Examination of phytoplankton communities in the Seram Sea Maluku.

Frans Lumoindong 1, Christine Mamuaya 2, Lis M Yapanto 3

1.Marine Science Study Program, FPIK, Universitas Sam Ratulangi Manado 95115, Indonesia

2.Department of Agricultural Technology, Faculty of Agriculture, Sam Ratulangi University, Jl. Kampus Unsrat, Manado 95115, Indonesia

3. Management Aquatic Faculty of Fishery and Marine Science Universitas Negeri Gorontalo

Abstract

The purpose of this research is to learn more about the phytoplankton community structure in Maluku's Seram Sea, Manipa Strait, and North Banda Sea. A phytoplankton net (Kitahara net) was used to collect samples at depths of 150-250 meters and 0-150 meters. The sampling was done only once. The phytoplankton samples were placed in a plastic container, tagged, and preserved with a 4% formalin solution. Samples were collected from the waters of the Seram Sea, Manipa Strait, and north of the Banda Sea from 1 (one) research site each. Each study station was sampled only once. A phytoplankton net (Kitahara net) was used to gather phytoplankton. The phytoplankton net is collected by lowering it from the boat until it reaches the appropriate depth, then pulling it vertically up to the surface at a speed of 0.5 m/s. The 87 species found in the three waters are divided into 16 families for the Diatomophyceae class, 8 families for the Dinophyceae class, 5 families for the Prymnesiophyceae class, 1 family for the Prasinophyceae class, and 1 family for the Chlorophyceae class. Ceratium (Tripoceratium) sp., Rhizosolenis sp., Chaetoceros spp., planktoniella sol, Centrodinium sp., Amphisolenia sp., Protopperidinium sp., Climaodcium frauenfeldianium, and coscinodiscus stellaris are common phytoplankton species.

Keywords: Exploratory research, Phytoplankton, Community Structure, Seram sea

Introduction

The phytoplankton samples were then identified at the Marine Science Laboratory, UNSRAT Faculty of Fisheries and Marine Sciences. The results of environmental parameter measurements showed that the average sea temperature of Seram, Manipa Strait and North Banda Sea was 23°C, while the average salinity in the three study locations was 33 PSU. The results of nutrient measurements show the average content of nitrate, Phosphates, nitrites and silicates in the north of the Banda Sea were higher when compared to the Seram Sea and the Manipa Strait, namely 8.47μg at.L-1, 1.84μg at.L-1, 0.37μg at.L- respectively 1, and 12.96μg at.L-1. The types of phytoplankton obtained were 87 species consisting of 63 species from the Diatomophyceae class, 13 from the Dinophyceae class, 7 species from the Prymnesiopjyceae class, 1 species from the Cyanophyceae class, 1 species from the Prasinophyceae class, and 2 species from the Chlorophyceae class. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. and silicate in the north of the Banda Sea is higher when compared to the Seram Sea and the Manipa Strait, namely 8.47μg at.L-1, 1.84μg at.L-1, 0.37μg at.L-1, and 12 respectively .96μg at.L-1. The types of phytoplankton obtained were 87 species consisting of 63 species from the Diatomophyceae class, 13 from the Dinophyceae class, 7 species from the Prymnesiopjyceae class, 1 species from the Cyanophyceae class, 1 species from the Prasinophyceae class, and 2 species from the Chlorophyceae class. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. and silicates in the north of the Banda Sea were higher when compared to the Seram Sea and the Manipa Strait, namely 8.47μg at.L-1, 1.84μg at.L-1, 0.37μg at.L-1, and 12 respectively .96μg at.L-1. The types of phytoplankton obtained were 87 species consisting of 63 species from the Diatomophyceae class, 13 from the Dinophyceae class, 7 species from the Prymnesiopjyceae class, 1 species from the Cyanophyceae class, 1 species from the Prasinophyceae class, and 2 species from the Chlorophyceae class. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. and 12.96μg at.L-1. The types of phytoplankton obtained were 87 species consisting of 63 species from the Diatomophyceae class, 13 from the Dinophyceae class, 7 species from the Prymnesiopjyceae class, 1 species from the Cyanophyceae class, 1 species from the Prasinophyceae class, and 2 species from the Chlorophyceae class. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance

