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Plankton Community Structure in Kasiak Island Waters Pariaman City, West Sumatra Province

Struktur Komunitas Plankton di Perairan Pulau Kasiak Kota Pariaman, Provinsi Sumatera Barat

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Abstract

This study was conducted in September 2022 in Kasiak Island Water, Pariaman City, West Sumatra Province. This study aimed to analyze the community structure of phytoplankton and zooplankton and the relationship between the abundance of phytoplankton and zooplankton in the waters of Kasiak Island. The method used is the survey method. Plankton sampling was carried out at four stations with three sampling points. Plankton samples were obtained by filtering 100 L of surface water to 125 mL and then analyzed in the laboratory. The results obtained were 21 species of phytoplankton and 11 species of zooplankton. The average abundance of phytoplankton in the morning ranged from 923.15–2400.19 ind/L, and during the day ranged from 1200.09–2,492.50 ind/L. The average abundance of zooplankton in the waters of Kasiak Island in the morning went from 369,26–1,200.09 ind/L and, during the day, ranged from 369,26–1,384.72 ind/L. Phytoplankton biological indicators such as the diversity index (H') in the morning ranged from 0.6096–2.3075 and during the day ranged from1.3894–2.0129, the uniformity index (E) in the morning ranged from 0.4844–0.9851 and during the day ranged from 0.9060–0.9624, and the dominance index (D) in the morning ranged from 0.2181–0.6617 and during the day ranged from 0.2833–0.4248. While zooplankton biological indicators such as the diversity index (H') in the morning ranged from 0.2704–0.8617 and during the day ranged from 0.3333–1.1950, the uniformity index (E) in the morning ranged from 0.2704–0.6667 and during the day ranged from 0.3333–0.6667, and the dominance index (D) in the morning ranged from0.6111–0.8750 and during the day ranged from 0.5278–0.8333. The relationship between the abundance of phytoplankton and zooplankton in the morning and during the day is a moderate (positive). The regression equation in the morning is$Y = 0.1356x + 434.5$ 3and during the day it is$Y = 0.1845x + 362.01$.

Keywords: Community Structure, Kasiak Island, Phytoplankton.

Abstrak

Penelitian ini telah dilaksanakan pada bulan September 2022 di perairan Pulau Kasiak, Kota Pariaman, Provinsi Sumatera Barat. Tujuan penelitian ini adalah untuk menganalisis struktur komunitas fitoplankton, zooplankton, dan hubungan kelimpahan antara fitoplankton terhadap zooplankton di perairan Pulau Kasiak. Metode yang digunakan adalah metode survei. Pengambilan sampel plankton dilakukan di empat stasiun dengan tiga titik sampling. Sampel plankton diperoleh dengan menyaring air permukaan sebanyak 100 L menjadi 125 ml, selanjutnya dianalisis di laboratorium. Hasil yang diperoleh terdapat 21 spesies fitoplankton dan 11 spesies zooplankton. Rata-rata kelimpahan fitoplankton pada pagi hari berkisar antara 923,15–2.400,19 ind/L dan pada siang hari berkisar antara

1.200,09–2.492,50 ind/L. Rata-rata kelimpahan zooplankton pada pagi hari berkisar antara 369,26–1.200,09 ind/L dan pada siang hari berkisar antara 369,26–1.384,72 ind/L. Indeks-indeks biologi fitoplankton seperti indeks keanekaragaman (H') pada pagi hari berkisar antara 0,6096–2,3075 dan pada siang hari berkisar antara 1,3894–2,0129. Nilai indeks keseragaman (E) fitoplankton pada pagi hari berkisar antara 0,4844–0,9851 dan pada siang hari berkisar antara 0,9060–0,9624. Nilai indeks dominansi (D) fitoplankton pada pagi hari berkisar antara 0,2181–0,6617 dan pada siang hari 0,2833–0,4248. Indeks-indeks biologi zooplankton seperti indeks keanekaragaman (H') pada pagi hari berkisar antara 0,2704–0,8617 dan pada siang hari berkisar antara 0,3333–1,1950. Nilai indeks keseragaman (E) zooplankton pada pagi hari berkisar antara 0,2704–0,6667 dan pada siang hari berkisar antara 0,3333–0,6667. Nilai indeks dominansi (D) zooplankton pada pagi hari berkisar antara 0,6111–0,8750 dan pada siang hari berkisar antara 0,5278–0,8333. Keterkaitan kelimpahan fitoplankton terhadap zooplankton pada pagi hari dan siang hari memiliki hubungan sedang (positif). Persamaan garis regresi pada pagi hari yaitu Y = 0,1356x + 434,53 dan pada siang hari yaitu Y = 0,1845x + 362,01.

