, L. P. P.; Putra, I. D. N. N. and Faiqoh, E. (2018). The correlation between phytoplankton abundance and diversity and zooplankton abundance and diversity in Serangan Island Waters, Bali, Journal of Marine and Aquatic Sciences, 4(2): 324 - 335.

Effendi, H. (2003). Study of water quality for management resources and environment waters, Yogyakarta: Kanisius. 258pp.

Fajar, M. G. N.; Rudiyanti, S. and A'in, C. (2016). The influence of nutrients on phytoplankton abundance as a bioindicator of pollution in the Gambir River, Tembalang, Semarang City, Diponegoro Journal of Maquares, 5(1): 32 - 37.

Fitrianti, F. B.; Ario, R. and Widianingsih. (2022). Community structure of phytoplankton in coastal waters of the Batang PLTU Megaproject, Central Java, Journal of Marine Research**,** 11(3): 437 - 445.

Giyanto; Abrar; Hadi, M.; Agus, B.; Muhammad, H.; Abdullah, S. and Marindah, Y. I. (2017). Status of Indonesia's Coral Reefs 2017. Jakarta. 30pp.

Isnaini. (2012). Community structure of phytoplankton in the waters of the Banyuasin Estuary, Banyuasin Regency, South Sumatra, Maspari Journal, 4(1): 58 - 68.

Kadim, M. K.; Pasisingi, N. and Kasim, F. (2018). Spatial and temporal distribution of phytoplankton in the Gorontalo Bay, Indonesia, AACL Bioflux, 11(3): 833 - 845.

Kadir, M. A.; Damar, A. and Krisanti, M. (2015). Spatial and temporal dynamics of zooplankton community structure in Jakarta Bay. Jurnal Ilmu Pertanian Indonesia, 20(3): 247 - 256.

Katili, V. R. A. and Kasim, M. (2022). Community structure of plankton in Tanjung Kasuari Coastal Waters, West Sorong District, Sorong City, Siganus: Journal of Fisheries and Marine Science, 3(2): 222 - 228.

Kusumaningtyas, M.; Bramawanto, R.; Daulat, A. and Pranowo, W. (2014). The quality of Natuna waters in the transition season, Depik, 3(1): 10 - 20.

Lagus, A.; Suomela, J.; Wethoff, G.; Heikkila, K.; Helminen, H. and Sipura, J. (2004). Species-specific differences in phytoplankton responses to N and P enrichment and the N:P ratio in the Archipelago Sea, northern Baltic Sea. Journal of Plankton Research, 26(7): 779 - 798.

Lestari, H. A.; Samawi, M. F.; Faizal, A.; Moore, A. M. and Jompa, J. (2021). Diversity and abundance of phytoplankton in the coastal waters of South Sulawesi, HAYATI Journal of Biosciences, 28(3): 199 - 211. doi: 10.4308/hjb.28.3.199.

Mason, B. (1981). Biology of freshwater pollution. Scientific and technology Longman. New York. 250 pp.

Meirinawati, H. and Fitriya, N. (2018). Effect of nutrient concentration on phytoplankton abundance in Halmahera Waters Maluku, Oseanologi dan Limnologi di Indonesia, 3(3): 183 - 195. doi: 10.14203/oldi.2018.v3i3.129.

Munthe, Y. V.; Aryawati, R. and Isnaini. (2012). Community structure and distribution of phytoplankton at Sungsang Waters, South Sumatera, Maspari Journal, 4(1): 122 - 130.

Mustofa, A. (2015). Nitrate and phosphate content as factors in coastal water fertility levels, Jurnal Dipostek, 6(1): 113 - 27.

Mutmainnah and Yuliana. (2023)**.** Management and utilization of small island resources, PT. Pena Persada Kerta Utama, Purwokerto. 45pp.

Nastiti, A. S. and Hartati, S. T. (2013). Plankton community structure dan their environment as one of factors to support fish resources management in Jakarta Bay, Bawal, 5(3): 131 - 150.

Nontji, A. (2006). There is no life on earth without the existence of plankton. LIPI Press, Jakarta. 248pp

Nontji, A. (2008). Marine plankton. LIPI Press, Jakarta. 331pp.

Nurmalitasari, M. and Sudarsono. (2023). Diversity of plankton and levels of primary productivity between the two seasons in the waters of Bantul District, Jurnal Kingdom (The Journal of Biological Studies), 9(1): 16 - 34. doi: 10.21831/kingdom.v9i1.18156.

Nybakken, J. W. (1992). Marine biology. An ecological approach. Translation of marine biology: An ecological approach. Interpreters: M. Eidman, Koesoebiono, D.G. Bengen and M. Hutomo. Gramedia, Jakarta. 459 pp.

Odum, E. P. (1998**).** Fundamentals of ecology: Translation of the fundamentals of ecology. Interpretation of Samingan, T. Third Edition. Gadjah Mada University Press, Yogyakarta. 697pp.

Pugesehan, D. J. (2010). Assessment of eutrophication of coastal waters using the trophic index method (TRIX), Oseana, 42(2): 23 - 33.

Putri, C. R.; Djunaedi, A. and Subagyo, S. (2019). Phytoplankton ecology: viewed from the aspects of composition, abundance, distribution, community structure and saprobity index in Morosari Waters, Demak, Journal of Marine Research, 8(2): 197 - 203.