of the type of phytoplankton. and 12.96μg at.L-1. The types of phytoplankton obtained were 87 species consisting of 63 species from the Diatomophyceae class, 13 from the Dinophyceae class, 7 species from the Prymnesiopjyceae class, 1 species from the Cyanophyceae class, 1 species from the Prasinophyceae class, and 2 species from the Chlorophyceae class. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. 1 species from class Cyanophyceae, 1 species from class Prasinophyceae, and 2 species from class Chlorophyceae. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. 1 species from class Cyanophyceae, 1 species from class Prasinophyceae, and 2 species from class Chlorophyceae. The results of the analysis of the phytoplankton community showed that the diversity and evenness varied, where some locations did not experience ecological pressure and others experienced moderate ecological pressure. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton. Meanwhile, the evenness value indicates that the condition of the waters at the study site is relatively stable. The dominance value indicates that there is no dominance of the type of phytoplankton.

INTRODUCTION

In recent years, attention to the sea has increased, due to the growing awareness and interest from various groups of people on the importance of the sea as a source of food, reserves of minerals, transportation, and tourism.

The sea is a medium that never stops moving, both on the surface and beneath it. This causes the circulation of water, can be small scale or very large scale. In the South China Sea, Java Sea, Flores Sea to near the Banda Sea, the current pattern changes completely twice a year according to the development of the seasons. In the east monsoon (August) there is an increase in water mass (upwelling) in the Banda Sea which raises water rich in nutrients from the deepest layers to the surface to make the Banda Sea fertile (Nontji 1993).

The fertility of a waters can be seen by the number of fish which is closely related to the density of plankton content in these waters in addition to several other environmental factors that also influence such as temperature, salinity, phosphate, nitrate, and others (Anonymous 1995)

Disclosure of plankton data in the waters of the Seram Sea, Manipa Strait and north of the Banda Sea (southern part of Buru Island) is still lacking, even though based on observations so far these waters are very potential fishing grounds because they are very fertile.

This has become an attraction for conducting research on the distribution and abundance of phytoplankton communities, especially in these waters. For this reason, BPP Teknologi, supported by the Lamont-Doherty Earth Observatory, Columbia University (New York, USA), is collaborating with LIPI and UNSRAT to conduct research in the Seram Sea, Manipa Strait and the northern part of the Banda Sea.

The depth of the waters around the Seram Sea, Manipa Strait and north of the Banda Sea ranges from 540-4010 meters with an average salinity of 33.00-34.00 PSU, temperature 28-30°C, which is widespread in these waters (Yusuf and Sutomo 1989).

The purpose of this study was to identify the types of phytoplankton, determine the distribution and abundance of phytoplankton at 2 depths for each research station (150-0m and 250-150m), and determine the structure of the phytoplankton community presented in the form of diversity, evenness, and adaptation strategies of phytoplankton. located in the Seram Sea, Manipa Strait, and in the north of the Banda Sea,

Research Methods

Samples were taken from the waters of the Seram Sea, Manipa Strait and north of the Banda Sea, each of which consisted of 1 (one) research station. Sampling was only done once for each research station. Phytoplankton collection was carried out using a phytoplankton net (Kitahara net). The collection of phytoplankton is carried out by lowering the phytoplankton net from the boat until it reaches the specified depth, then the net is pulled vertically up to the surface at a speed of 0.5 m/s.

Identification and Classification

The phytoplankton samples obtained were put in a plastic container and then labeled and 4% formalin solution was added for preservation. The names of stations 1a and 1B are stations in the Seram Sea at depths of 0-150 m and 150-250 m respectively, stations 2a and 2b are stations in the Manipa Strait at depths of 0-150 m and 150-250 m respectively. As well as stations 3a and 3b in the

North Banda Sea at depths of 0-150 m and 150-250 m respectively.

The phytoplankton samples were then identified and classified at the Marine Science Laboratory, Faculty of Fisheries and Marine Science, Unsrat Manado. Take 1 ml of sample and then drop it on the "sedgwick rafter" and then observe it under a microscope with a magnification of 200 times or 400 times. The observed phytoplankton will be identified using manuals from Yamaji (1982), Sournia (1986), Richard (1987), and Chretiennot-Dinnet (1990).