Kata kunci: Struktur komunitas, Pulau kasiak, Fitoplankton.

1. Introduction

Plankton are microscopic organisms that live in floating waters, and their movements are limited by currents (Ode et al., 2019). Plankton has an essential role in the balance of aquatic ecosystems, namely as the primary provider of oxygen in the waters and the main component of the food chain in the waters. Plankton consists of phytoplankton and zooplankton. In the food chain, phytoplankton are primary producers, zooplankton are primary consumers, and the primary producer is linked with biota at the trophic level above it (Yuliana & Mutmainnah, 2019). The community structure is the species in the community, bound in biotic interactions and functioning as an integrated unit. Ecologically, phytoplankton has an important function as a primary producer, often used as an indicator of the fertility of the waters. Phytoplankton also affects the existence of zooplankton and is a food source for zooplankton.

In oceanic ecosystems, the predator-prey relationship between zooplankton and phytoplankton is an important biotic interaction factor that can affect the community structure of both. So, the predation pressure from zooplankton can reduce the abundance of phytoplankton. Conversely, reducing certain phytoplankton can also cause a decrease in the abundance of some types of zooplankton, which are their predators. According to Saito in Dewanti et al. (2018), the link between zooplankton and phytoplankton can be seen from the process of predation (grazing) of phytoplankton and its role as a link with biota at the equatorial level above it such as fish larvae and juveniles.

Kasiak Island is one of the islands in Pariaman City, West Sumatra, right in front of Pariaman City. Kasiak Island waters are one of the waters included in the marine waters conservation zone because they are rich in biota diversity. The condition of the island's waters is not like the previous year. These changes can be caused naturally or due to human activities carried out on land and in the waters concerned. Therefore, the presence and activity of plankton are related to the surrounding aquatic environment and are indicators of the quality and level of water fertility.

Research on the structure of plankton communities and the relationship between the abundance of phytoplankton and zooplankton is still done in this area. Research that has little to do with this topic includes Sihotang et al. (2021) on the relationship between coral reef cover and coral fish of the Pomacentridae family with the abundance of phytoplankton and Silaban et al. (2022) on the abundance of phytoplankton and primary productivity. Based on this, researchers are interested in researching the Community Structure of Plankton in Kasiak Island Waters, Pariaman City, West Sumatra Province.

2. Material and Method

2.1. Time and Place

This research was conducted in September 2022 in the waters of Kasiak Island, Kota Pariaman, West Sumatra Province. Plankton was identified and analyzed at the Marine Biology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau. The location of the station was determined

purposefully, namely, by taking into account various conditions at the research location, which consisted of 4 stations. Each station consists of 3 sampling points (Figure 1).

Figure 1. Research location

2.2. Methods

The method used in this study is a survey method by collecting primary data (temperature, salinity, brightness, pH, current velocity, DO, nitrate samples, phosphate samples, and plankton samples) obtained from direct observations in the field. The samples obtained were then analyzed in the laboratory.

2.3. Procedures

2.3.1. Plankton Sampling

Phytoplankton and zooplankton were sampled at 07.00 - 09.00 WIB and 11.00 - 12.00 WIB on the surface of the waters. Plankton samples were taken using a 10 L bucket with 100 L of surface water. Then, it was filtered using a plankton net number 25 with a mesh size of 55 µm to 125 ml and then transferred to a sample bottle that had been prepared and labelled. Then, it is preserved by adding 3-4 drops of 4% Lugol's solution and taken to the laboratory for analysis.

2.3.2. Plankton Identification and Analysis

The Plankton identification was carried out in the laboratory using the visual field method with three repetitions. The observed samples were first homogenized manually so that the plankton spread evenly. The samples were taken using a dropper, dripped into object glass, and covered with a cover glass measuring 25 x 25 mm^2. Phytoplankton samples were observed with the help of an Olympus CX 21 microscope with a magnification of 10 x 40, while zooplankton samples were observed with a magnification of 10 x 10. Furthermore, they were identified using the identification book Davis (1995); Yamaji (1976).