Rahmadani, D. and Kuntjoro, S. (2021). The diversity of tolerant plankton in the coastal waters of Lusi Island Sidoarjo Regency, LenteraBio: Berkala Ilmiah Biologi, 9 (3): 258 - 266.

Rahmah, N.; Zulfikar, A. and Apriadi, T. (2022). Phytoplankton abundance and its relation to several water environment parameters in the Sei Carang Estuary, Tanjungpinang, Journal of Marine Research, 11(2): 189 - 200. doi: 10.14710/jmr.v11i2.32945.

Ramili, Y.; Umasangaji, H. and Drakel, A. (2023). Composition and abundance of phytoplankton with potential harmful algal blooms (HABs) on Ternate Island coastal waters, North Maluku, AGRIKAN - Jurnal Agribisnis Perikanan, 16(1): 83 - 94.

Rashidy, E. A.; Litaay, M.; Salam, M. A. and Umar, M.R. (2013). Phytoplankton composition and abundance in the coastal waters of Tekolabbua Village, District Pangkajene, Pangkep Regency, South Sulawesi Province, Jurnal Alam dan Lingkungan, 4(7): 12 - 16.

Raymont, J. E. (1980). Plankton and productivity in the ocean. New York : Mc. Millan Co. 489 pp.

Rimper, A. M.; Warouw, V.; Rimper, J. R. T. S. L.; Lintang, R.A.J.; Ompi, M. and Pangkey, H. (2023). Phytoplankton community structure in seagrass beds in Tiwoho Village, North Minahasa Regency, Jurnal Ilmiah PLATAX, 11(1): 105 - 113.

Sachlan, M. (1982). Planktonology. Faculty of fisheries and marine science, University of Diponegoro, Semarang. 269 pp.

Samiaji, J. (2015). Marine planktonology. Teaching materials for marine planktonology lectures, Department of Marine Science, Faculty of Fisheries and Marine Sciences, University of Riau.

Sumardianto. (1995). Structure of phytoplankton community in the waters of Teluk Ratu, West Java. Thesis. Aquatic Resources Management Study Program, Faculty of Fisheries, Bogor Agricultural University, Bogor. 57pp

Syakti, A. D.; Idris, F.; Koenawan, C. J.; Asyhar, R. and Apriadi, T. (2019). Biological pollution potential in the water of Bintan – Riau Islands Province, Indonesia: First appearance of harmful algal bloom species, Egyptian Journal of Aquatic Research, 45:117-122.

Tambaru, R.; Burhanuddin, A. I.; Massinai, A. and Amran, M. A. (2021). Detection of marine microalgae (phytoplankton) quality to support seafood health: A case study on the west coast of South Sulawesi, Indonesia, Biodiversitas, 22(11) : 5179 - 5186. doi: 10.13057/biodiv/d221156.

Tomas, C. R. (1997). Identifying marine phytoplankton. Academic Press Harcourt & Company, San Diego-New York-Boston-London-Sydney-Tokyo-Toronto. 858 pp.

Tungka, A. W.; Haeruddin, H. and Ain, C. (2016). Concentration of nitrate and orthophosphate at Banjir Kanal Barat Estuary and their relationship with the abundance of harmful algae blooms (HABs), Journal of Fisheries Sciences and Technology, 12(1): 40 - 46.

Widjaja, F.; Suwignyo, S.; Yulianda, F. and Effendi, H. (1994). Species composition, abundance and distribution of marine plankton in Pelabuhan Ratu Bay, West Java. Research report, Faculty of Fisheries and Marine Sciences, IPB Bogor, 10 pp.

Yamaji, C. S. (1979). Illustration of the marine plankton of Japan. Hoikiska Publ. Co. Ltd., Japan. 572 pp.

Yuliana; Mutmainnah; Irfan, M; Nasir, A. and Djamhur, M. (2023). Phytoplankton quality based on species composition in the Kastela waters, Ternate, North Maluku, Indonesia, AACL Bioflux, 16(2): 743 - 752.

Yuliana; Mutmainnah and Irfan, M. (2021). The use of phytoplankton as a fertility indicator of the Sasa waters, Ternate, North Maluku, Indonesia, Aquaculture, Aquarium, Conservation & Legislation, 14(6): 3741 - 3749.

Yuliana. (2015). Distribution and community structure of phytoplankton at Jailolo waters, West Halmahera Barat, Akuatika, VI(1): 41 - 48.

Yuliana and Mutmainnah. (2021). Assessment of coastal water productivity of Fitu Village, Ternate Island based on its zooplankton community structure. IOP Conference Series: Earth and Environmental Science, 890(1). doi: 10.1088/1755-1315/890/1/012011.

Yusuf, M.; Robin; Adi, W.; Hudatwi, M.; Widianingsih; Hartati, R.; Mahendrajaya, R.T. and Manullang, C. (2021). Phytoplankton community structure and it's relationships with water quality in Bangka Island, Indonesia, Ilmu Kelautan: Indonesian Journal of Marine Sciences, 26(1): 37 - 44. doi: 10.14710/ik.ijms.26.1.37 - 44.

Zulfandi, Z.; Zainuri, M. and Widowati, I. (2014). Study of distribution of phytoplankton and zooplankton in waters and flood estuaries of the West Canal of Semarang City, Central Java. Prosiding Seminar Nasional Kelautan IX Universitas Hang Tuah Surabaya, pp. 24 - 31.