Temperature and Salinity

For temperature and salinity measurements, CTD meters (Condutivity, Temperature, Density) were used which were placed at depths of 10, 20, 40, 60, 80, 100, 120, 140, 150, 180, 200, 220, 240, 250 meters. For nutrient measurements, it only refers to the results of the P3O analysis of LIPI, Ambon, where the data was collected at the same time as the research.

Data analysis

Phytoplankton density (cells/liter) was calculated based on the method proposed by Clesceri, et al (1989):

$$\boldsymbol{E = \frac{C \times A}{fa \times V}}$$

Where:

E = density (cells/liter)

C = total cells observed

fa = volume of plankton sub sample (liters)

A = volume of plankton concentrate (liters)

V = volume of filtered water (liters)

To see the effect of different depths on the value of phytoplankton density, the t test was used (Walpole and Myers 1985) with the following formula:

$$t = \frac{(x1 - x2)}{Sp\sqrt{\left(\frac{1}{n1}\right) + \left(\frac{1}{n2}\right)}}$$

Where:

t = calculated value

Sp = combined standard deviation (Pooled),

$$Sp2 = \frac{(n1-1)S1^2 + (n2-1)S2^2}{n1+n2-2}$$

Where :

n: number of samples (individuals)

X : mean - average with degrees of freedom

v = n1 + n2 – 2 : σ1 = σ2

To determine the distribution of the abundance of phytoplankton in relation to the adaptation strategy of these organisms to the environment, it was studied using the rank-frequency succession method (Frontier 1976, 1977).

To determine species diversity, the formula proposed by Shannon-Winer in Odum (1996) is used:

$$H' = -\Sigma \frac{ni}{N} IN \frac{ni}{N}$$

Where :

H' = diversity index

Ni: The number of individuals in the i-th species

N: Total number of individuals

To see the evenness of species, the formula proposed by Ludwig and Reynolds (1988) :

$$E: \frac{H}{In\, S}$$

Where :

H: Shannon–Wiener index for species diversity

S: Number of Species

To determine species dominance, the formula proposed by Odum (1996) is used, namely:

$$C: \Sigma\ (ni/N)^{2}$$

Where :

ni: the number of individuals

N: number of individuals of all species

To see the grouping hierarchy arranged in a structure like a dendogram hierarchical tree using the NTSys-PC program(1992).

RESULTS AND DISCUSSION

Types of Phytoplankton

There are 87 species of phytoplankton found in the study locations. The phytoplankton community at station 1 (Seram Sea) consists of 6 classes, namely the Cyanophyceae class. Diatomophyceae or Bacillariophyceae, Dinophyceae, Prasinophyceae. Chlorophyceae, and Prymnesiophyceae or Haptophyceae, where 37 species were found at station 1a and 46 species of phytoplankton were found at station 1b

(Figure 3).

The phytoplankton community at station 2 (Manipa Strait) consists of 5 classes, namely the Cyanophyceae class. Diatomophyceae, Dinophyceae, Prasinophyceae, and Prymnesiophyceae. where at station 2a found 47 types of phytoplankton and station 2b found 9 types of phytoplankton (Figure 4).

The phytoplankton community at station 3 (north of the Banda Sea) consists of 4 classes, namely the Cyanophyceae class. Diatomophyceae. Dinophyceae. and Prymnesiophyceae, of which the classes Diatomophyceae and Dinophyceae are found in large numbers. At station 3a found 43 types of phytoplankton and 14 types of phytoplankton at station 3b (Figure 5).