Plankton abundance was calculated using the APHA (1989) as follows:

$$N=\frac{Oi}{Op} \times \frac{Vr}{Vo} \times \frac{1}{Vs} \times \frac{n}{p}$$

Information:

N : Abundance of individual plankton (individual/liter)
Oi : Wide cover glass (25 x 25 mm^2)
Op : Wide one visual field (1.306 mm^2)
n : The number of individual plankton found in all fields of view
Vr : Water volume filtered sample (125 mL)
Vo : Volume of 1 drop of water (0.06 mL)
vs : Volume-filtered plankton sample (100 L)
P : Number of visual fields observed (12)

The diversity index (H) used is the Shannon Wiener index (Adiprayoga et al., 2017):

$$H'=-\sum_{i=0}^{s} pi \, Log_2 \, pi$$

Information:

H' = Shannon- Wiener diversity index
pi = ni /N (proportion of the i-th type)
ni = number of individuals of each type i
N = total number of individuals
Log2= 3.321928

By criteria: H'< 1 = the biota community is unbalanced, or the water quality is heavily polluted; 1 ≤ H' ≤ 3= The balance of the moderate biota community and the quality of moderately polluted waters; H' > 3 =Biota balance in prime condition and clean water quality. The uniformity index (E) used is the Pilou index (Lubis et al., 2019):

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

Information:

E	: Uniformity index
H'	: Diversity index
H'max	: Log2 S
Log2	: 3.321928
S	: Number of species found

Criteria used: E < 0.4: little uniformity; 0.4 ≤ E ≤ 0.6: Moderate uniformity; E > 0.6: High uniformity. The dominance index (D) is calculated using the Simpson formula (Lubis et al., 2019) as follows:

$$D = \sum_{i=0}^{n} \left(\frac{Ni}{N} \right)^2$$

Information:

D	: dominance index
Ni	: The number of individuals of the i-th species
N	: Total number of individuals

Criteria used: D is close to 0 (< 0.5): no species dominates; D is close to 1 (≥ 0.5): some species predominate.

Waters with low species diversity also tend to have low uniformity. The uniformity index (E) and dominance index (C) values range from 0 – 1. If the uniformity index is close to 0, the dominance index value will be close to 1.

2.4. Data Analysis

All data obtained is presented as tables and graphs and then analyzed descriptively. Furthermore, a one-way ANOVA statistical test was performed using Statistical for Social Science (SPSS) version 23 to see the abundance comparison between stations. The relationship between the abundance of phytoplankton and zooplankton in the waters was analyzed using a simple linear regression test using Microsoft Excel 2010 software. The equation used, according to Tanjung (2014), is:

$$Y = a + bx$$

Information:

Y	= Dependent variable (Abundance of zooplankton)
a	= Constant
b	= Regression coefficient
x	= Independent variable (Phytoplankton abundance)

The correlation coefficient (r) is used to find the relationship where the r value is between 0 – 1. According to Tanjung (2014), the closeness of the values is: 0.00 – 0.25 = weak relationship; 0.26 – 0.50 = moderate; relationship; 0.51 – 0.75= strong relationship; 0.76 – 1.00= relationships are very strong

3. Result and Discussion

3.1. General Conditions of Research Locations

Kasiak Island is one of the islands located west of Pariaman City, West Sumatra Province. This island is at coordinates 00o35'44"-00o35'48.3" South Latitude and 100o4'28.4"-100o4'31.9" East Longitude. Kasiak Island has an area of about 2.16 ha. This island has a sloping beach accompanied by white sand almost all around the island, clear waters, and overgrown with several trees ranging from coconut trees, sea hibiscus, and mangroves. It is also overgrown with shrubs and some flower plants. This island is one of the islands recorded as uninhabited. Even so, on this island, there are several official residence buildings and a lighthouse in the middle of the island (Directorate for the Empowerment of Small Islands, 2012).

3.2. Water Quality Parameters

Water quality parameters measured include physical and chemical parameters. Physical parameters include temperature, brightness, and current speed, while chemical parameters include pH, salinity, dissolved oxygen (DO), nitrate, and phosphate (Tables 1 and 2).

Table 1. Quality value in Kasiak Island waters

Station	Temperature (°C)	Brightness (m)	pH	Current Speed (m/s)	Salinity (‰)	DO (mg/L)
1	32	1.89	6	0.45	32	7.88
2	31	1.79	6	0.39	32	7,84
3	30	1.72	6	0.42	33	7.85
4	31	1.75	6	0.41	32	7.86

Table 2. Average nitrate and phosphate concentrations in Kasiak Island waters

Station	Nitrate concentration (mg/L)		Phosphate concentration (mg/L)	
	Average	Standard deviation	Average	Standard deviation
1	0.77	±0.04	1.04	±0.01
2	0.80	±0.01	0.98	±0.01
3	1.05	±0.02	0.91	±0.01
4	0.78	±0.02	0.87	±0.01

3.3. Types of Phytoplankton and Zooplankton

Based on the results of observations, there were 14 species of phytoplankton found in the morning consisting of 5 classes: Bacillariophyceae (9 species), Coscinodiscophyceae (1 species), Cyanophyceae (1 species), Dynophyceae (2 species), and Flagillariophyceae (1 species). While the phytoplankton found during the day, as many as 15 species consisting of 4 classes, Bacillariophyceae (8 species), Cyanophyceae (1 species), Dynophyceae (4 species), and Flagillariaphyceae (2 species).

Table 3. Types of phytoplankton found in Kasiak Island waters

No	Class	Species	Observation time							
			Morning (Station)				Afternoon (Station)			
			1	2	3	4	1	2	3	4
1	Bacillariophyceae	*Dactyliosolen* sp	+	+	+	+	+	+	+	+
2		*Leptocylindrus* sp	+	-	+	-	+	-	-	-
3		*Cocconeis* sp	+	-	-	-	-	-	-	-
4		*Guinardia* sp	-	-	-	-	-	+	-	-
5		*Rhizosolenia* sp	-	-	+	-	+	-	+	+
6		*Amphiphora* sp	-	-	+	-	-	-	-	-
7		*Navicula* sp	-	-	-	+	-	-	-	+
8		*Chaeteceros* sp	-	-	-	-	-	-	-	+
9		*Bacteriastrum* sp	-	-	+	-	-	-	-	-
10		*Stephanopyxis* sp	+	-	+	+	+	+	+	+
11		*Isthmia* sp	-	-	-	+	+	+	+	+
12	Coscinodiscophyceae	*Coscinodiscus* sp	+	+	+	+	-	-	-	-
13	Cyanophyceae	*Aphanizomenon* sp	+	+	+	-	-	-	-	-
14		*Microcytis* sp	-	-	-	-	-	+	-	-
15		*Heterocapsa* sp	-	+	+	-	-	-	-	-
16		*Noctiluca* sp	-	-	+	-	-	-	+	-
17	Dinophyceae	*Azadinium* sp	-	-	-	-	-	+	-	-
18		*Ceratium* sp	-	-	-	-	-	-	+	-
19		*Procentrum* sp	-	-	-	-	-	-	+	-
20	Fragilariophyceae	*Synedra* sp	-	+	+	+	-	+	-	-
21		*Thalassionema* sp	-	-	-	-	+	-	+	+
	Total		6	5	11	6	6	7	8	7

Description: (+) Found (-) Not found

Based on Table 3, the most common types of phytoplankton in the morning and afternoon are at station 3. *Dactyliosolen* sp, *Coscinodiscus* sp, *Stephanopyxis* sp, and *Isthmia* sp. are the phytoplankton species found at each station. This is because the phytoplanktons from the Bacillariophyceae class have the highest tolerance in marine waters, and *Coscinodiscus* sp can make optimal use of environmental conditions. This is supported by the opinion of Aryawati & Thoha (2011) that the Bacillariophyceae class has the highest number of genera and abundance and has a higher reproductive capacity than other phytoplankton classes. The opinion of Sari et al. (2014) stated that the Bacillariophyceae class has cosmopolitan, tolerance and high adaptability characteristics. Besides that, according to Arinaldi's opinion in Mery et al. (2018), *Coscinodiscus* sp can utilize nutrients more quickly than other species.

Based on observations, there were eight species of zooplankton found in the morning consisting of 7 classes: Maxillopoda (1 species), Hexanauplia (2 species), Thaliacea (1 species), Ophiuroidea (1 species), Thecostraca (1 species), Malacostraca (1 species), and Appendicularia (1 species). The most common type of zooplankton found was at station 1. *Calanus* sp are zooplankton species found at each station. This is because copepods are a type of zooplankton that are often found in waters, and this is supported by Fitriya's opinion in Ginting et al. (2019) stated that copepods are the most dominant zooplankton in the waters.

Table 4 shows that there are seven species of zooplankton found during the day consisting of 5 classes, namely Maxillopoda (2 species), Ophiuroidea (1 species), Thecostraca (1 species), Malacostraca (2 species), and Appendicularia (1 species). The most common type of zooplankton found was at station 3. Barnacle larvae (barnacles) were zooplankton species found at each station. This is because crustaceans are a type of zooplankton that are often found in waters (Faiqoh et al., 2015).