In each class there are several families, in which as many as 16 families can be identified for the Diatomophyceae class. 8 families in class Dinophyceae, 5 families in class Prymnesiophyceae. 1 family of class Cyanophyceae and 1 family of class Prasinophyceae and 1 family of class Chlorophyceae

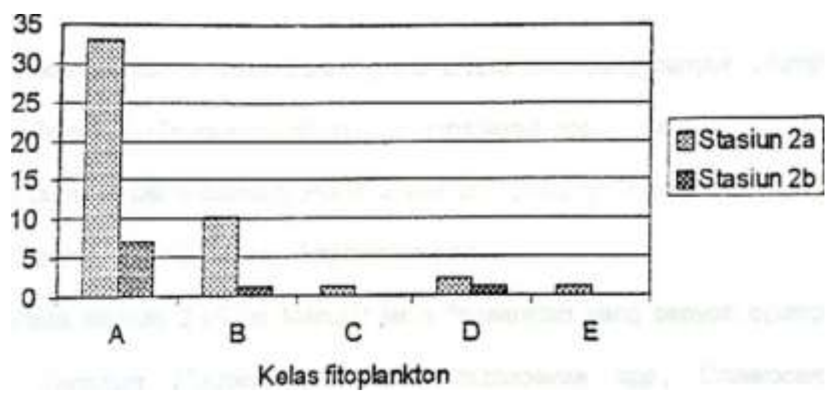

Figure 1. Number of phytoplankton species by class in the Seram Sea

Notes : A ■ Diatomophyceae, B = Dinophyceae, C = ■ Cyanophyceae, D = Prymnesiophyceae, E = Prasinophyceae, F = Chlorophyceae

At station 1 (Seram Sea) the most common types of phytoplankton found were Ceratium (Tripoceratium) sp., Rhizosolenia spp., Centrodinium sp., Climacodium frauenfeldianum, Planktonieila sol, Dinophysis sp., Chaetoceros mitra, Eucampia zodiacus, and Amphisolenia sp.

At station 2 (Manipa Strait) the types of phytoplankton that were often found were Ceratium (Tripoceratium) sp.. Rhizosolenia spp., Chaetoceros constrictus, Ornithocercus sp., Protoperidinium sp., Planktonieila sol, and Melosira nummulcides.

At station 3 (north of the Banda Sea) the most common types of phytoplankton found were

Ceratium (Tripoceratium) sp., Pyrocystis sp., Centrodinium sp., Planktonieila sol, Amphisolenia sp., Protoperidinium sp., Rhizosolenia spp., Chaetoceros affinis, Climacodium frauenfeldianum, Coscinodiscus stellaris, Lauderia annulata. Bellenochea horologicalis, Gossleria tropica, Phaeocystis sp., and Thallasionema nitzchioides.

Phytoplankton density

At each station it shows that the highest density is at station 3a which is 223851 sel.L'1, and then at station 1a which is 147463 sel.L'1. The results of the density analysis for each station are presented in Table 1.

Table 2. Results of analysis of phytoplankton density at each station

Stasiun	1a	1b	2a	2b	3a	3b
Kepadatan (sel. L^{-1})	147463	38292	84178	1914	223851	664

All stations at depths of 0-150 m (1a, 2a, 3a) have a much higher average density than stations at depths of 150-250 m . This indicates a difference in density at the two depths (Table 3).

Table 3. Comparison of the average density of phytoplankton at two different depths. (* = significantly different) (a = 0.05).

Stasiun	1a	1b	2a	2b	3a	3b
Jumlah spesies	37	46	47	9	42	14
Rata-rata	4031,68	865 11	1834,35	212,67	5205,84	47,43
Simpangan baku	7118,51	1282,44	2455,64	76,73	8583,85	22,45
t-hitung	2,93		1,89		2,23	
Hubungan	*		*		*	

Phytoplankton Diversity, Evenness, and Dominance

The results of the analysis of the diversity, evenness, and dominance indices for each station are shown in Table 4. The highest diversity index (H') was at station 1b of 3.2204 and the lowest was at station 2b of 2.1442. For the evenness index (E), the highest value is at station 2b, which is 0.9758 and the lowest is at station 1a, which is 0.6701. The highest domination value was found at station 2b which was 0.1237 and the lowest dominance was 0.0284 at station 1b.