Table 4. Types of zooplankton found in Kasiak Island waters

No	Class	Species	class	Observation time							
				Morning (Station)				Afternoon (Station)			
				1	2	3	4	1	2	3	4
1	Maxillopods	*Coryceaus*sp.	Holoplankton	+	+	-	-	-	-	-	-
2		*Acrocalanus*sp.	Holoplankton	-	-	-	-	-	-	+	-
3		*Tortanus*sp.	Holoplankton	-	-	-	-	-	-	+	-
4	Hexanauplia	*Calanus*sp.	Holoplankton	+	+	+	+	-	-	-	-
5		*Oithona*sp.	Holoplankton	-	-	+	-	-	-	-	-
6	Thaliacea	Salps	Meroplankton	+	-	-	-	-	-	-	-
7	Ophiuroidea	Ophiopluteus larvae	Meroplankton	+	-	+	-	-	-	+	-
8	Thecostraca	Barnacle Larvae (Barnacles)	Meroplankton	+	+	+	-	+	+	+	+
9	Malacostraca	Zoea	Meroplankton	+	+	-	+	-	+	-	+
10		Euphasid larvae	Meroplankton	-	-	-	-	+	-	+	-
11	Appendicularia	Tunicate larvae	Meroplankton	-	-	-	+	+	+	-	+
	Total			6	4	4	3	3	3	5	3

Description: (+) Found (-) Not found

3.4. Phytoplankton and Zooplankton Abundance

Based on the results of the analysis, the abundance of phytoplankton in the morning can be seen in Table 5.

Table 5. Phytoplankton abundance in Kasiak Island waters in the morning

Station	Phytoplankton Abundance (ind/L)		
	Total	Average	Standard deviation
1	7200.56	2,400.19	±423.04
2	2,769.44	923.15	±576.51
3	5815.84	1938,61	±479.68
4	4,985.00	1661.67	±1684.59

Table 5 shows the values. The average abundance ranged from 923.15–2,400.19 ind/L. The highest abundance was at station 1, with an average abundance of 2,400.19 ind/L, and the lowest was at station 2, with an average abundance of 923.15 ind/L. This is presumably because the brightness at station 1 is higher than the other stations, i.e., 1.89 ind/L. This is supported by the opinion of Hutami et al. (2017) that brightness values can affect the abundance of phytoplankton because phytoplankton needs light in photosynthesis.

In addition to brightness, nitrate and phosphate also affect phytoplankton's abundance because they need these nutrients for their growth. Table 2 shows the phosphate concentration at station 1, which is higher than at station 2. This shows that the higher the phosphate concentration, the higher the phytoplankton abundance. This is reinforced by the statement of Ginting et al. (2015) that phytoplankton can grow and develop appropriately if the nutrients needed are available in sufficient quantities and the statement of Darmawan et al. (2017) that an increase in phosphate concentration will increase the abundance of phytoplankton. Likewise, an increase in nitrate will increase the abundance of phytoplankton. The lower nitrate concentration at station 1 than at station 2 is because it is widely used and consumed by phytoplankton for its growth. This is supported by the statement of Rozalina et al. (2020) that low nitrate levels on the surface are since these nutrients have been used by phytoplankton for their growth, and the statement of Ulqodry et al. (2010), nitrate will always be taken up in the surface layer during the primary productivity process.

Based on the analysis of the One-way ANOVA statistical test, the average abundance of phytoplankton between stations in the morning showed no significant difference with a p-value >0.05, namely 0.344. This is presumably because the range of distances between stations is still in the same waters, namely the waters of Kasiak Island. Based on the analysis results, the abundance of zooplankton in the morning can be seen in Table 6.

Table 6. The abundance of zooplankton in Kasiak Island waters in the morning

Station	Zooplankton abundance (ind/L)		
	Total	Average	Standard deviation
1	1661.67	553.89	±276.95
2	1107.78	369,26	±159.90
3	1661.67	553.89	±479.69
4	3,600.28	1200.09	±423.04

Table 6 shows the average values of the abundance ranges 369,26–1,200.09 ind/L. The highest abundance is at station 4, with an average abundance of 1200.09ind/L; the lowest is at station 2, with an average abundance of 369,26 ind/L. This is suspected because the brightness value at station 4 is smaller than at station 2. At station 4,

the brightness value is 1.75 m; at station 2, it is 1.79 m. According to Ginting et al. (2015), zooplankton have negative phototaxis, which will rise to the surface at night and descend to the lower layers of water during the day. Based on the results of the analysis, the abundance of phytoplankton during the day can be seen in Table 7.