Table 2. Indices of diversity, evenness, and dominance of phytoplankton at each station

Stasiun	Keanekaragaman (H')	Kemerataan (E)	Dominasi (C)
1a	2,4220	0,6701	0,1082
1b	3,2204	0,8411	0,0284
2a	3,1350	0,8140	0,0419
2b	2,1442	0,9758	0,1237
3a	2,9560	0,7850	0,0839
3b	2,5421	0,9632	0,0863

Frequency Ranking Graphic Analysis

The results of the frequency ranking chart analysis can be seen in Figure 6. The figure shows the pattern of stage I at stations 1a, 1b, 2a, 3a, and the pattern of stage II at stations 2b and 3b.

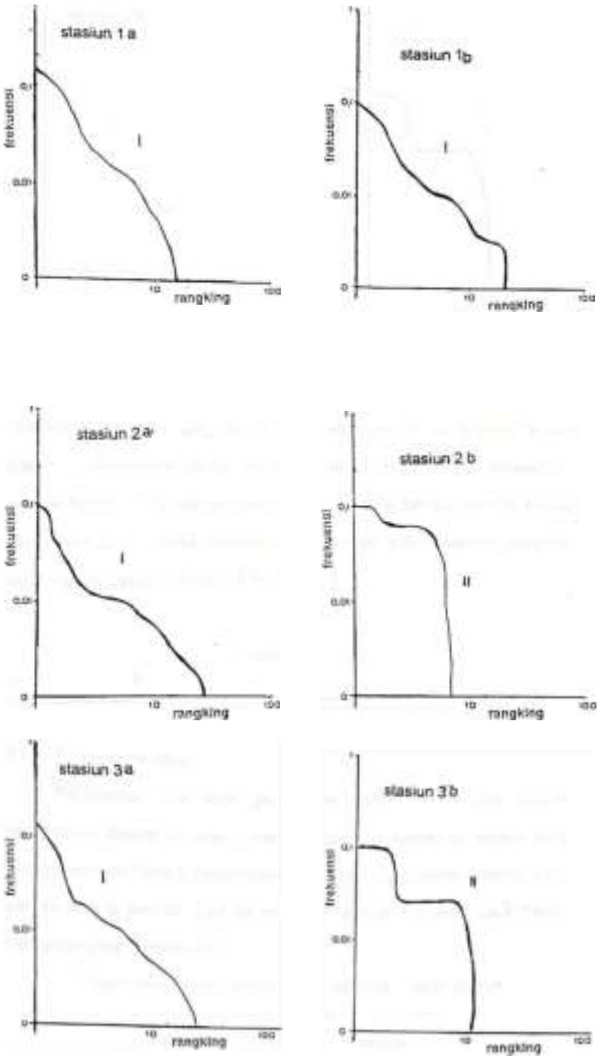

Figure 2. Rank-frequency graph at each research location

Clustering Analysis

The grouping analysis results show that stations 2b and 3b have the highest similarity (more than 96%). Station 1a and station 1b have a high affinity with the two previous stations of almost 88%. The next two stations (2a and 3a) have a further affinity. Overall, the similarity between research stations is high, which is more than 84% (Figure 7).

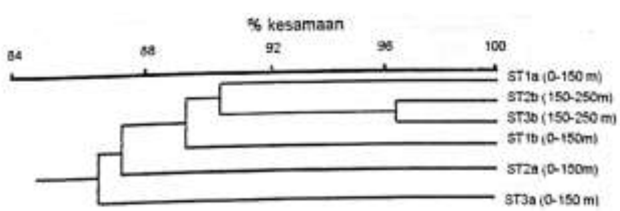

Figure 3. Results of the level of similarity of phytoplankton between study locations

Temperature and Salinity

Based on data from temperature and salinity measurements during sampling at the study site, the range is obtained as shown in Table 5.

Table 3. Results of temperature and salinity measurements at each station

Stasiun	Kisaran suhu (^{0}C)	Kisaran salinitas (PSU)
1a	22,35 - 30,00	33,21 - 33,92
1b	11,96 – 18,37	33,88 - 33,98
2a	18,74 – 29,27	33,20 - 33,90
2b	13,65 – 18,48	33,80 - 33,93
3a	16,78 – 29,88	33,12 - 33,93
3b	12,84 – 16,58	33,74 - 34,04

Nutrients (Nitrates, Nitrites, Phosphates, Silicates)

The results of the nutrient analysis at each station are shown in Table 6 and Table 7.