Table 7. Phytoplankton abundance in Kasiak Island waters during the day

Station	Zooplankton Abundance (ind/L)		
	Total	Average	Standard deviation
1	4985.01	1661.67	±1107.78
2	3,600.28	1200.09	±890.25
3	6923,62	2,307.87	±423.04
4	7,477.50	2,492.50	±1,465.46

Table 7 shows the average abundance value ranging from 1200.09–2,492.50 ind/L. The highest abundance is at station 4, with an average abundance of 2,492.50ind/L; the lowest is at station 2, with an average abundance of 1200.09 ind/L. This is presumably because the dissolved oxygen (DO) at station 4 is higher than at station 2. At station 4, the dissolved oxygen value is 7.86 mg/L; at station 2, it is 7.74 mg/L. This shows that the photosynthesis of the phytoplankton at station 4 produces more oxygen than at station 2. According to Salim in Sari et al. (2018), Dissolved oxygen (DO) is the amount of oxygen dissolved in water that comes from photosynthesis and diffusion in the air.

Nitrate and phosphate also affect phytoplankton's abundance because they need these nutrients for their growth. The lower concentrations of nitrate and phosphate at station 4 than at station 2 are because they are widely used and consumed by phytoplankton for their growth. This is supported by the statement of Rozalina et al. (2020) that low levels of nitrate on the surface are because these nutrients have been utilized by phytoplankton for their growth and the statement of Simanjuntak et al. (2012) low levels of phosphate in the surface layer may also be caused by intensive phytoplankton activity. Based on the analysis results, the abundance of zooplankton during the day can be seen in Table 8.

Table 8. Abundance of zooplankton in Kasiak Island waters during the day

Station	Zooplankton abundance (ind/L)		
	Total	Average	Standard deviation
1	1107.77	369,26	±159.90
2	1107.77	369,26	±159.90
3	2215.55	738.52	±423.04
4	4154.17	1,384.72	±276.95

Table 8 shows the average abundance values ranging from 369,26 to 1,384.72 ind/L. The highest abundance is at station 4, with an average abundance of 1,384.72 ind/L, and the lowest abundance was found at stations 1 and 2, with an average abundance of 369,26 ind/L. It is suspected because the brightness value at station 4 is smaller than at stations 1 and 2. At station 4, the brightness value is 1.75 m, and stations 1 and 2 are 1.89 m and 1.79 m, respectively. According to Ginting et al. (2015), zooplanktons have negative photo-taxis, which will rise to the surface at night and descend to the lower layers of water during the day.

3.5. Phytoplankton and Zooplankton Biological Indices

Based on the results of the analysis performed, the diversity index (H'), uniformity index (E), and dominance index (D) of the phytoplankton can be seen in Table 9.

Table 9. Phytoplankton biological indices in Kasiak Island waters

Station	Diversity (H')		Uniformity (E)		Dominance (D)	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
1	1.8083	1.6511	0.9042	0.9107	0.3129	0.3778
2	0.6096	1.3894	0.4844	0.9624	0.6617	0.4248
3	2.3075	2.0129	0.9584	0.9142	0.2181	0.2833
4	1.6849	1.7786	0.9851	0.9060	0.3429	0.3307

Table 9 shows the value of the diversity index (H') of phytoplankton in the morning, which ranges from 0.6096–2.3075, and during the day, it ranges between 1.3894–2.0129. According to Shannon Wienar's statement in Adiprayoga et al. (2017), low species diversity has an H' value < 1, moderate species diversity has a value of 1 ≤ H' ≤ 3, and high species diversity has an H' value > 3. Based on this statement, phytoplankton species diversity in the morning at Station 2 is classified as low, and at stations 1, 3, and 4, it is classified as moderate. Meanwhile, the diversity of phytoplankton species during the day is moderate.

The value of the uniformity index (E) of phytoplankton in the morning ranges between 0.4844 and 0.9851, and during the day, it ranges between 0.9060–0.9624. According to Pilou's statement in Sari et al. (2019), low

uniformity has an E value < 0.4; moderate uniformity has a value of 0.4 ≤ E ≤ 0.6, and high uniformity has a value of H'> 0.6. Based on this statement, the uniformity of phytoplankton in the morning at station 2 was classified as moderate, and at stations 1, 3, and 4, it was classified as high. Meanwhile, the uniformity of phytoplankton during the day is high.

The value of the dominance index (D) of phytoplankton in the morning ranged from 0.2181–0.6617, and at noon, 0.2833–0.4248. According to Simpson's statement in Sari et al. (2019), no species dominates if the dominance value is close to 0, whereas if the dominance value is close to 1, species dominate. Based on this statement, the station that found that the waters had zooplankton that dominated was station 2 in the morning. Based on the results of the analysis of the diversity index (H'), uniformity index (E), and dominance index (D) of zooplankton can be seen in Table 10.

Table 10. Biological indices of zooplankton in Kasiak Island waters

Station	Diversity (H')		Uniformity (E)		Dominance (D)	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
1	0.8617	0.3333	0.6667	0.3333	0.6111	0.8333
2	0.3333	0.6667	0.3333	0.6667	0.8333	0.8333
3	0.2704	1.1950	0.2704	0.6667	0.8750	0.5278
4	0.5228	0.5765	0.5228	0.5765	0.7593	0.7269

Table 10 shows the value of the diversity index (H') of zooplankton in the morning ranges from 0.2704–0.8617, and during the day, it ranges between 0.3333–1.1950. According to Shannon Wienar's statement in Adiprayoga et al. (2017), low species diversity has an H' value < 1, moderate species diversity has a value of 1 ≤ H' ≤ 3, and high species diversity has an H' value > 3. Based on this statement, the diversity of zooplankton species in the morning is relatively low. Meanwhile, the diversity of zooplankton species during the day at stations 1, 2, and 4 was classified as low, and at station 3 was classified as moderate.

Macrozooplankton uniformity index (E) in the morning ranges between 0.2704 and 0.6667; during the day, it ranges between 0.3333 and 0.6667. According to Pilou's statement in Sari et al. (2019), low uniformity has an E value < 0.4; moderate uniformity has a value of 0.4 ≤ E ≤ 0.6, and high uniformity has a value of H'> 0.6. Based on this statement, the uniformity of zooplankton in the morning at station 1 was classified as high; at stations 2 and 3, it was classified as low; and at station 4, it was classified as moderate. Meanwhile, the uniformity of zooplankton during the day at station 1 was classified as low; at stations 2 and 3, it was classified as high; and at station 4, it was classified as moderate.

The dominance index (D) of zooplankton in the morning ranged from 0.6111 to 0.8750, and during the day, it ranged between 0.5278 and 0.8333. According to Simpson's statement in Sari et al. (2019), no species dominates if the dominance value is close to 0, whereas if the dominance value is close to 1, species dominate. Based on this statement, there are dominant types of zooplankton in these waters, both in the morning and during the day.

3.6. Relationship of Phytoplankton Abundance to Zooplankton

Analysis of the relationship between the abundance of phytoplankton and zooplankton was carried out using a simple linear regression correlation equation. The results of simple linear regression correlation analysis of the average abundance of phytoplankton to the average abundance of zooplankton in the morning can be seen in Figure 2.

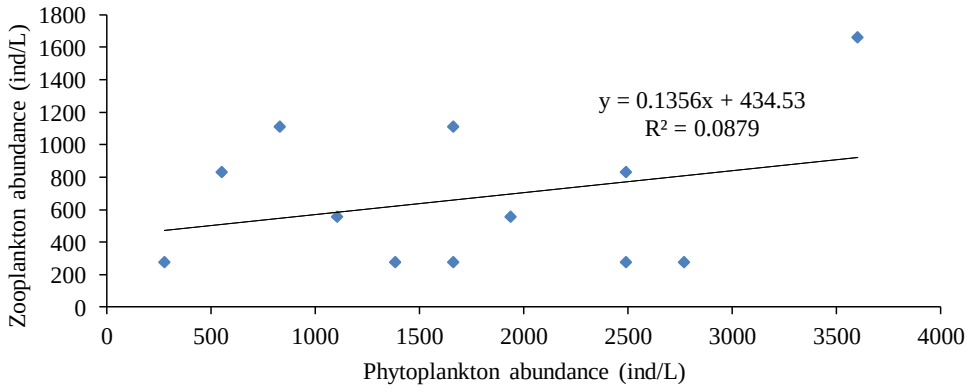

Figure 2. Relationship between average phytoplankton abundance and morning zooplankton abundance