Table 6. Analysis of nitrate and nitrite at each station

Stasiun	Kisaran nitrat (µg at.L^{-1})	Kisaran nitrit (µg at.L^{-1})
1a	0,53-0,49	2,20-0,57
1b	4,69-8,80	0,45-0,57
2a	0,81-9,24	0,31-0,49
2b	8,48-8,81	0,41-0,43
3a	0,89-18,06	0,06-,051
3b	0,51-0,89	0,20-0,593

Table 4. Phosphate and silicate analysis at each station

Stasiun	Kisaran fosfat (µg at.L^{-1})	Kisaran silikat (µg at.L^{-1})
1a	0,61-1,78	1,15-10,06
1b	1,61-1,78	3,97-9,20
2a	0,28-1,44	1,44-12,99
2b	1,44-1,56	0,46-11,72
3a	0,61-2,94	0,80-8,05
3b	1,61-2,06	10,17-15,75

Table 6 and Table 7 show that the highest average nitrate content was found at station 2b of 2.65 µg at.L-1, the highest average of nitrate at station 1b was 0.51 µg at.L-1 ; the highest average phosphate at station 3b was 1.84 µg at.L-1; and the highest average silicate at station 3b was 12.96 µg at.L-1.

DISCUSSION

The results of the studies above show that the dominant types of phytoplankton, namely

Chaetoceros sp. This is the same as that found in research stations. Apart from this genus, the relatively abundant phytoplankton are Rhizosolenia sp., Ceratium (Tripoceratium) sp., and Planktonieila sol.

The total density of phytoplankton shows that station 3a (northern part of the Banda Sea) has the highest density value of 223851 sel.L-1, followed by station 1a (Seram Sea) and station 2a (Manipa Strait). Meanwhile, the density of phytoplankton at a depth of 150-250 m showed that station 1b had the highest density, namely 38292 cells.L-1, followed by station 2b and station 3b.

The density of phytoplankton in the two water columns is significant where the average density is higher in the surface area (0-150 m). This may be due to a lot of plankton moving from a certain depth to the surface (vertical migration) and also because there is more light received than at a depth of 150-250 meters which is used for photosynthesis and perhaps a lack of predators.

Phytoplankton density in the northern Banda Sea (station 3a) is higher than in the Seram Sea (station 1a) and the Manipa Strait (station 2a). This may be due to the relatively low predation in the water column and more available nutrients (especially phosphate and nitrate) when compared to the Seram Sea and Manipa Strait.

According to the research results, the number of cells from Chaetoceros spp. of 5410000 cells/m3 or 5410 cells.L-1 at station 1a (Seram Sea), 3455000 cells/m3 or 3455 cells.L-1 at station 2a (Manipa Strait), and 5366000 cells/m3 or 5366 cells.L- 1 at station 3a (north of the Banda Sea).

To see the adaptation strategy to the environment of the phytoplankton community in the Seram Sea, Manipa Strait, and the northern part of the Banda Sea, a frequency ranking analysis was used based on the abundance of each species. The graphic pattern in Figure 6 shows that stations 1a, 1b, 2a, and 3a provide stage I reflections. This means that the phytoplankton community structure is in a stable condition, low biological productivity, high inter-species competition and minimum survival rates. At stations 2b and 3b the graphical pattern shows stage II reflection which shows that biological productivity is low, conditions are stable, competition between species is high and survival rate is maximum. The maximum survival is thought to be due to the lack of predators at the station.

The highest diversity index value was 3.2204 at a depth of 150-250 m. This value indicates that life at that depth does not have ecological pressure (William and Dorris in Dahuri and Suryadiputra 1986). This shows that the distribution of individuals within each species is relatively even.

For a depth of 0-150 m, the highest diversity index value is 3.1350. This indicates that there is no ecological pressure on life in the water column. The high diversity indicates that these types of phytoplankton can tolerate environmental conditions. This means that the phytoplankton community in these waters is increasingly diverse and not dominated by just one or two taxa (Arinardi et al 1997). At stations that have diversity index values of 2 and 3, it indicates that these stations are experiencing moderate ecological pressure. This is due to the uneven distribution of individuals.

Evenness index values at each station with a depth of 0-150 m indicate an increase from station 1 to station 2 and then decreased to station 3. This indicates that the distribution of individual phytoplankton is not evenly distributed in the three locations. While the evenness index value at the depth station is 150-250 m. shows the same trend. In general, the evenness index value is high (>0.7), except for station 1a. This means that the distribution of the number of each species of phytoplankton is relatively high. In general, the domination index value is smaller than 0.2. This shows that no phytoplankton dominates in the waters of the Seram Sea, the Manipa Strait and the north of the Banda Sea.

The high similarity of stations 2b and 3b is due to the similarity of the species owned by the two stations, namely Rhizosolenia setigera and Planktoniella sol. and the two stations only have a few species compared to other stations. At station 3b there are several types that are almost not found at other stations such as Chaetoceros terraces, Gossleria tropica. Ceratium (Ceratium) sp. On the other hand, at station 2b. all types of phytoplankton can be found at other stations, but not many other types are found at these stations. This is what causes the two stations are different from the others. However, overall the similarity of species from all research stations was very high (> 85%). So the ecosystem conditions of the three research locations are relatively similar.

CONCLUSIONS

Stations at depths of 0-150 meters (1a,2a,3a) have much higher densities than stations at The evenness value obtained is 0.6701-0.9758. Dominance values range from 0.0284-0.1237.

The frequency-range graphs obtained reflect the pattern of stage I at stations 1a, 1b, 2a, 3a, and the pattern of stage II at stations 2b, 3b. The level of similarity between the types of phytoplankton between stations is very high (> 85%).

REFERENCES

Usman, MS, Kusen, JD, & Rimper, JR (2013). Structure of the Plankton Community in the Waters of Bangka Island, North Minahasa Regency. Journal of Coastal and Tropical Seas, 1(2), 51-57.

Paena, M., Syamsuddin, R., & Tandipayuk, H. (2020). Analysis of Phytoplankton Community Structure and Its Potential Use as Bioindicator of Organic Waste in Laburane Bay, South Sulawesi. Journal of Aquaculture Research, 15(2), 129-139.

Munthe, YV, & Aryawati, R. (2012). Community structure and distribution of phytoplankton in the breech waters of South Sumatra. Maspari Journal: Marine Science Research, 4(1), 122-130.

Triawan, AC, & Arisandi, A. (2020). Phytoplankton community structure in estuary and sea waters, Kramat Village, Bangkalan District, Bangkalan Regency. Juvenil: Scientific Journal of Marine Affairs and Fisheries, 1(1), 97-110.

Armiani, S. (2015). Phytoplankton Community Structure in Pond Locations, Sekotong District, West Lombok Regency. Bioscientist: Scientific Journal of Biology, 3(2), 88-91.

Meirinawati, H., & Fitriya, N. (2018). Effect of nutrient concentration on the abundance of phytoplankton in Halmahera-Maluku waters. OLDI (Oceanology and Limnology in Indonesia), 3(3), 183-195.

Sartimbul, A., Ginting, FR, Pratiwi, DC, Rohadi, E., Muslihah, N., & Aliviyanti, D. (2021). Phytoplankton Community Structure in Mayangan Waters, Probolinggo, East Java. JFMR (Journal of Fisheries and Marine Research), 5(1), 146-153.

Fitrianti, FB, Ario, R., & Widianingsih, W. (2022). Phytoplankton Community Structure in Coastal Waters of the Batang PLTU Megaproject, Central Java. Journal of Marine Research, 11(3), 437-445.

Ananda, Y., Restu, IW, & Ekawaty, R. (2019). Tropical Status and Community Structure of Phytoplankton in Lake Beratan, Candikuning Village, Baturiti District, Tabanan Regency, Bali Province. Journal of Metamorphosis, 6(1), 58-66.

Anzani, YM, Soetignya, WP, & Adijaya, M. (2023). PHYTOPLANKTON COMMUNITY STRUCTURE IN THE MEMPAWAH RIVER, WEST KALIMANTAN, INDONESIA. TRITON: Journal of Aquatic Resources Management, 19(1), 20-28.