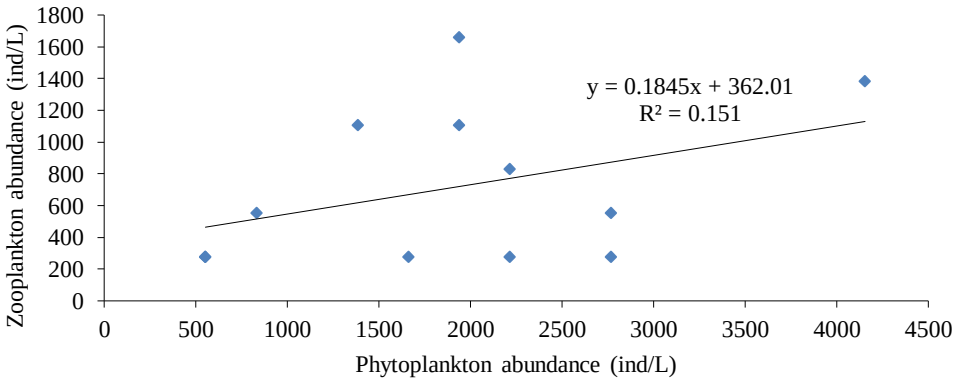

Figure 3. Relationship between average phytoplankton abundance and daytime zooplankton abundance

In Figure 2, the regression line equation Y = 0.1356x + 434.53 with a coefficient of determination (R2) = 0.0879 and a correlation coefficient (r) = 0.2965. A constant value of 434.53 indicates that if phytoplankton (x) abundance is zero, then zooplankton abundance is 434.53 ind/L. The regression coefficient value of variable x (phytoplankton abundance) is 0.1356, indicating that if the abundance of phytoplankton increases by one mg/L, then the abundance of zooplankton will increase by 0.1356 ind/L. Based on value r, the relationship between the abundance of phytoplankton and zooplankton in the morning is moderate, and the regression coefficient x is positive, indicating a positive relationship. This shows that as the amount of phytoplankton abundance increases, the abundance of zooplankton will also increase. Based on the equation of the coefficient of determination (R^2), it can also be seen that the effect of the abundance of phytoplankton on the abundance of zooplankton is 8.79%. In comparison, 91.21% is influenced by other environmental factors, namely water physics (temperature, brightness, and current speed) and water chemistry (pH, dissolved oxygen (DO, salinity, nitrate, and phosphate).

In Figure 3, the regression line equation Y = 0.1845x + 362.01 with a coefficient of determination (R2) = 0.151 and a correlation coefficient (r) = 0.3866. A constant value of 362.01 indicates that if the abundance of phytoplankton (x) is zero, then the abundance of zooplankton is 362.01 ind/L. The regression coefficient value of variable x (phytoplankton abundance) is 0.1845, indicating that if the abundance of phytoplankton increases by one mg/L, then the abundance of zooplankton will increase by 0.1845 ind/L. Based on value r, the relationship between the abundance of phytoplankton and zooplankton in the morning is moderate, and the regression coefficient x is positive, indicating a positive relationship. This shows that as the amount of phytoplankton abundance increases, the abundance of zooplankton will also increase. Based on the equation of the coefficient of determination (R2), it can also be seen that the effect of phytoplankton abundance on zooplankton abundance is 15.1%. In comparison, 84.9% is influenced by other environmental factors, namely water physics (temperature, brightness, and current speed) and water chemistry (pH, dissolved oxygen, salinity, nitrate, and phosphate).

4. Conclusions

In the waters of Kasiak Island, as many as 21 phytoplankton species were found. The phytoplankton species present at each station, namely *Dactyliosolen* sp, *Stephanopyxis* sp, *Isthmia* sp, and *Coscinodiscus* sp. The average abundance of phytoplankton in the morning ranged from 923.15–2,400.19 ind/L, and during the afternoon ranged from 1200.09–2,492.50 ind/L. Level diversity (H') in the morning and afternoon is low to moderate. The uniformity (E) level in the morning and afternoon is moderate to high. The dominance value (D) found is the type of phytoplankton that dominates. In the waters of this island, as many as 11 species of zooplankton were found. The zooplankton species at all stations were *Calanus* sp and barnacle larvae (barnacles). The average abundance of zooplankton in the morning ranges from 369,26–1200.09 ind/L, and during the day ranges from 369,26–1,384.72 ind/L. Level diversity (H') is low to moderate in the morning and afternoon. The uniformity (E) level in the morning and afternoon is classified as low to high. The dominance value (D) found is that the type of zooplankton dominates. The abundance of phytoplankton to zooplankton in the morning and afternoon has the same pattern: the increasing abundance of phytoplankton, the greater the abundance of zooplankton. In addition, the relationship between the abundance of phytoplankton and zooplankton in the morning and afternoon was moderate.

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